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Geochemical analyses and summaries of shale from Kentucky

By

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards or nomenclature

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INTRODUCTION

This report summarizes results of a study of geochemical variability in shale of Paleozoic age in Kentucky. The study was undertaken as a field experiment in geochemical sampling and was based on an attempt to collect samples of shale from outcrop in an objective fashion. Kentucky is typical of many areas in the cratonic part of the eastern United States in that a combination of low relief and pervasive weathering has resulted in a general paucity of bedrock exposures. This study illustrates a few of the effects of such constraints on objective sampling. These difficulties notwithstanding, the data resulting from this study were used to identify 6 stratigraphic-geochemical subpopulations in the Paleozoic shale of Kentucky. An earlier report (Connor, 1981) described the results of a similar study of carbonate rocks.

Kentucky was chosen for these studies because of an ongoing U.S. Geological Survey-Kentucky Geological Survey cooperative mapping program at the time sampling was undertaken (1964-1965). Although only a third or so of the State was covered by mapping at that time, the available 7-1/2'-scale maps formed a reasonably solid stratigraphic base for relating the samples on a regional scale. Because a prime requirement for geochemical target definition is that it be unequivocally identifiable in the field, sampling was restricted to those areas covered by 7-1/2' quadrangle maps at the time of sample selection.

Numerous U.S. Geological Survey mappers contributed time and effort in helping to locate outcrops for sampling. L. Artis, S. Botts, G. Chloe, Nancy Conklin, Paul Elmore, J. Glenn, R. G. Havens, W. W. James, Lorraine Lee, L. F. Rader, H. Smith, D. Taylor, and J. A. Thomas analyzed over 200 rock samples for some 50 elements for this work. Mel Johnson made thin sections of each sample.

STRATIGRAPHIC SETTING

Shale of Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian age crop out in Kentucky (fig. 1). No shale of Ordovician or Silurian age was sampled in this study because of limited outcrop (Siliurian) or paucity of mapping (Ordovician) at the time of collection. The most lithically distinct shale in the Paleozoic of Kentucky is the organic-rich deposits of the Chattanooga, New Albany, and Ohio Shales (Upper Devonian to Lower Mississippian). This unit is generally less than 15 m thick over much of the State. The strata thicken northward to a maximum of 70 m in northeastern Kentucky, where the Ohio Shale is overlain by deltaic deposits of the Berea and Bedford Formations. These two formations are, in turn, overlain by another organic-rich shale--the Sunbury Shale. Conant and Swanson (1961, p. 50) concluded that these black shales were deposited on a stable interior platform ringed by areas of low relief. One sample in this work (DSH-P111, in the Briensburg Quadrangle of western Kentucky) was white and contained less than 1% organic carbon. Cluff and Reinbold (1978) reported that similar interbeds in the Illinois Basin reflected deposition in an oxygenated interval of an oxygen-stratified basin.

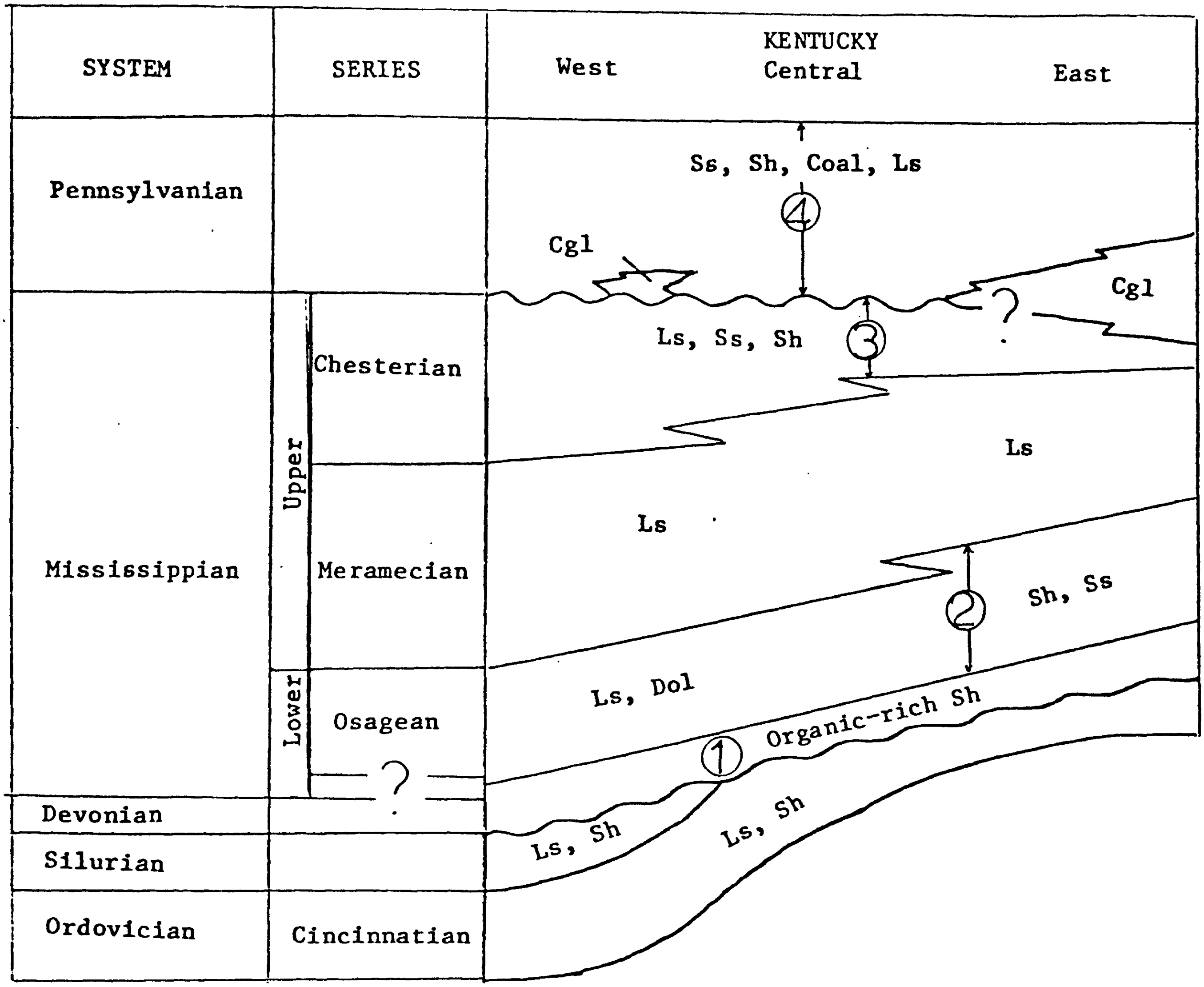


Figure 1.--Regional stratigraphic relations of Paleozoic rocks in Kentucky. Sampled shale units are numbered.

Shale of Osagean age (Lower Mississippian) in Kentucky is represented largely by the Borden and Fort Payne Formations (Sable, 1979). These formations consist of a heterogeneous assortment of interbedded limestone, dolomite, sandstone, shale, siltstone and chert. Deltaic clastics are dominant to the northeast (Borden Formation) whereas carbonates are dominant to the southwest (Fort Payne Formation). In northeastern Kentucky, the Borden attains a thickness of more than 200 m and consists of shale, siltstone, and fine-grained silty sandstone (Chaplin and Mason, 1978). In western Kentucky the Fort Payne ranges up to 200 m in thickness (Lambert and MacCary, 1964), and consists of dark, finely crystalline, cherty limestone or dolomitic limestone. In west-central and south-central Kentucky, the Borden-Fort Payne interval contains interbedded shale, sandstone and crinoidal limestone (Thaden and others, 1961, p. B88; Kepferle, 1966). Bedded chert is locally prominent in this same area in outcrop. The uppermost Borden strata of east-central Kentucky are apparently time equivalents of the lowermost strata in the Salem-Warsaw interval of west-central Kentucky (Sable and others, 1966).

The Borden-Fort Payne interval is overlain by a highly variable thickness of nearly pure limestone (mostly of Meramecian age), which in turn is overlain by an interbedded sequence of limestone, sandstone and shale (mostly Chesterian in age). Together, these rocks, which comprise nearly all of the Upper Mississippian Series in the State (Sable, 1979), exceed 600 m in thickness in western Kentucky where 18 formations are recognized. These strata thin to about 200 m over the Cincinnati Arch in south-central Kentucky and are locally absent in northeastern Kentucky because of pre-Pennsylvanian erosion.

The Meramecian strata mark the peak of Mississippian transgression in Kentucky and consist of light- to dark-gray, finely to coarsely crystalline, cherty, fossiliferous limestone. The Chesterian rocks reflect the closing phases of Mississippian deposition in western Kentucky. In the Illinois Basin, this phase consisted of at least 70 reversals of shore-line movement (Swann, 1964, p. 654) before final withdrawal of the sea to the southwest (Siever, 1951, p. 575). In eastern Kentucky, the Chester is represented by the Pennington Formation, a sequence of interbedded limestone, sandstone and shale. Near the Tennessee line, the Chester includes the Hartsel and Bangor Formations.

The Pennsylvanian rocks comprise a heterogeneous assortment of interbedded, poorly sorted sandstone, shale, siltstone, claystone, coal, conglomerate and carbonate. These rocks are more than 900 m thick in the Illinois Basin and over 1500 m thick in the Appalachian Basin of southeastern Kentucky (McKee and Crosby, 1975, Pl. 11). In many outcrops, the base of these rocks is marked by a conspicuous unconformity separating interlayered, well bedded, fine-grained carbonate and clastics below from interfingering conglomeratic sandstones and carbonaceous siltstone or shale above. In eastern Kentucky, the relation of the basal conglomerate in the Lee Formation to the underlying shale of the Mississippian Pennington Formation is in dispute. Wanless (1975a, p. 23) notes the presence of intertongues of Lee-type rocks in the Pennington in both northeastern and southeastern Kentucky, and Horne, Ferm and Swinchatt (1974) suggest that this contact may not even be disconformable.

The great bulk of the Pennsylvanian interval, however, contains no conglomerate but rather represents rapid accumulation of sandstone and shale with interbeds of coal and carbonaceous shale. These deposits are particularly thick in extreme southeastern Kentucky reflecting proximity to source (Wanless, 1975a). The deposits were laid down on a large piedmont alluvial fan built westward or northwestward from the Appalachian geosyncline (Siever, 1951, p. 578). Sources of the Pennsylvanian rocks of western Kentucky apparently lay to the northeast (Wanless, 1975b).

ANALYTICAL METHODS

Each sample was trimmed of obvious weathering rinds, where possible, and about 200 g were crushed, ground to pass 100 mesh and split into two parts. Duplicates from each season's collection were placed in a randomized sequence prior to submission to the laboratory in order to circumvent analytical drift. All chemical analyses were performed in laboratories of the U.S. Geological Survey. The common rock-forming oxides were determined by rapid rock methods in Washington, D. C., as described in Shapiro and Brannock (1962). Most trace elements were determined in Denver, Colo., by a direct-reading emission spectrographic method described in Havens and Myers (1973). Mercury and silver in the organic-rich shales were determined by atomic absorption. Total carbon in these shales was determined by induction furnace combustion, carbonate carbon was determined gasometrically, and organic carbon was determined by difference.

The geochemical analyses are listed in tables 1A-1D. All samples (except LMSHE211, LMSHE212, LMSHE221 and LMSHE222 in table 1B, and UMSHK111 and UMSHK112 in table 1C) were analyzed in duplicate. Thus in table 1A, the first two rows (DSH-E111) are replicate analyses of a single sample; the next two rows (DSH-E112) are replicate analyses of another sample; and so forth. Trace elements commonly looked for but rarely detected by emission spectrography are listed in table 2 along with their approximate lower limits of determination. Thin-section modes, based on 50 points per section, were counted on all samples. Average modes are listed in table 3.

SAMPLING DESIGN

Four Paleozoic shale units were sampled in this work (fig. 1); in ascending stratigraphic order, they are

1. Organic-rich shale of the Chattanooga, New Albany, and Ohio Shales (Upper Devonian and Lower Mississippian)
2. Shale of Lower Mississippian age (Borden and Fort Payne Formations)
3. Shale of Upper Mississippian age (probably all of Chesterian age)
4. Shale of Pennsylvanian age

The same sampling design was used for each stratigraphic unit. The design is a hierarchical one in which each level of the design includes paired sampling units separated by a given distance or a range of distances. The State was arbitrarily divided into one-degree areas. For each stratigraphic unit sampled, two mapped 7-1/2' quadrangles were selected randomly within each one-degree area, if possible. (For some one-degree areas and some stratigraphic units, only two quadrangles were available). In each 7-1/2' quadrangle two sampling localities of a size 300 by 450 m were selected randomly from those parts of the quadrangle underlain by the unit. In each locality, two random samples of 4-8 kg were taken from outcrop. For the organic-rich shale (unit 1) and the Borden-Fort Payne shale (unit 2), two random samples were collected from an exposed stratigraphic section in each locality. (Units 3 and 4 were too thick to permit exposure of a complete section within a locality.) The quadrangles are listed in figure 2, and the sampling sites are described in tables 4A-4D. The quadrangle pairs in each one-degree area for each stratigraphic unit are identified in Part II of tables 6A-6D. Because of lack of suitable outcrop, one pair of 7-1/2' quadrangles for the organic-rich shale came from different one-degree areas (Briensburg and Eddyville quadrangles), as did a pair from the Upper Mississippian unit (Wrigley and Portsmouth quadrangles). For a similar reason, in one area of Borden rocks, three adjacent quadrangles (Head of Grassy, Wesleyville and Brushart) were used instead of two.

Histograms of the theoretical, planned and actual distributions of distance between samples in each locality and between localities in each 7-1/2' quadrangle are shown in figure 3A. The theoretical frequency distribution of a distance between two points in a rectangle was based on work of Ghosh (1951). Figure 3B shows the distribution of samples through stratigraphic sections of units 1 (organic-rich shale) and 2 (Borden and Fort Payne Formations). In figure 3A, the planned frequency distributions are based on distances between sample pairs (or locality pairs) as picked in the office using randomization procedures. The actual frequency distributions are based on distances between sample (locality) pairs as actually occurred in the field. The planned distances are slightly less than the theoretical distances; the actual distributions of distance between samples in a locality, however, are strongly biased with respect to both the planned and theoretical distances. This bias, which results largely because of outcrop constraints, indicates the severity with which operational problems can influence sampling design. Theoretical and actual average distances associated with three levels of the design are compared below:

Level of sampling design and rock unit	Theoretical distance (km)	Actual distance (km)
Between samples:		
Upper Mississippian	.27	.091
Pennsylvanian	.27	.23
Between localities:		
Organic-rich shale	6.4	5.2
Lower Mississippian	6.4	6.0
Upper Mississippian	6.4	4.0
Pennsylvanian	6.4	6.0
Between quadrangles:		
Organic-rich shale	53	24
Lower Mississippian	53	30
Upper Mississippian	53	31
Pennsylvanian	53	33

Commonly, a randomly picked locality lacked outcrop. In such a case, samples were collected as close as possible to the randomly picked locality. The errors resulting from such problems in locating samples are diagrammed in figure 4.

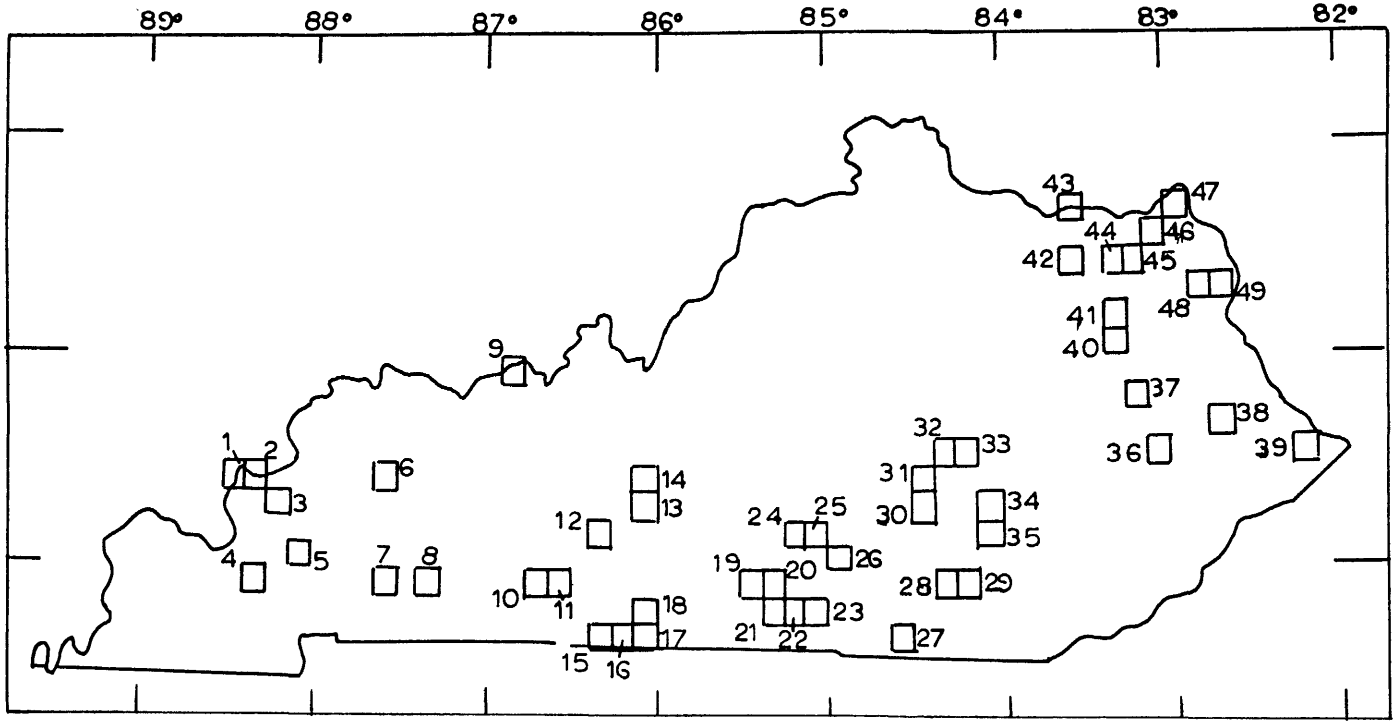


Figure 2.--Location of 7-1/2' quadrangles from which shale rocks of Paleozoic age were collected from Kentucky [C, rocks from the organic-rich Chattanooga Shale and lithic equivalents; LM, rocks of Lower Mississippian age; UM, rocks of Upper Mississippian age; P, rocks of Pennsylvanian age]

Quadrangle No.	Name	Unit sampled	U.S.G.S. Map GQ-	Author and year
1.	Shetlerville	UM,P	400	D. H. Amos, 1965
2.	Rosiclare	UM	400	D. H. Amos, 1965
3.	Salem	P	206	R. D. Trece, 1962
4.	Brienaburg	C	327	T. W. Lambert and L. M. MacCary, 1964
5.	Eddyville	C	255	W. B. Rogers, 1963
6.	Slaughters	P	360	T. M. Kehn, 1964
7.	Pleasant Green Hill	UM	321	W. H. Nelson, 1964
8.	Honey Grove	UM	376	Harry Klemic, 1965
9.	Tell City	P	356	F. D. Spencer, 1964
10.	South Union	UM	275	Harry Klemic, 1963
11.	Rockfield	UM	309	H. C. Rainey, III, 1964
12.	Brownsville	P	411	Benjamin Gildersleeve, 1965
13.	Cub Run	UM	386	C. A. Sandberg and C. G. Bowles, 1965
14.	Millerstown	UM	417	F. B. Moore, 1965
15.	Adolphus	LM	299	W. H. Nelson, 1964
16.	Petroleum	C	352	W. B. Myers, 1964
17.	Holland	LM	174	W. H. Nelson, 1762
18.	Austin	C	173	S. L. Moore, 1961
19.	Breeding	C	287	A. R. Taylor, 1964
20.	Amandaville	LM	186	A. R. Taylor, 1962
21.	Burksville	C	220	J. M. Cattermole, 1963
22.	Wolf Creek Dam	LM	177	R. Q. Lewis, Sr., and R. E. Thaden, 1962
23.	Cumberland City	UM	475	R. Q. Lewis, Sr., and R. E. Thaden, 1965
24.	Knifely	C,LM	294	C. H. Maxwell, 1964
25.	Dunnville	C,LM	367	C. H. Maxwell, 1965
26.	Eli	C,LM	393	R. E. Thaden and R. Q. Lewis, Sr., 1965
27.	Barthell	UM	314	J. B. Pomerene, 1964
28.	Sawyer	UM,P	179	W. P. Puffett, 1962
29.	Vox	P	224	W. P. Puffett, 1963
30.	Maretburg	UM	330	S. O. Schlanger, 1965
31.	Brodhead	C	662	J. L. Gualtieri, 1967
32.	Berea	LM	649	G. W. Weir, 1967
33.	Bighill	UM	900	G. W. Weir, K. Y. Lee, and P. E. Cassity, 1971
34.	Parrot	P	236	D. F. Crowder, 1963
35.	London	P	245	N. L. Hatch, Jr., 1963
36.	Tiptop	P	1/	S. W. Welch, 1958
37.	White Oak	P	2/	W. L. Adkison, 1957
38.	Lancer	P	347	C. L. Rice, 1964
39.	Matewan	P	373	V. A. Trent, 1965
40.	Wrigley	UM,P	170	J. W. Hosterman, S. H. Patterson,
41.	Haldeman	P	169	S. H. Patterson and J. W. Hosterman, 1961
42.	Burtonville	C	396	R. H. Morris, 1965
43.	Manchester Islands	C	581	J. H. Peck and K. L. Pierce, 1966
44.	Head of Grassy	LM	484	R. H. Morris, 1966
45.	Wesleyville	LM	1305	J. C. Philley and J. R. Chaplin, 1976
46.	Brushart	LM	324	C. S. Denny, 1964
47.	Portsmouth	UM	312	R. A. Sheppard, 1964
48.	Rush	P	408	J. E. Carlson, 1965
49.	Boltsfork	P	316	F. D. Spencer, 1964

1/ Published in U.S. Geological Survey Bulletin 1042-P (Geology and Coal Resources of the Tiptop Quadrangle, Kentucky).
2/ Published in U. S. Geological Survey Bulletin 1047-A (Coal Geology of the

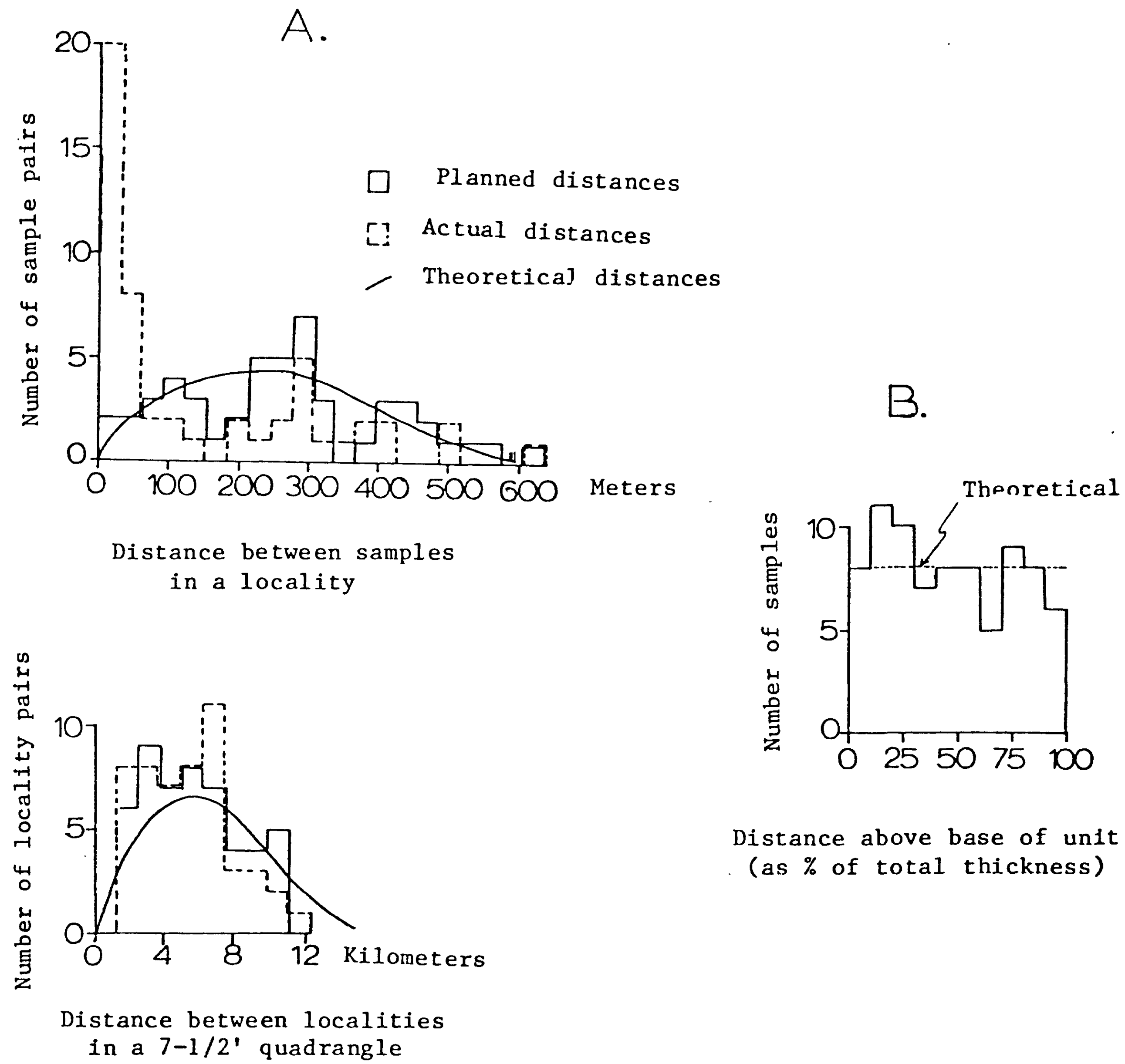


Figure 3.--A. Comparison of theoretical, planned and actual distances between samples and between sampling localities in the hierachical sampling plan used in the study of the Upper Mississippian and Pennsylvanian shale units in Kentucky.

B. Distance above base of unit for samples from the Chattanooga (and equivalents) and Lower Mississippian shale units in Kentucky. Distance above base measured as a percentage of total thickness of each unit.

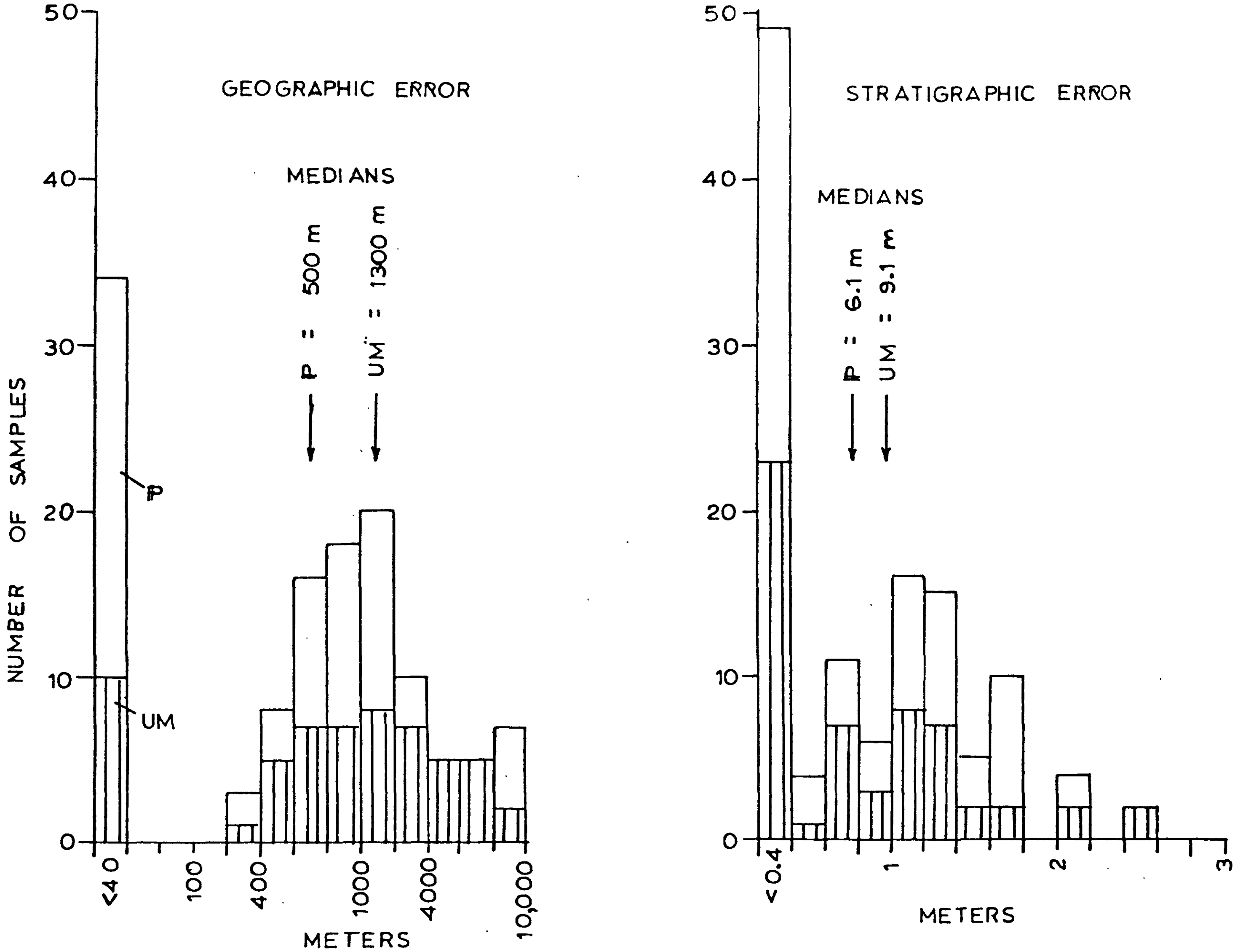


Figure 4.--Average distance (error) between planned and actual sampling sites for samples of Upper Mississippian [UM] and Pennsylvanian (P) shale in Kentucky.

The sampling design is a special case of the analysis of variance. The statistical model is

$$\text{Log } X(ijklm) = M + A(i) + B(ij) + C(ijk) + D(ijkl) + E(ijklm) \qquad (1)$$

where X(ijklm) represents an analytical value reported by the analyst; M represents the grand average (in logs) for that element in the stratigraphic unit (or sampling target) and the remaining terms are deviations, each reflecting a separate source of variation. The first term, A(i), represents the difference between M and the average (in logs) for the *i*th sampled one-degree area; the second, B(ij), represents the difference between the average (in logs) of the *j*th 7-1/2' quadrangle and the *i*th one-degree area; the third, C(ijk), represents the difference between the average (in logs) of the *k*th sampling locality and the *j*th 7-1/2' quadrangle; the fourth, D(ijkl), represents the difference between the average (in logs) of the *l*th sample and the *k*th locality, and the fifth, E(ijklm), represents the difference (in logs) between the observed analytical result and the true (but unknown) concentration. Logarithms of concentration in trace element work are commonly employed to help meet some of the assumptions underlying the statistical procedures used in data analysis (Miesch, 1976, p. 7-12). The estimate of total logarithmic variance in each sampled unit is equal to the sum of the estimates of the five components defined in equation (1):

$$V(\text{Log } X) = V(A) + V(B) + V(C) + V(D) + V(E) \qquad (2)$$

where V(Log X) is the total logarithmic variance.

DATA EVALUATION

Summary statistics of most of the distributions in this study are based on logarithms of the data. Thus, average values are given either as geometric means (GM) or as medians (M). In general, medians were calculated for sample subsets containing less than 10 samples (or 20 analyses where each sample was analyzed twice), and geometric means were calculated for sample sets of 10 or more. The scatter about these averages is measured by the geometric deviation (GD), a factor useful in computing expected ranges in concentration. For example, if a distribution is lognormal, about 68 percent of the determinations in a randomly selected suite should fall within the limits GM/GD to GMxGD, and about 95 percent should fall within the range GM/GDS to GMxGDS, where GDS is the square of GD.

A geochemical constituent is censored if a sample suite contains one or more samples in which the concentration is too low to be measured by the analytical method used. Where a constituent was censored, the mean and variance of the distribution, or their logarithmic counterparts, were adjusted in an unbiased manner (Miesch, 1976, 41-46). The analysis of variance, however, requires completely uncensored data, and the following arbitrary practice was used to circumvent problems of censoring. If a third or less of the frequency distribution was censored, a value equal to approximately seven-tenths of the lower limit of determination was used in place of the censored values. (If more than a third of the distribution was censored, the constituent was not subjected to the analysis of variance.) The justification for such a replacement is that substitution of any reasonable value below the analytical limit would not substantially alter geochemical conclusions drawn from the statistical analysis. The analysis of variance results are given in tables 5A-5D.

Where the analysis of variance indicated significant geochemical differences among areas (most areas in this work being represented by a pair of sampled 7-1/2' quadrangles), median values are listed for the areas (Part II, tables 6A-6D). A basic criterion for the sufficiency of differences among these medians is the conventional F-statistic, which is based on measures of variance between and within areas. If the F-statistic is found to be significantly different from zero, one can have a prescribed confidence that, at the least, one of the areas is different from some other.

A more stringent criterion, described by Miesch (1976, p. 101), requires that the mean variance ratio, v(m), exceed a value of 1.0 if differences among area means are to be viewed as reproducible. This ratio for balanced designs based on equation (1) is defined as

$$v(m) = V(A)/D \qquad (3)$$

where D is defined as

$$D = V(B)/2 + V(C)/4 + V(D)/8 + V(E)/16 \qquad (4)$$

The denominators in equation (4) are products of the number of sampling units defined at each level of the hierarchical design, which in this work was set to 2.0. Non-response in sampling and recognition of geochemical subpopulations following collection, however, resulted in some of the sampling units being less than 2.0. Where this happened, the resulting bias in v(m) is footnoted (tables 5C, 5D).

MINERALOGY

The normative mineralogy of the samples used in this study is shown in figure 5. The organic-rich shale (Chattanooga and lithic equivalents) was plotted on a quartz, illite, organic C triangle. Organic C is less abundant in the other shales. Although many Pennsylvanian shales are gray, they rarely contained more than a percent organic C. All Al2O3 was assigned to illite of 26 percent AL2O3 composition, and excess SiO2 assigned to quartz. For normative calcite and dolomite, concentrations of CaO and MgO were reduced slightly prior to computation in order to account for minor CaO and MgO in clay. Initially, all MgO was assigned to dolomite and excess CaO assigned to calcite. If these two minerals summed to less than 40 percent (which was common), the original MgO and CaO concentrations were reduced by one percent and one-half percent, respectively. If, in addition, the ratio of normative illite to normative quartz exceeded 2.0 (also common), the original MgO and CaO concentrations were reduced by two percent and one percent, respectively, and the two carbonate minerals computed one more time.

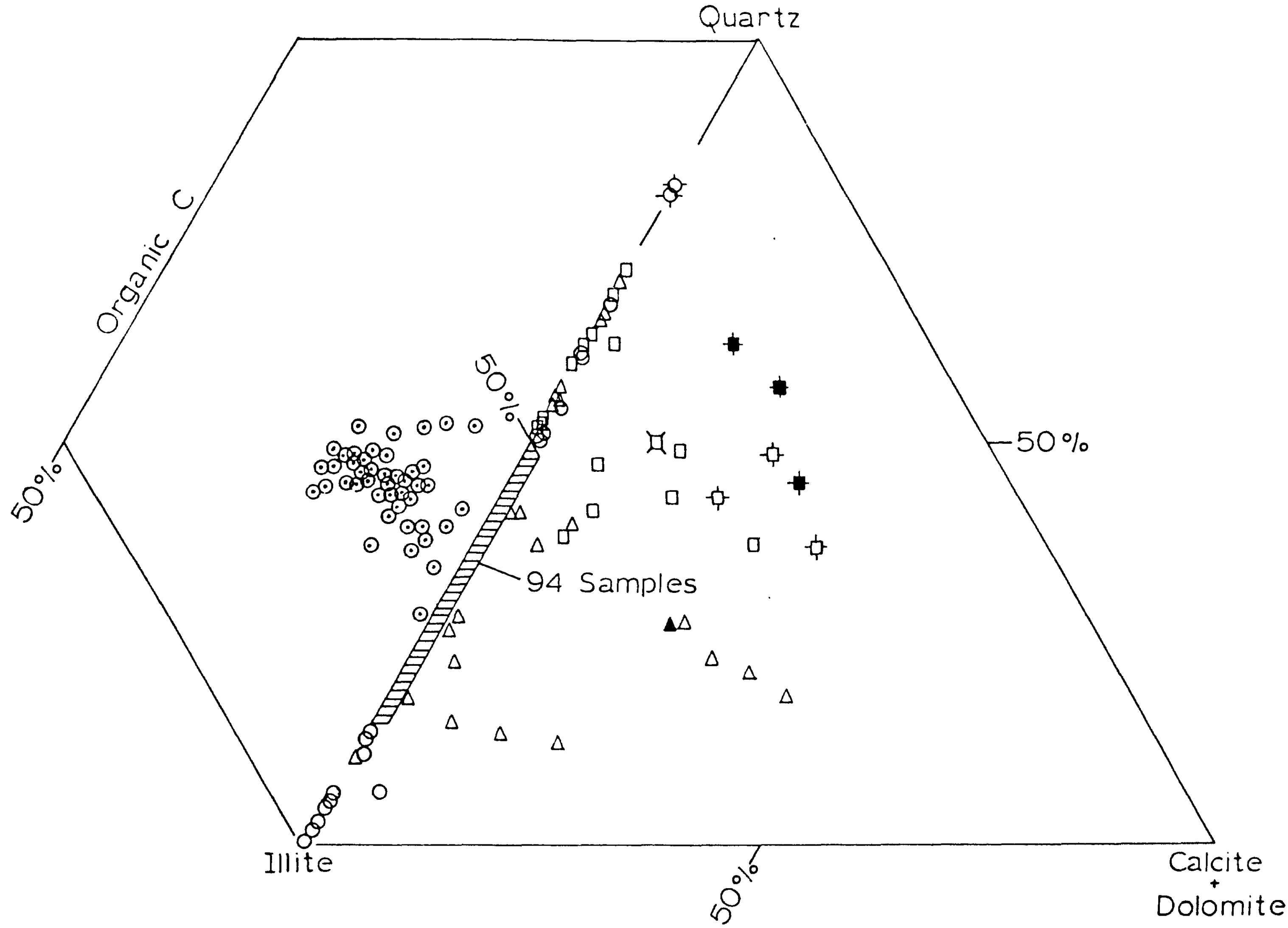


Figure 5.--Plot of normative mineralogy of and organic C in Paleozoic shale in Kentucky.

Stratigraphic unit	Shale	Dolomite>Calcite (where total carbonate>10%)
Pennsylvanian	○	
Siliceous shale		
Upper Mississippian	△	▲
Lower Mississippian	□	
Sandy shale		
Modal chert > 25%		
Chattanooga and lithic equivalents	⊙	

In thin section, the organic-rich rocks are finely laminated and variably silty. The organic material imparts some of the layering to the rock and, where oxidized, the texture takes on a felty appearance. Quartz, feldspar, flattened rock fragments and _Tasmanites_ are common framework grains. The rock fragments are mostly clay shale or micaceous siltstone although a few appear to be phyllitic. The _Tasmanites_ are translucent orange, isotropic, flattened rings, some of which are broken, convoluted or corrugated. Muscovite is common; secondary dolomite (in rhombs) and gypsum and hematite (after pyrite) are present locally.

Both the silt and the dolomite locally form distinct lamellae. The silt is commonly mixed with fine sand and averages about 0.03 mm in maximum diameter. Sample DSH-R111 (from the Petroleum quadrangle) contained a layer of angular sand grains as much as 0.2 mm in maximum diameter, that consisted of severely strained, polycrystalline quartz, glauconite, clay shale fragments and chert(?). The dolomite rhombs average about 0.1 mm in diameter and some show overgrowths. Pyrite is locally abundant, both as variably sized spheres (ranging from <.01-.2 mm in diameter) and larger ragged or cubical masses. Sample DSH-S212 (from the Breeding quadrangle) contained a cruciform mass of pyrite cored with gypsum(?). The laminations commonly bend around the pyrite indicating early formation (pre-lithification) of the pyrite.

The shales of Lower Mississippian age range from nearly pure claystone to argillaceous siltstone comprised of widely varying amounts of poorly sorted, angular detritus. Many of the claystones were collected from the basal Nancy Member of the Borden Formation. A few samples from south-central Kentucky (Amandaville, Wolf Creek Dam and Knifely quadrangles) were very calcareous and contained sand-sized grains up to 0.1 mm in diameter. This sandy shale is probably genetically related to the coarse-grained, high-energy deposits of the Fort Payne Formation in this area (for example, the Knifely Sandstone Member of the Fort Payne of Kepferle and Lewis, 1974).

The framework grains are dominated by quartz (or, in the case of the sandy shale, by carbonate clasts), which is generally clear although some stretched and polycrystalline grains are present. Potassium feldspar, plagioclase, clay pellets, glauconite, detrital chert, pelitic (schistose) fragments, muscovite, altered biotite, numerous heavy minerals, opaques (including pyrite in samples LMSHL121 and LMSHS212 from the Eli and Amandaville quadrangles, respectively), and phosphatic pellets were seen. Iron oxide stained much of the matrix and its intensity may reflect the degree of weathering imposed. Quartz overgrowths were rare.

The sandy shale contains abundant carbonate clasts and is commonly chertified. Two chert-bearing samples (LMSHR112, from the Adolphus quadrangle, and LMSHK222 from the Dunnville quadrangle) were determined to be limestones and were excluded from the the analysis of shale geochemistry. The dolomite occurs as secondary rhombs.

Samples of Upper Mississippian shale commonly consisted of interlaminated clay, siltstone and sandstone. The silt and sand layers averaged about a millimeter in thickness. Sand layers were commonly well-sorted and relatively coarse (0.1-0.2 mm grain diameter). Some samples exhibited abundant floating sand grains. The sand grains, in general, were subangular to subrounded and consisted of both strained and unstrained quartz, feldspar (including microcline), clay pellets, rock fragments (including some metamorphic-metavolcanic ones), and minor muscovite, chlorite, altered biotite, glauconite, amphibole, opaque and non-opaque heavy minerals (including pyrite), chert, and fine-grained ribbons of organic (?) material. Rarely, a detrital grain of "tan" chert similar to that seen in the Upper Mississipian limestones (Connor, 1981) was present, and samples UMSHJ121 and UMSHJ122 (from the Millerstown quadrangle) contained chert cement. In eastern Kentucky, these rocks were more texturally varied than in western Kentucky. Most samples were silty or sandy claystone and some so poorly sorted as to be graywackes. In many samples, the detritus was mainly poorly sorted ranging in size from fine silt to very coarse sand (over half millimeter in diameter). The larger grains tended to be very well-rounded.

Many samples of Upper Mississippian shale were visibly weathered, and five were judged to be true soils and, hence, deleted from the geochemical analysis. These samples were UMSHQ122, from the Honey Grove quadrangle; UMSHR212, Rockfield quadrangle; UMSHJ212, Cub Run quadrangle; UMSHL211, Bighill quadrangle; UMSHE211, Wrigley quadrangle. Such samples exhibited broken or chaotic textures. Some contained abundant unsorted, largely angular quartz grains. Bedding in some was absent and in others it was present but in seemingly randomly oriented fragments with abundant authigenic clay "skins" on cross-cutting joints. Iron-oxide staining was common. Two additional samples, collected from bedded sequences, also exhibited some of these features suggesting that they may be paleosols. Sample UMSHT112 (Barthell quadrangle) consisted of heavily iron-stained, plastic clay similar in color and texture to a B-horizon soil. Sample UMSHE122 (Portsmouth quadrangle) was brecciated and iron-stained.

Shale of Pennsylvanian age commonly consisted of interlaminated claystone and poorly sorted, argillaceous siltstone. Many contained floating, sand-sized quartz. Sample PSH-H121 (Salem quadrangle) was a fine-grained sandstone and PSH-H222 (Shetlerville quadrangle) was a texturally mature, silicified siltstone. They were excluded from the geochemical evaluation.

Framework grains included abundant monocrystalline quartz and, in some samples, clay pellets or pelitic rock fragments. Less common were plagioclase, microcline, schist, and stretched metaquartzite. Authigenic quartz was locally present. Muscovite was the common mica but much bleached biotite was locally present. Chlorite was rare, as were glauconite, hornblende, chert, and zircon. Opaque minerals include much fine-grained, disseminated hematite, perhaps largely from weathering. Leucoxene and pyrite were rare.

Samples PSH-L211 and PSH-L222 (Parrot quadrangle) were so weathered as to constitute C-zone soils, and PSH-F211 and PSH-F212 were, like UMSHT112 And UMSHE122 from the Upper Mississippian, fragmented and iron-stained and might be paleosols. These last four samples were excluded from the geochemical evaluation.

GEOCHEMICAL VARIABILITY

The analysis of geochemical variance and geochemical summaries for each shale unit are given in tables 5A-5D and 6A-6D, respectively. In the organic-rich shale (Chattanooga and lithic equivalents), a variety of elements exhibit statistically significant regional (between-areas) variance. Samples from westernmost Kentucky (the Briensburg and Eddyville quadrangles) are distinctly high in B and distinctly low in organic C and Cu. Pb appears to be distinctly low in samples from northeasternmost Kentucky (the Burtonville and Manchester Islands quadrangles). P2O5, Ni, Mn, Co, and organic C tend to be high over the Cincinnati arch, whereas B is relatively low over the arch. Organic C constitutes about 5-13 percent by weight of the rock (table 6A, Part II). Conant and Swanson (1961, p. 13) found that the organic content ranges from 5-25 percent over the entire basin of deposition. Leventhal (1978) reported that the organic matter was derived from both marine algae and lignin-type terrestrial materials (vitrinite).

The analysis of variance of the shale and siltstone in the Lower Mississippian is given in table 5B. Eight of 23 constituents exhibit regionally significant components of variation. This variation is summarized in table 6B, Part II. If calcareous rocks from the Amandaville-Wolf Creek Dam area are excluded from the analysis, the regional differences in CaO, MgO and Sr are greatly subdued; SiO2 and Zr are high and K2O, B, and Co are low in samples from the northeast (head of Grassy, Wesleyville and Brushart quadrangles), reflecting the more continental aspect of these rocks.

Three samples from the Holland quadrangle in south-central Kentucky (table 6, Part I, footnote 5) are unusually high in Ni compared to an expected value of 49 ppm. Samples of highly chertified Lower Mississippian limestone from the same general area were also elevated in Ni (Connor, 1981, p. 9). Further, Ni in the underlying organic-rich shale also appears to elevated in this general part of the State (table 6A, Part II); that is, over the Cincinnati arch. The common sedimentary ore elements, Cu and Pb, are not unusually high here and the origin of the high Ni rocks remains obscure.

The analysis of variance of shale of Upper Mississippian age is shown in table 5C. Five constituents exhibit statistically significant regional variation -- FeO, Na2O, P2O5, Ba and Cr. The high concentration of FeO in the Cub Run-Millerstown and Barthell-Sawyer areas (table 6C, Part II) may reflect a greater abundance of iron-bearing clay (chlorite?) in rocks from those quadrangles. Variation in Na2O probably reflects a greater content of plagioclase in samples from the Barthell quadrangle. P2O5 is also distinctly high in these samples and likely represents an increase in apatite. Ba increases systematically from southwest to northeast and conceivably reflects an increase in potassium-feldspar towards source.

The analysis of variance of Pennsylvanian shale is given in table 5D. Five constituents exhibit statistically significant regional variation -- CaO, Na2O, B, Co and Pb. Ni is significant at the 90% confidence level. Variation by area (table 6D, Part II) indicates that much of the significance in CaO and Na2O reflects the relative high concentrations in the Slaughters quadrangle. The failure of Al2O3 and K2O to exhibit a similar variation weakly suggests that these samples contain relatively more plagioclase than other Pennsylvanian shales. The samples were taken from the upper part of the Pennsylvanian, near the middle of the Sturgis Formation.

The geochemical nature of Pennsylvanian shale in Kentucky is demonstrated in figure 6. The frequency distributions in this figure are visual representations of the data in the summary tables. These summaries in turn were organized, in part, according to the statistical tests given in the analysis of variance tables (tables 5A-5D).

The distributions show that, in general, Paleozoic shale in Kentucky is rather geochemically uniform, much more so than the Paleozoic carbonate rocks (Connor, 1981). Whereas the point scatter in the carbonate histograms commonly equalled or exceeded 20-fold, most of the trace elements in the shale exhibit a point scatter at or below 10-fold. Exceptions for shale include such constituents as MgO and CaO, which reflect a highly erratic distribution of carbonate cement, or constituents such as Na2O and P2O5, for which about half the scatter arises from laboratory procedures (V(E) of equation 2).

Variation not specifically identified in the distributions of figure 6 include variation described by the intermediate-scaled components of equation (2). Such variation commonly accounts for more than half of the total. Differences among samples within localities is uniformly high (V(D)), and differences among localities within quadrangles (V(C)) is high for shale of Upper Mississippian age, but differences among quadrangles within one-degree areas (V(B)) are generally low. Presumably, much of the variation at the two lower levels (V(C) and V(D)) reflects variation in the clay-quartz ratio among samples and localities. On the whole, the fitted distributions look to be good, except for CaO, Na2O, Hg and Mn, and should prove useful in providing a "first approximation" to the definition of geochemical variability in Paleozoic shale of Kentucky.

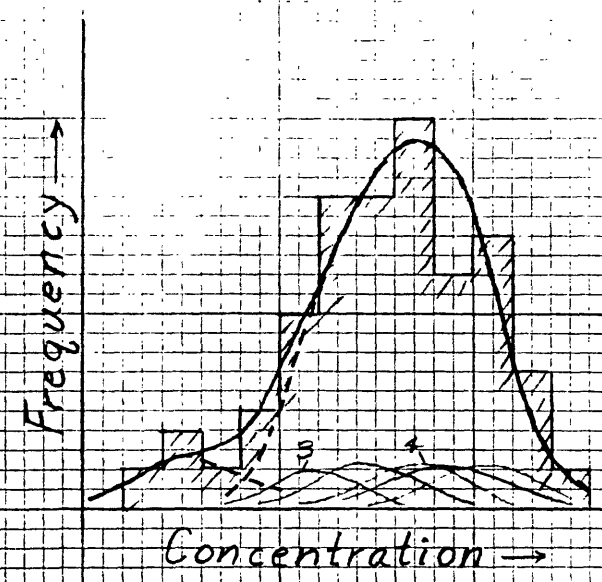
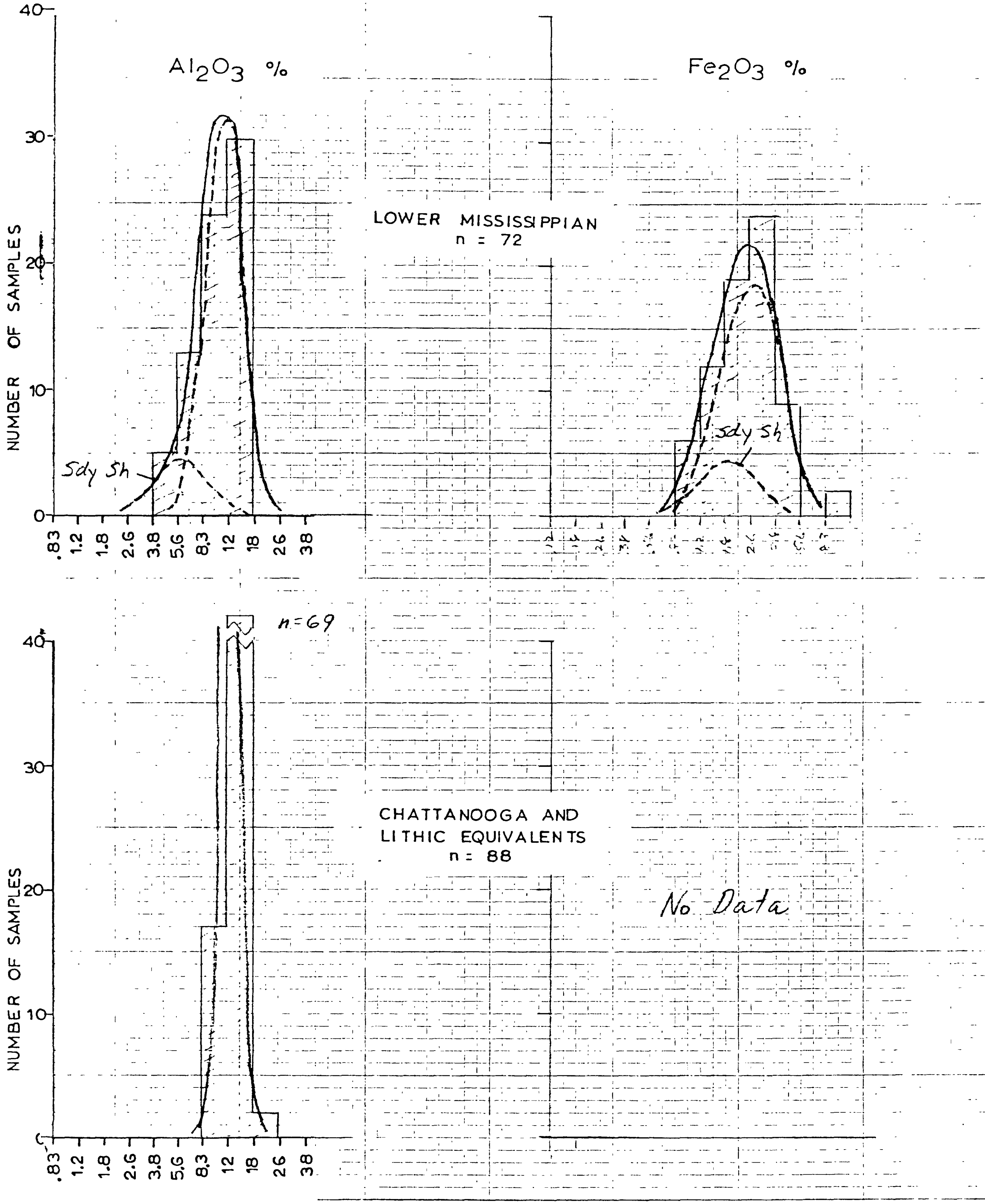


Figure 6.--Explanation of geochemical frequency distributions. The distributions shown on the following pages are meant to be visualizations of the summary data in tables 6A-6D. Histograms for each geochemical variable in each of the four major shale units are outlined by hachures. Each histogram is modeled by a heavy black solid line which, in the Lower Mississippian and Pennsylvanian units, is the "sum" of two lithically distinct subpopulations, shown by heavy, dashed, black lines. These subpopulations are listed in Part I of tables 6B (sandy shale--Sdy Sh in the figure) and 6D (siliceous shale--Sil Sh in the figures). Subpopulations shown by the light solid lines are based on the area means of Part II, tables 6A-6D. A number attached to one of these indicates that that line represents more than one such subpopulation. All subpopulations are based on the lognormal model. If a geometric deviation (GD) was not computed for a subpopulation (tables 6A-6D), a GD of 1.5 was assumed.



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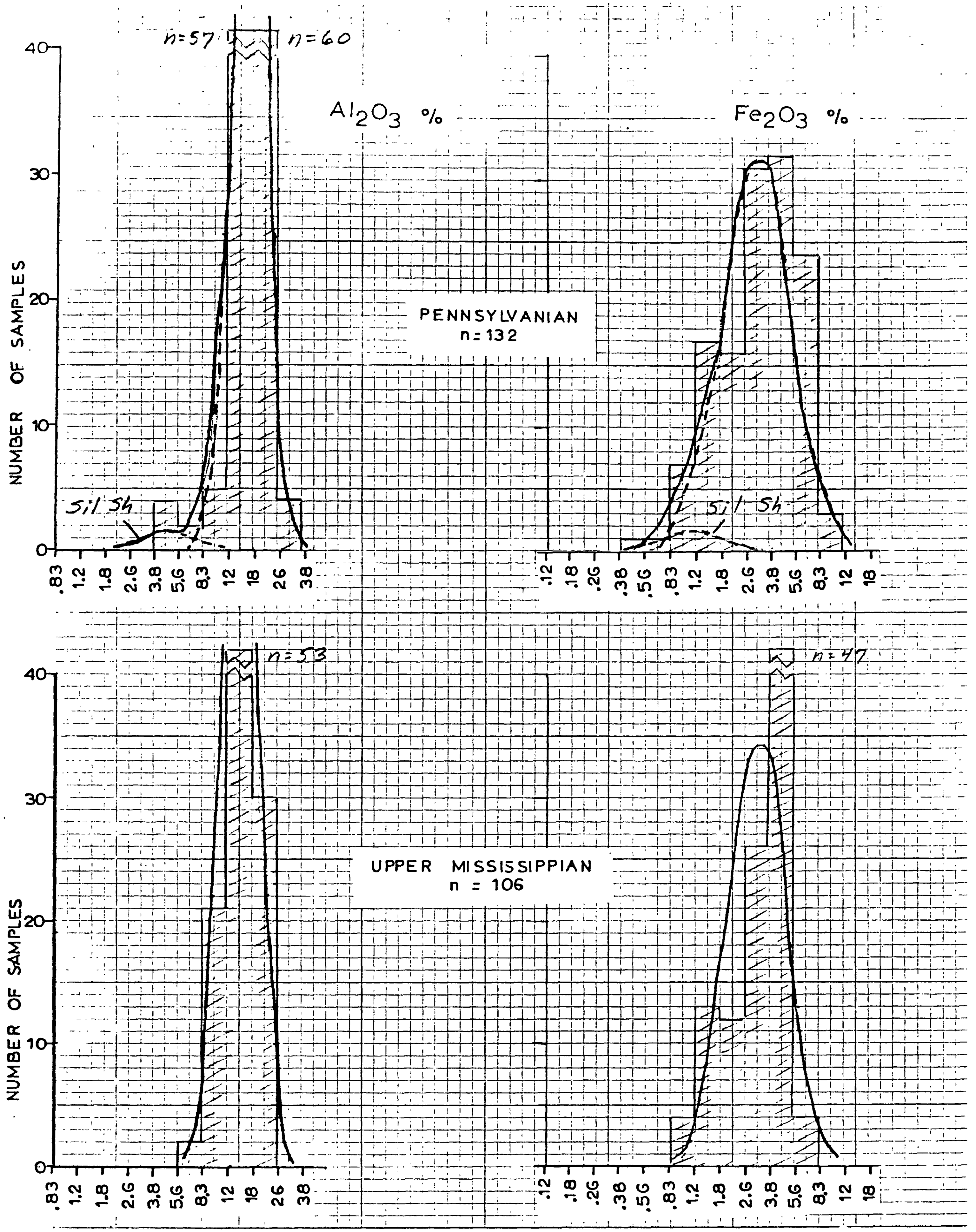

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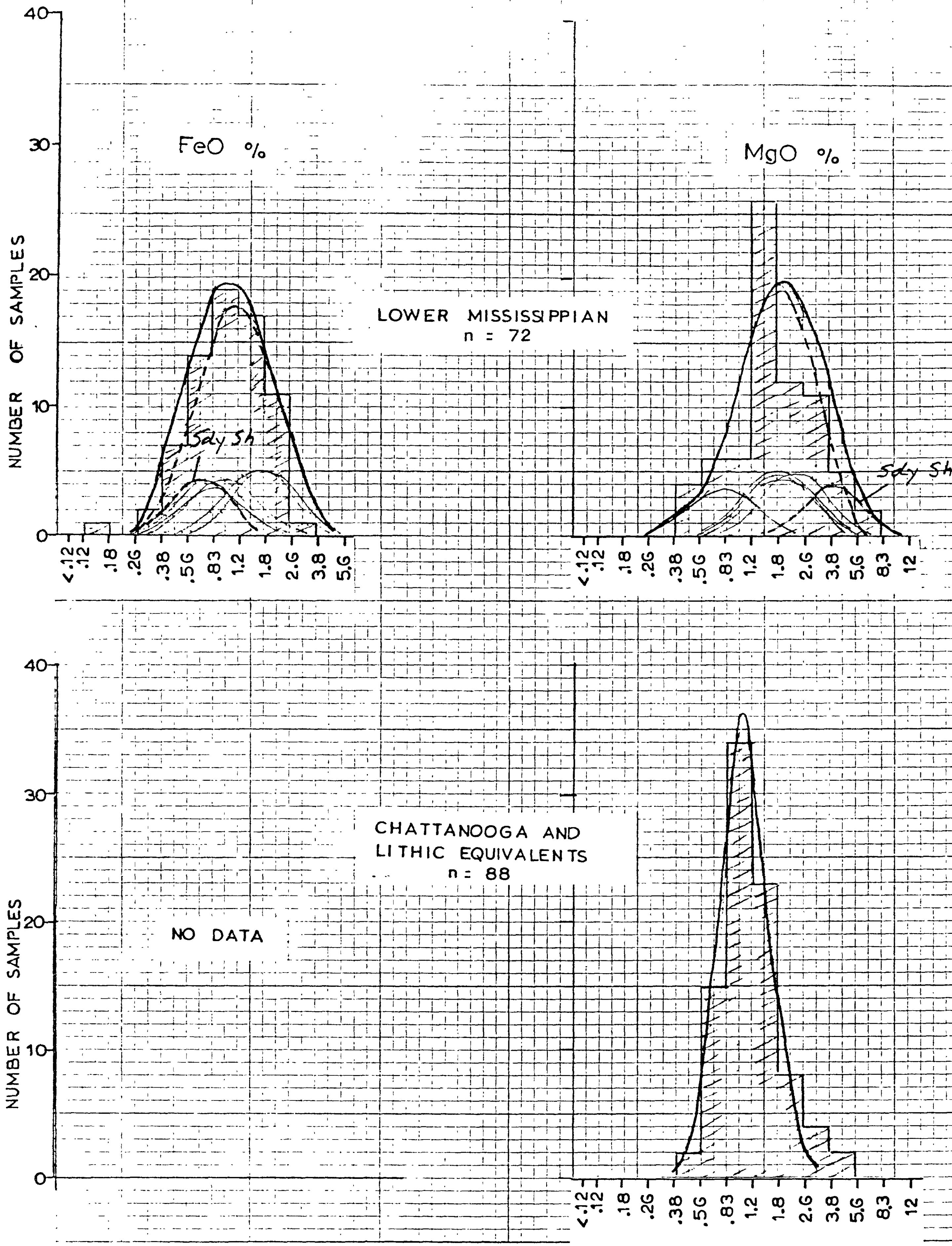

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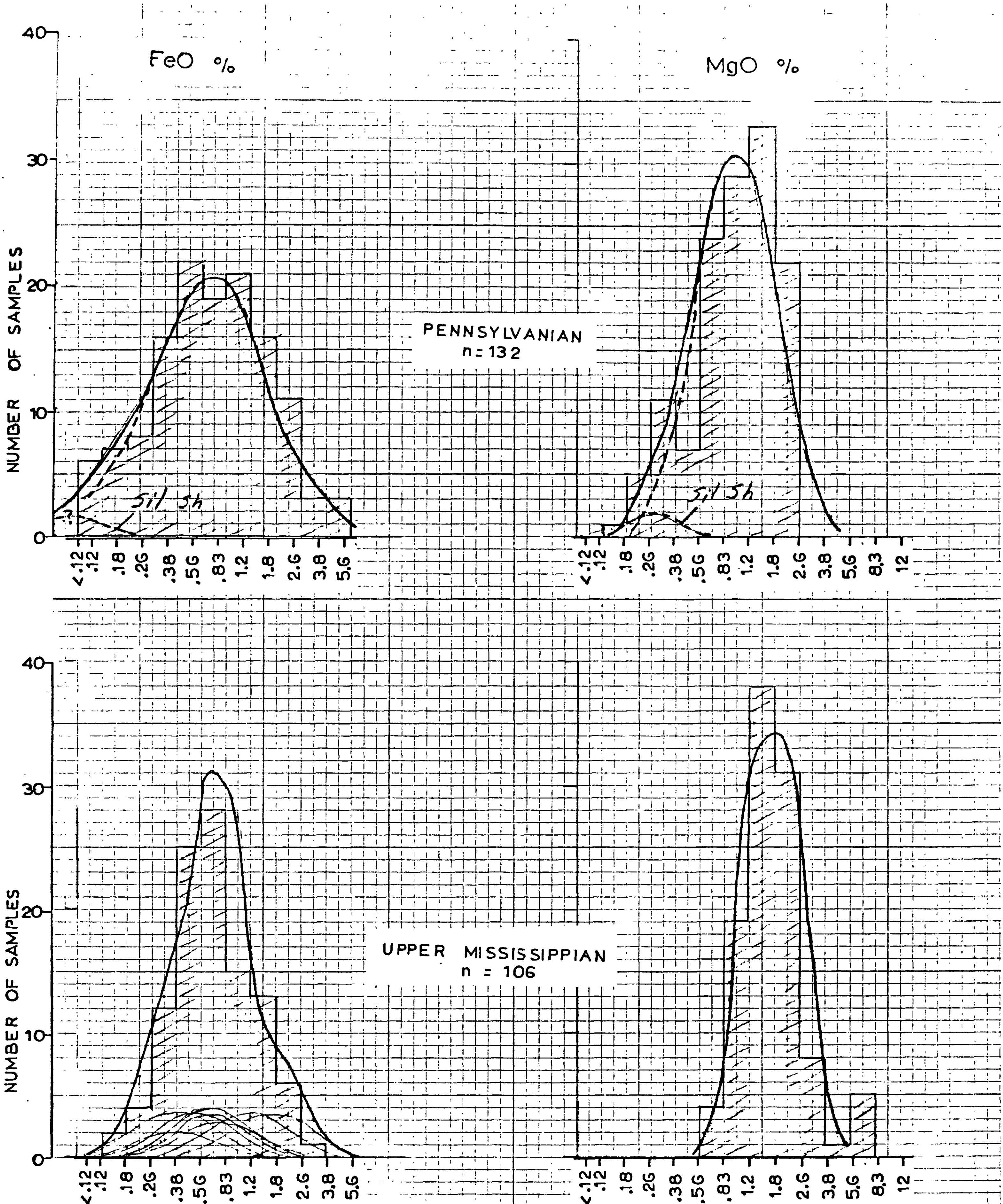

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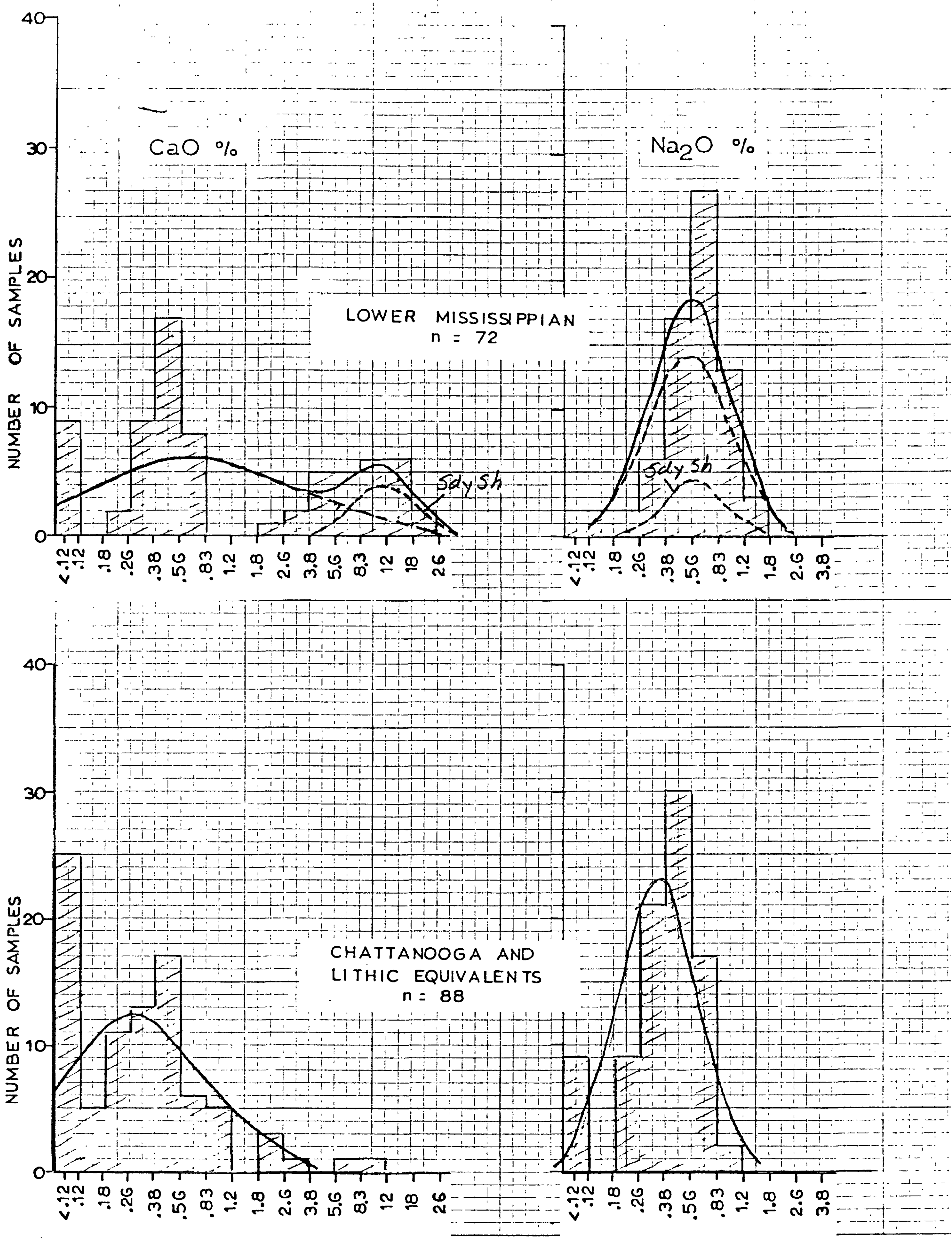

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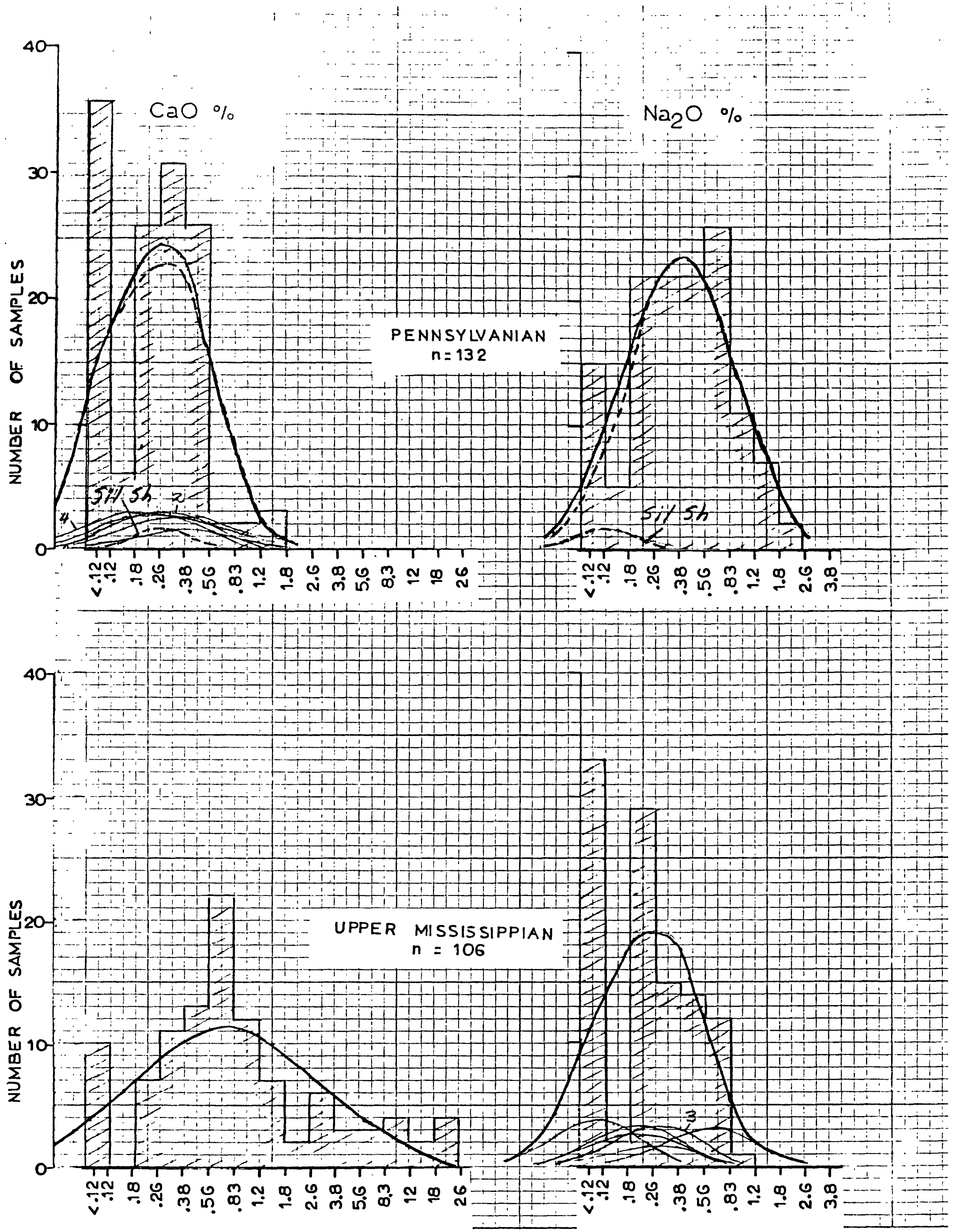

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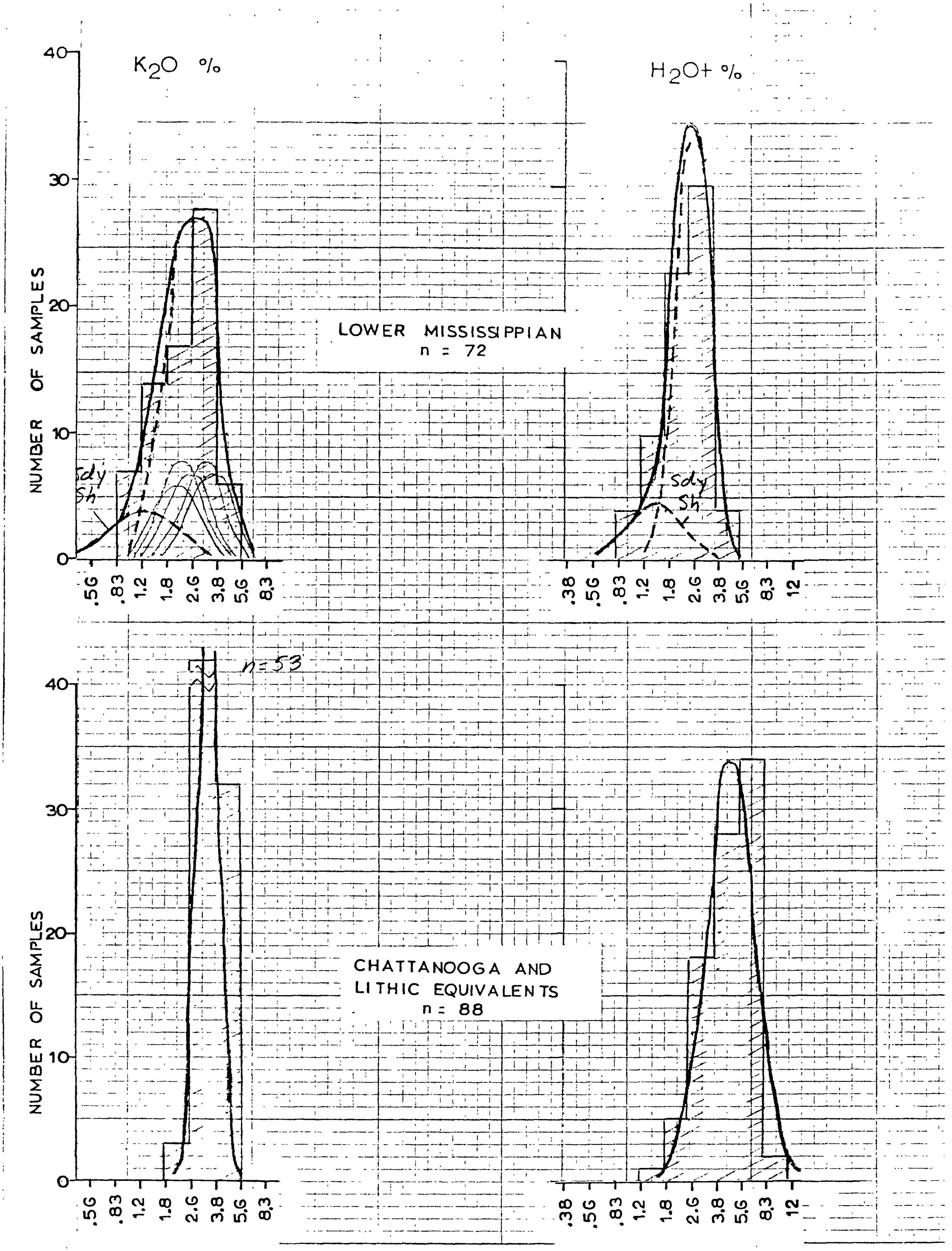

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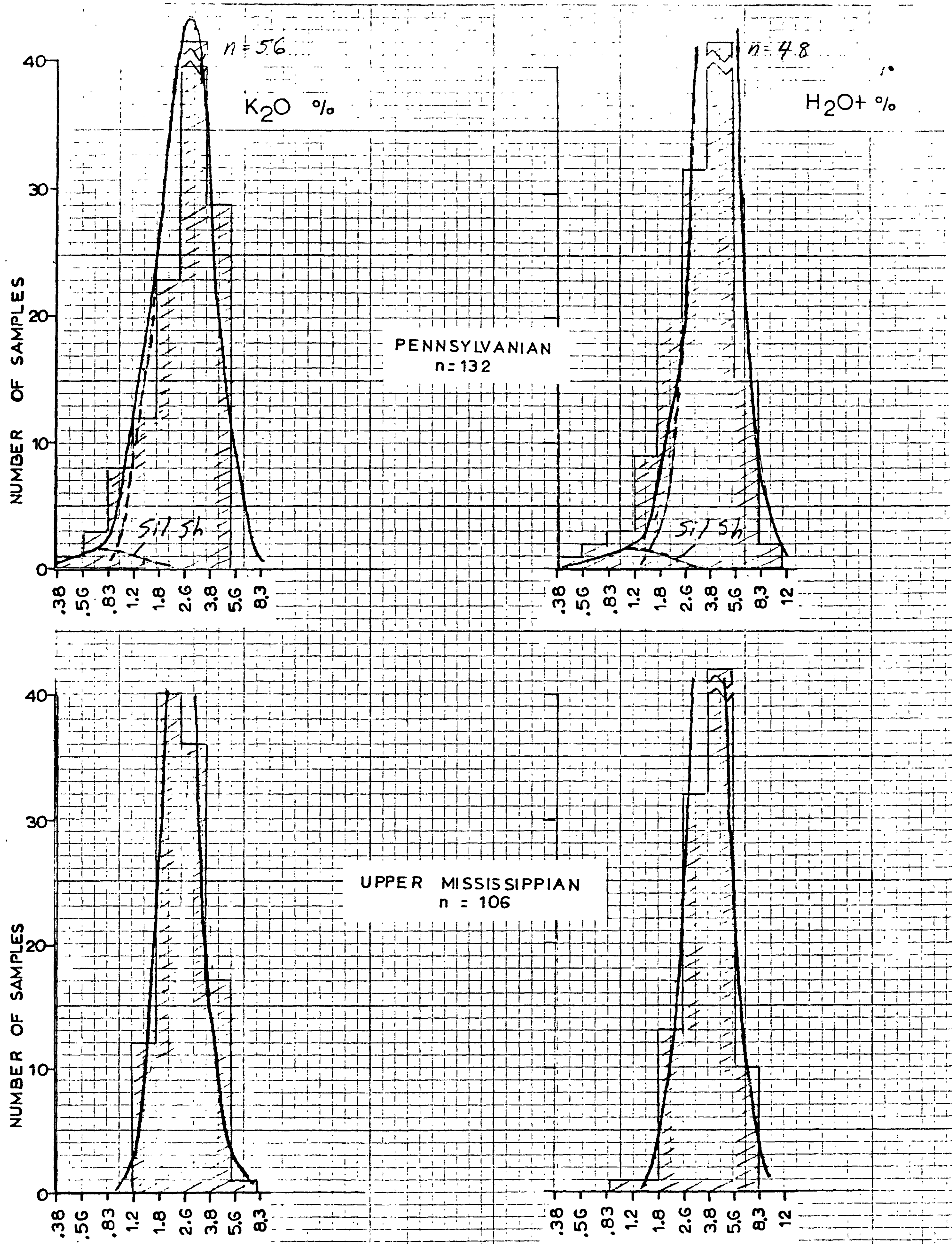

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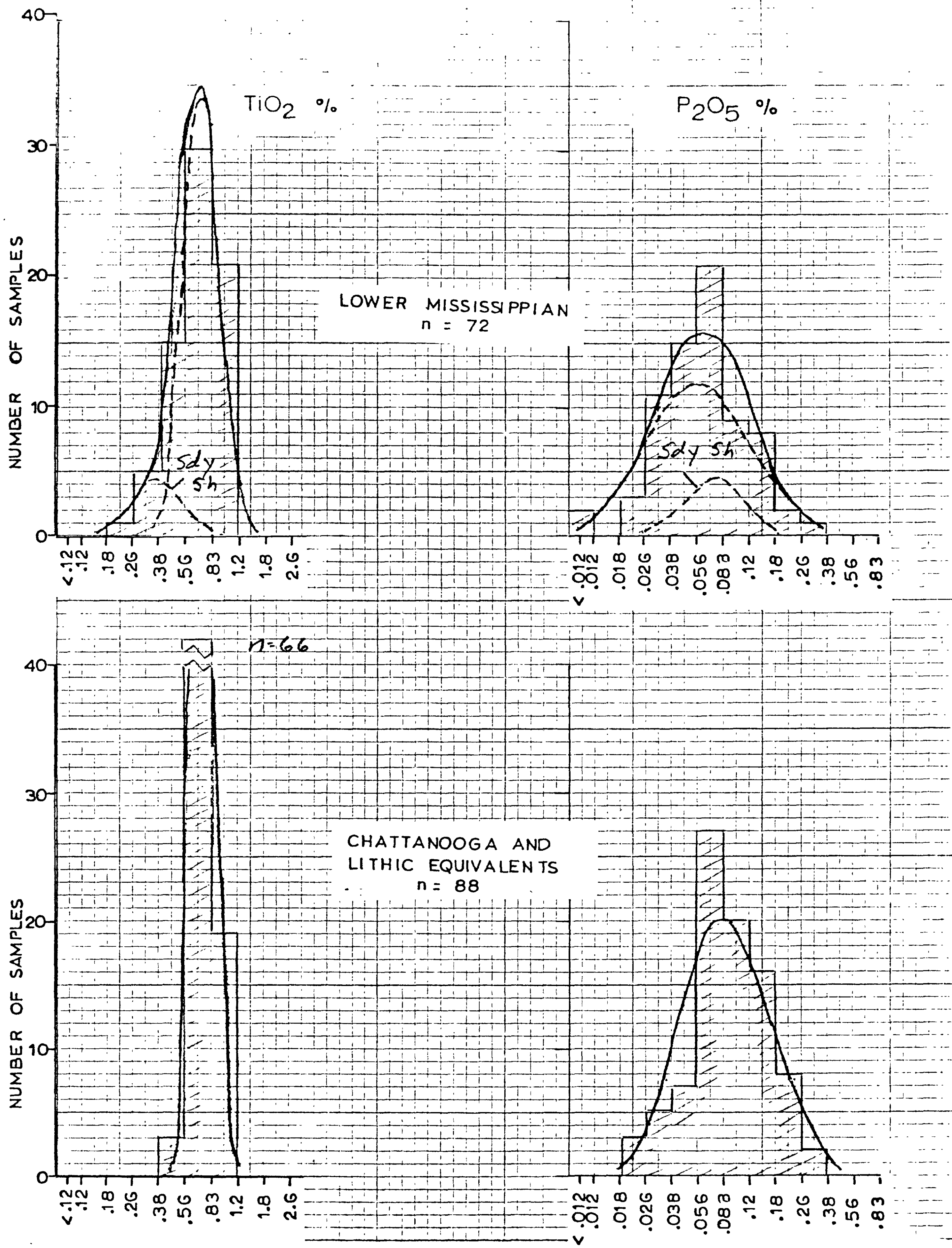

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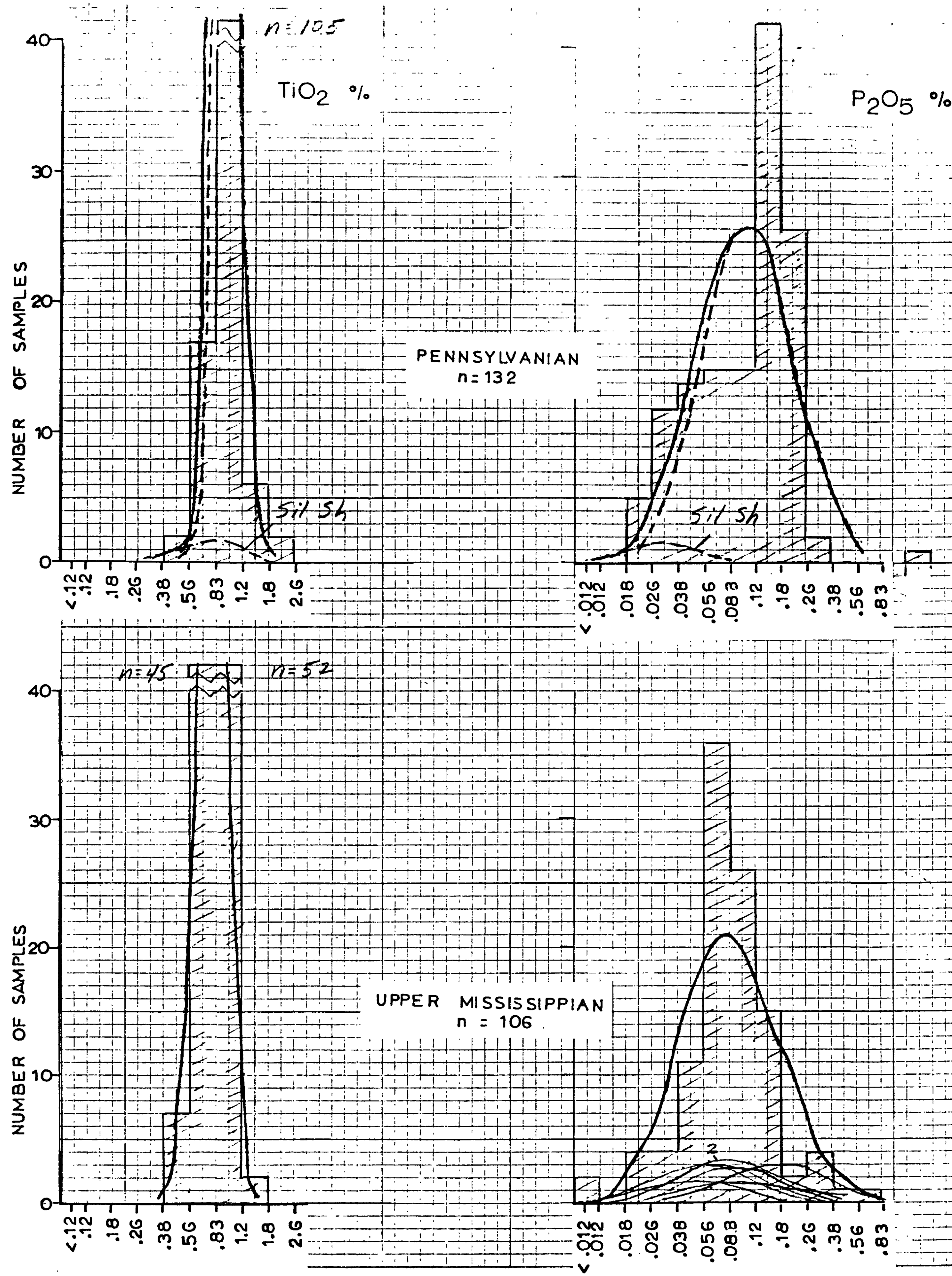

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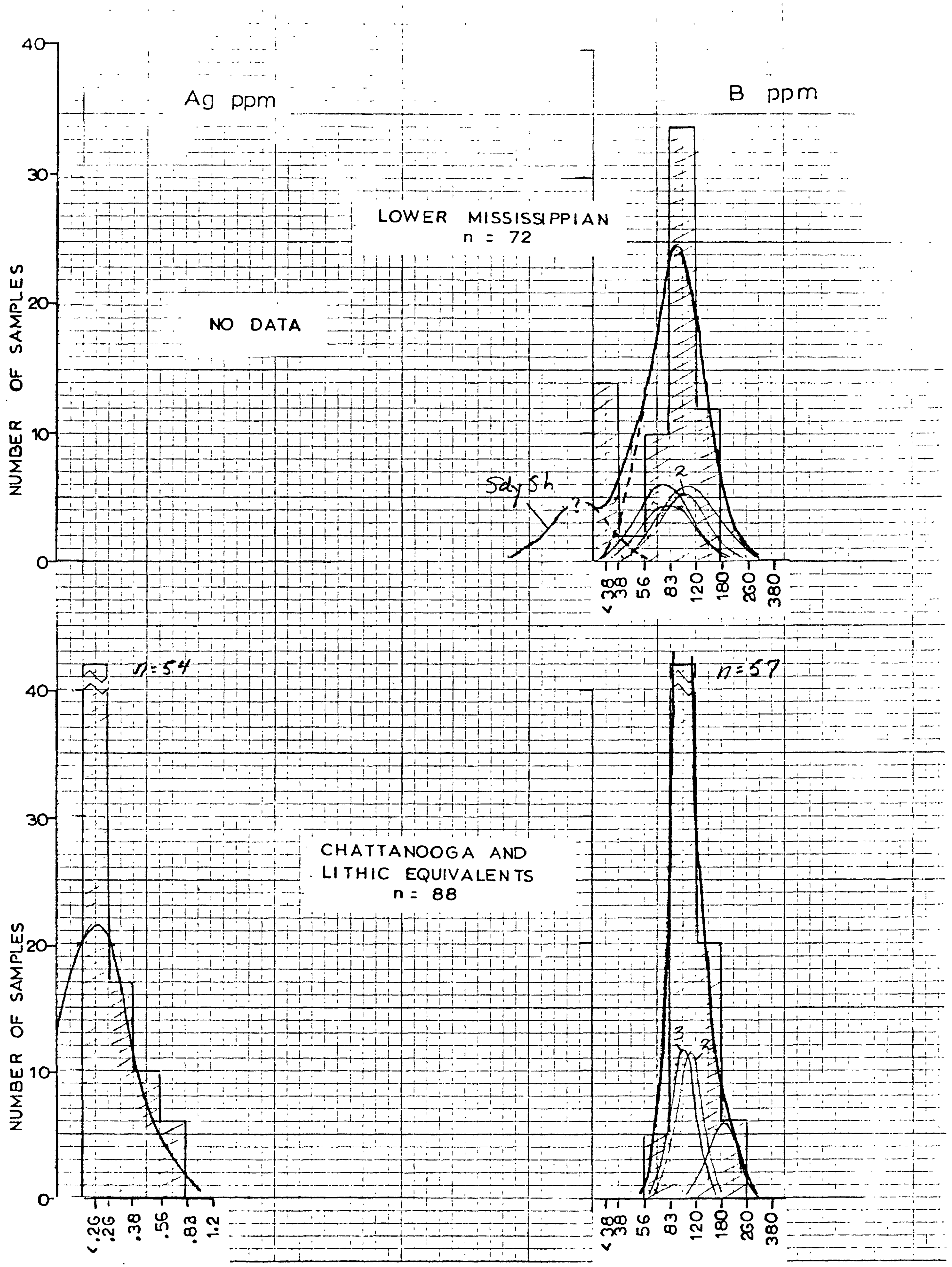

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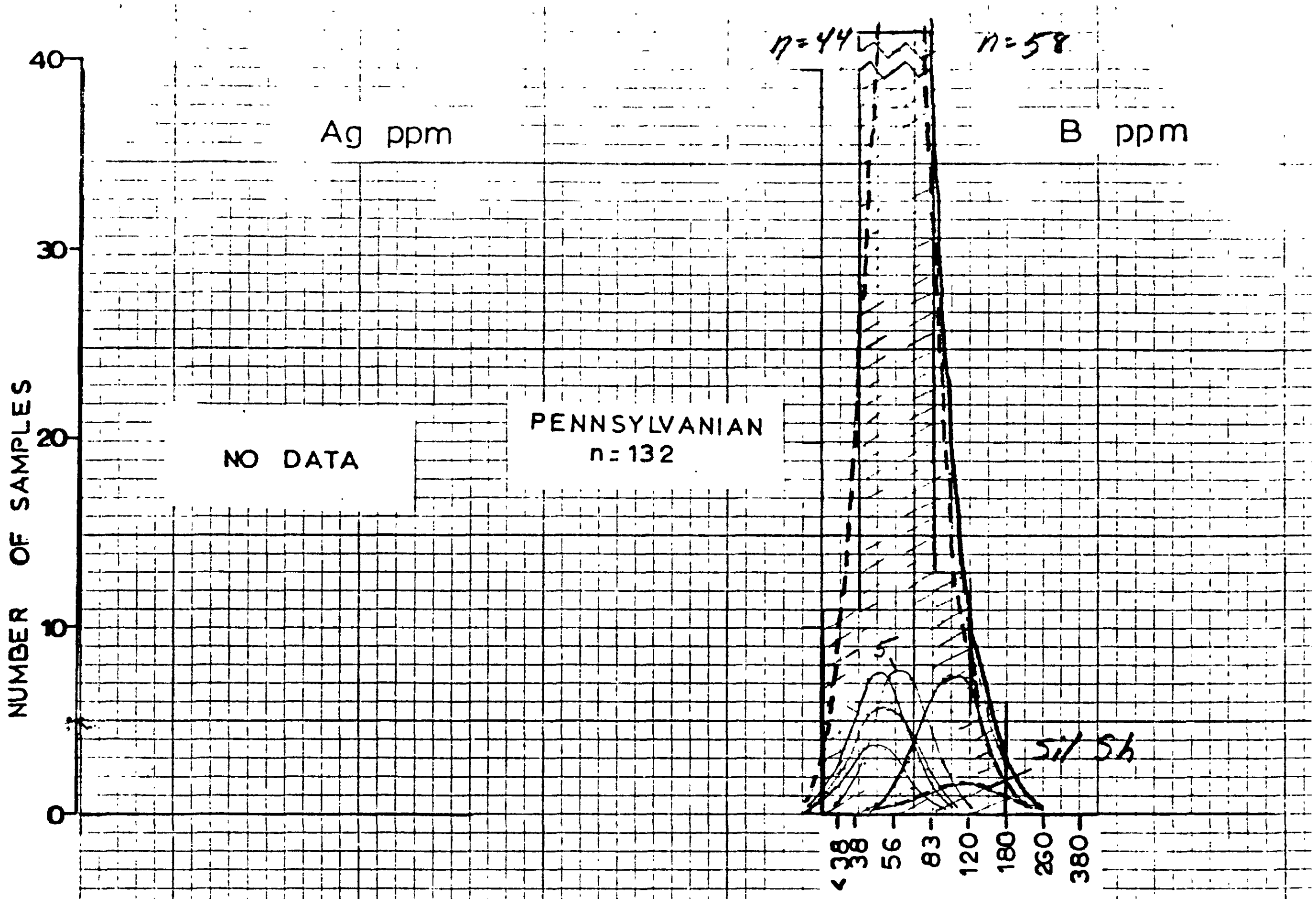

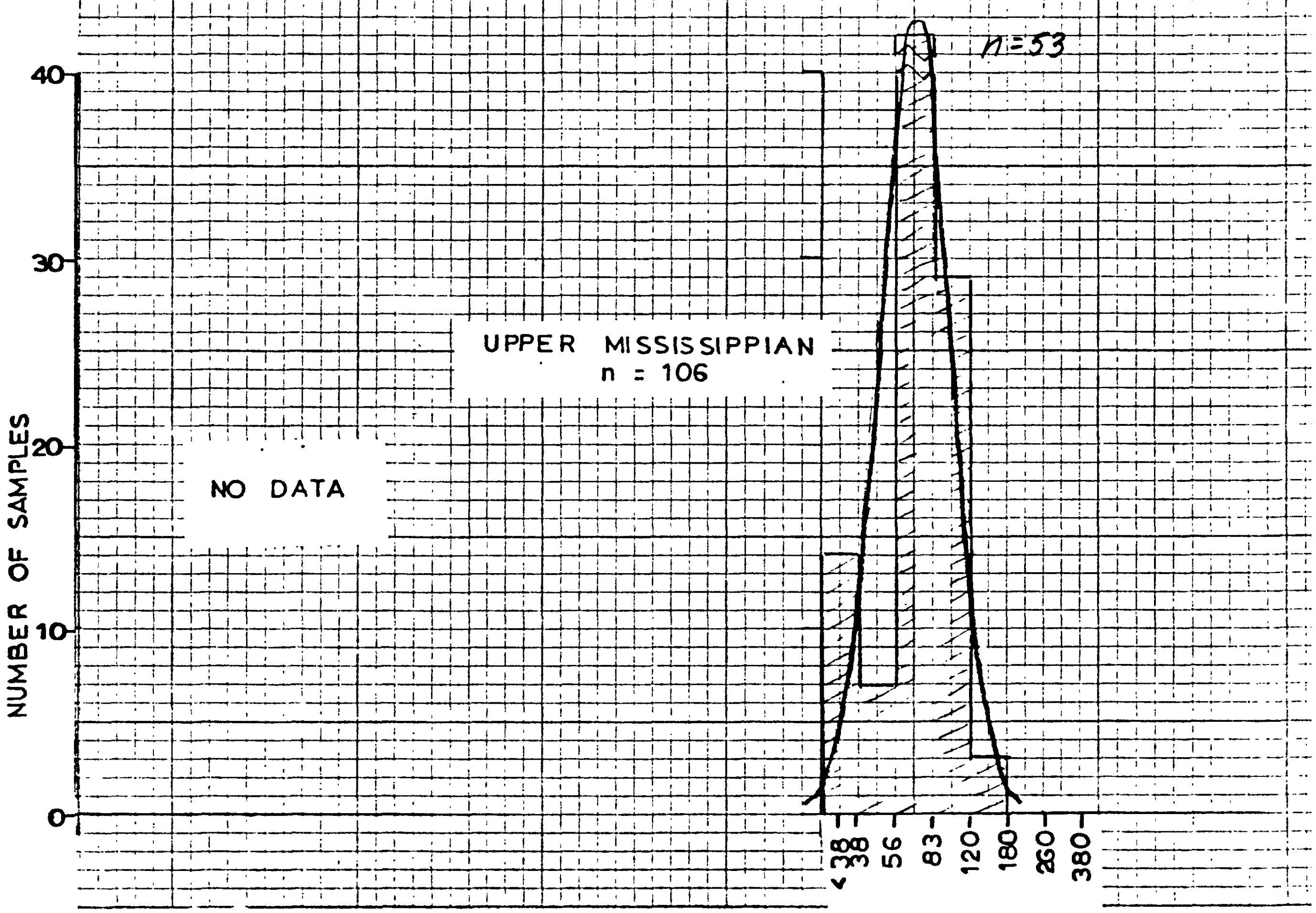

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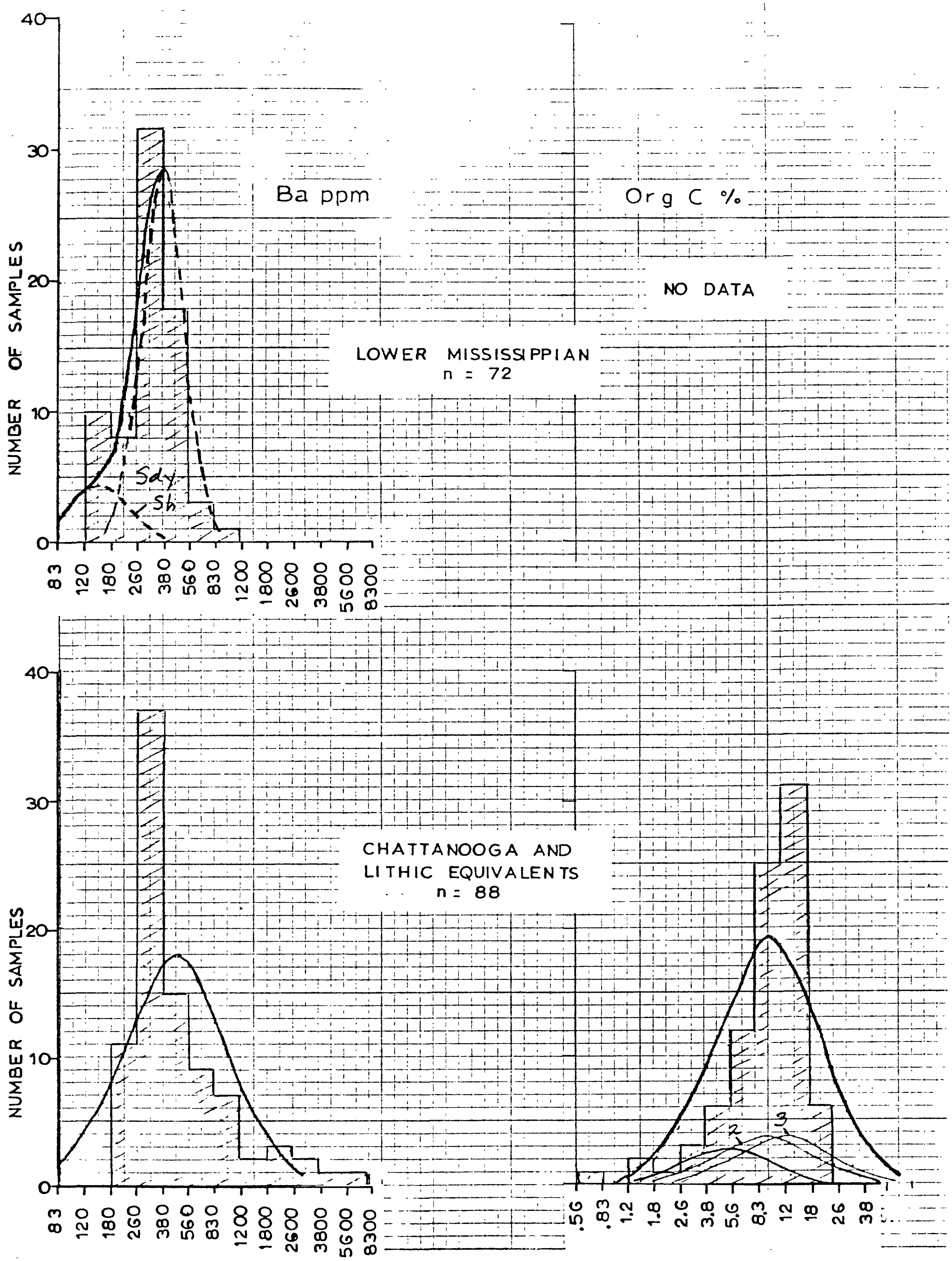

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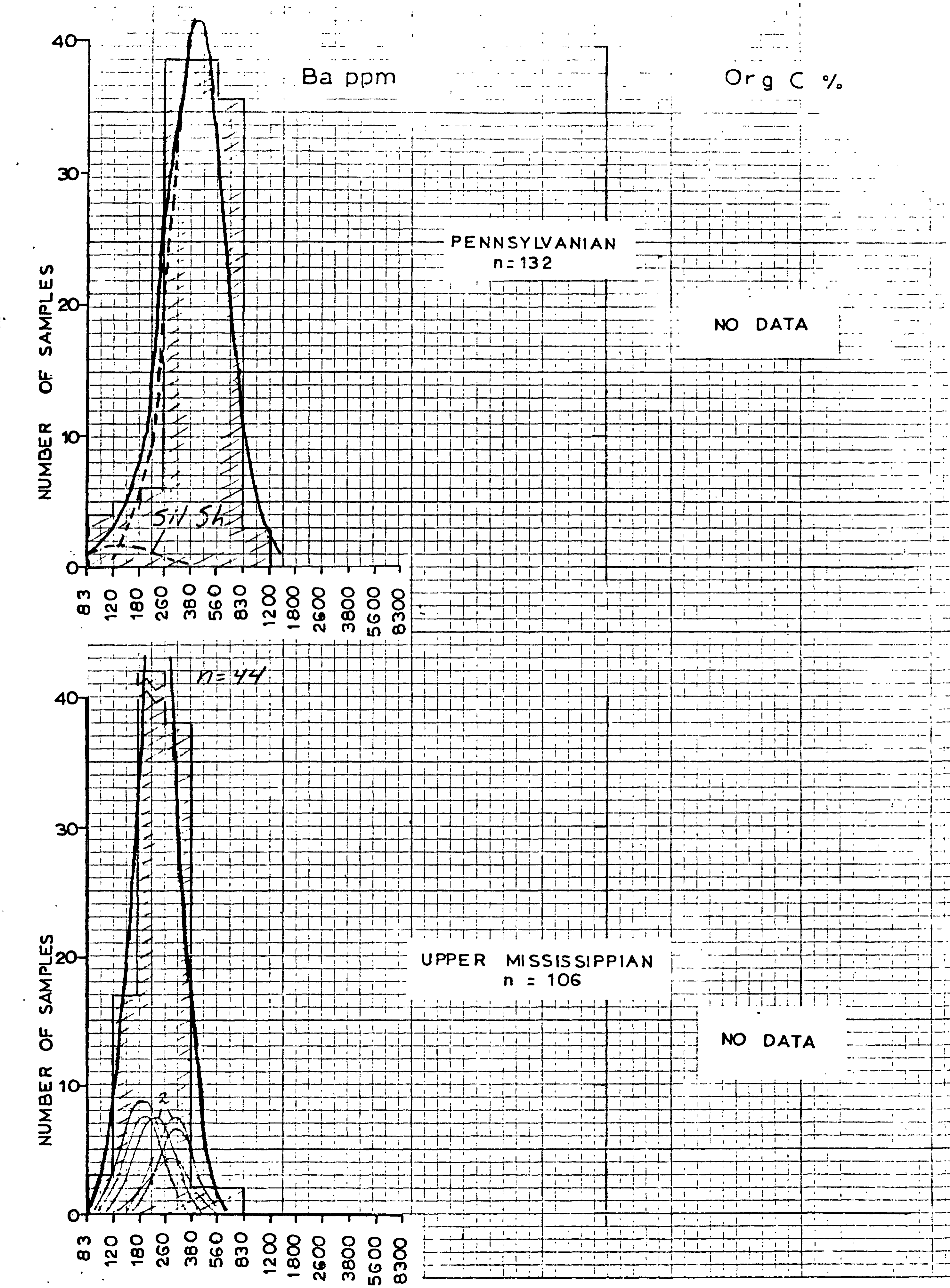

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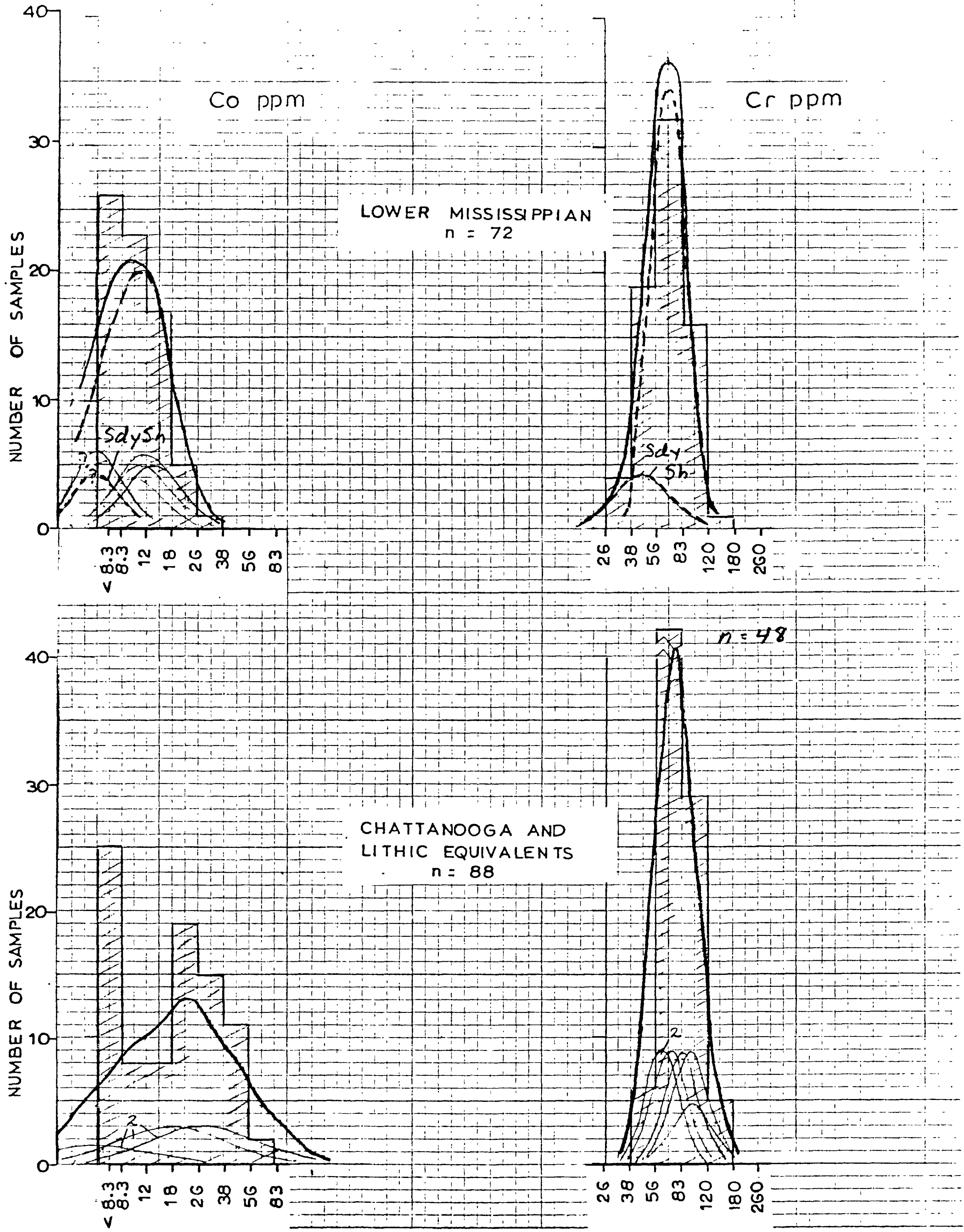

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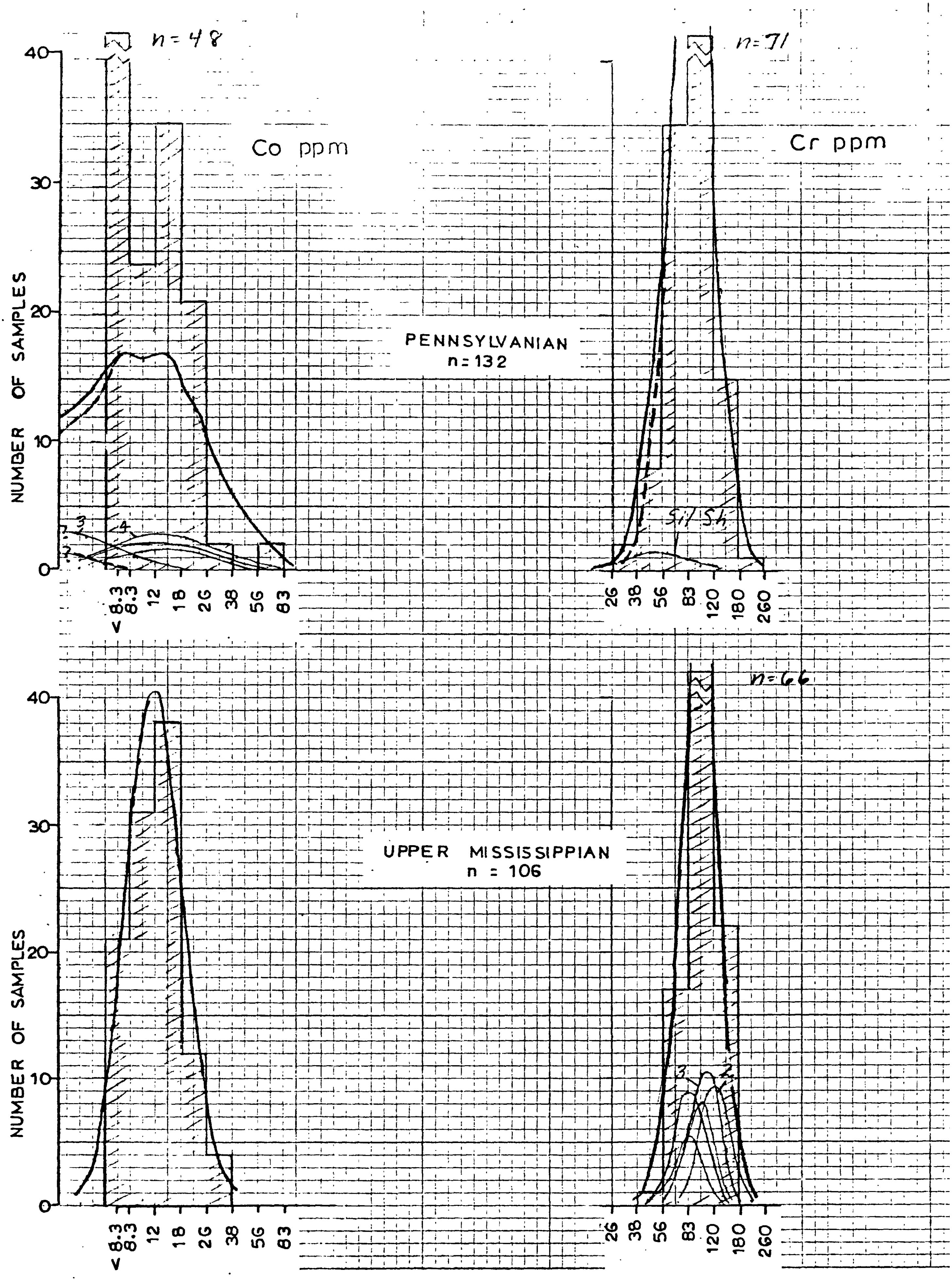

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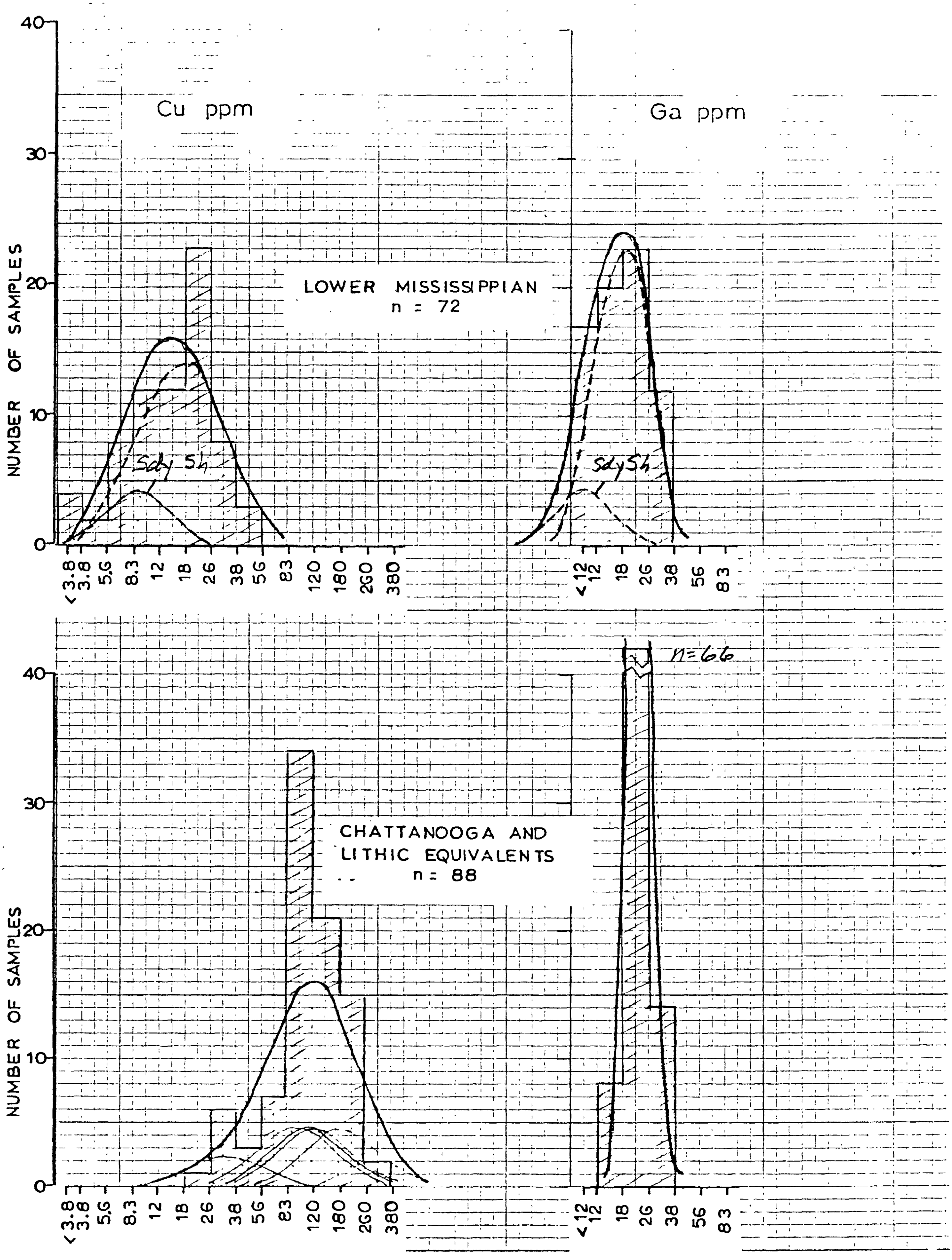

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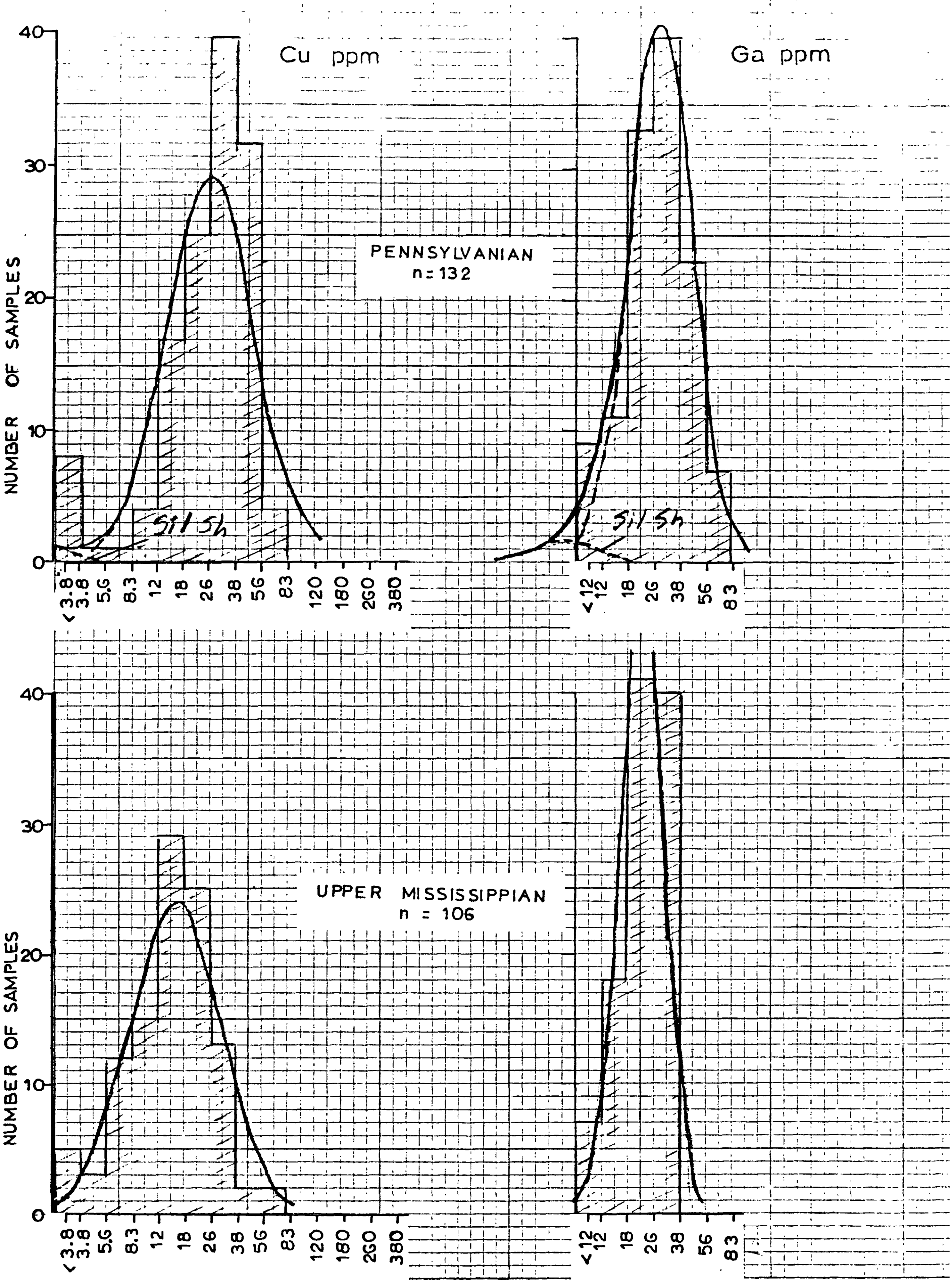

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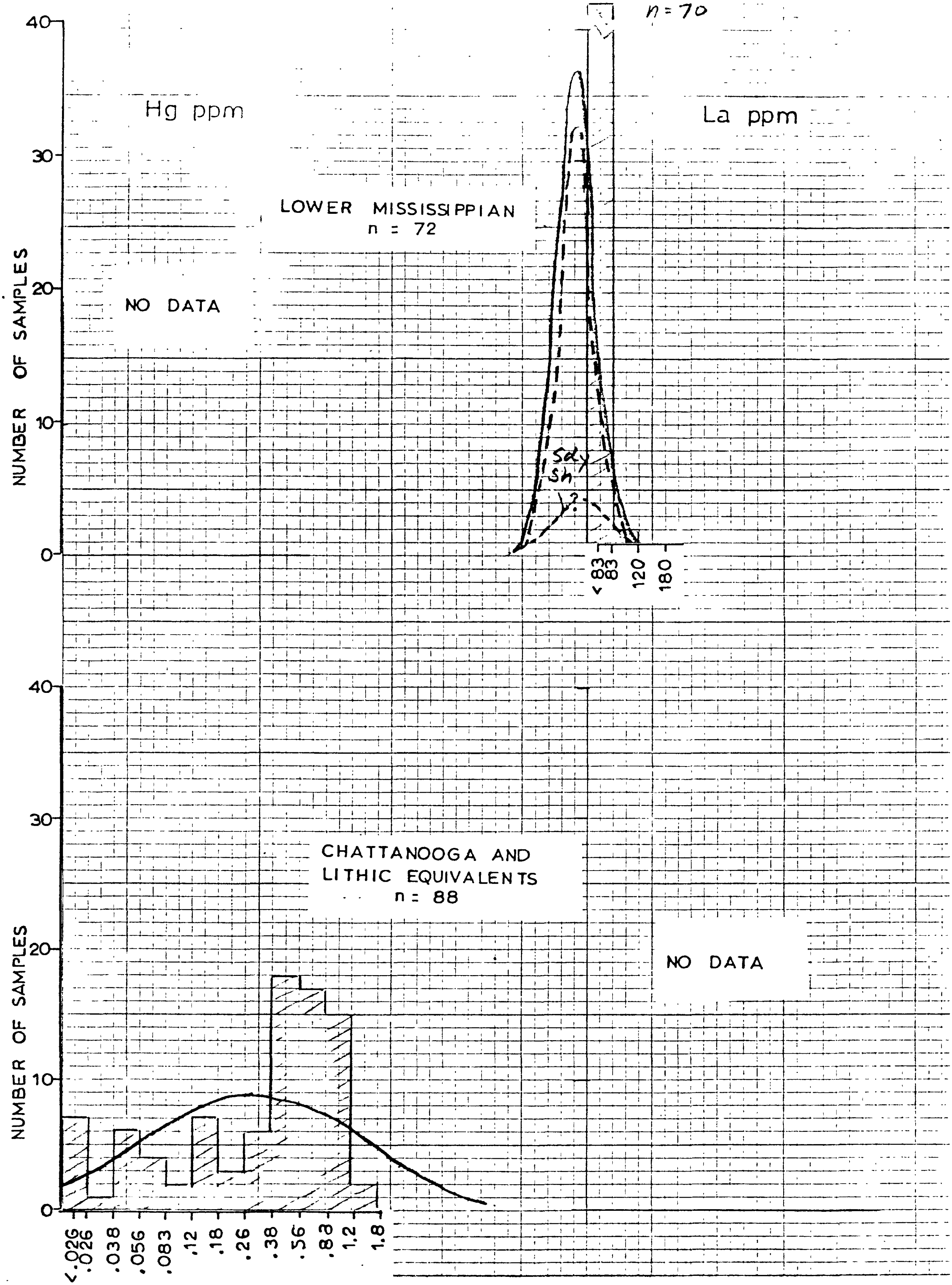

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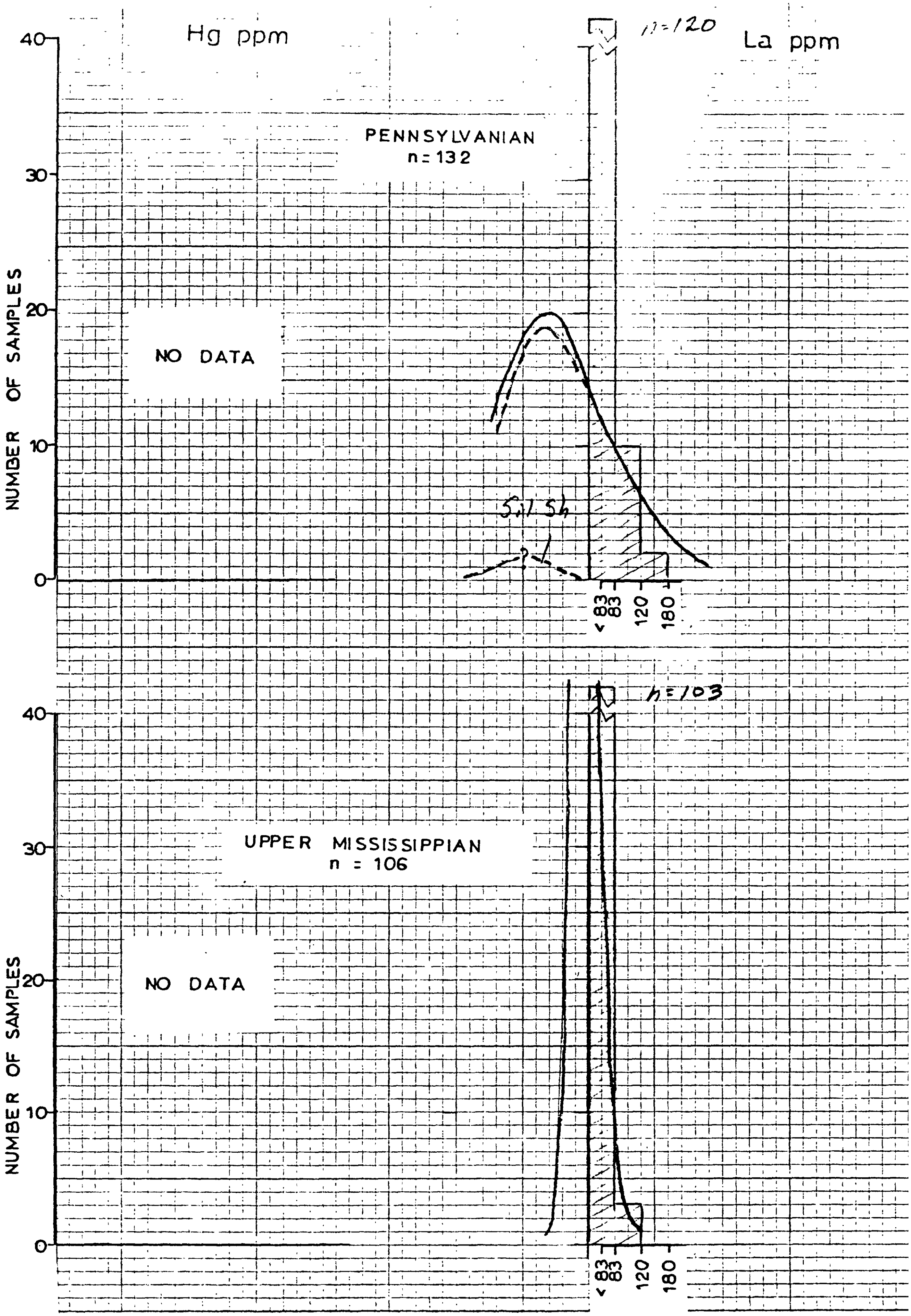

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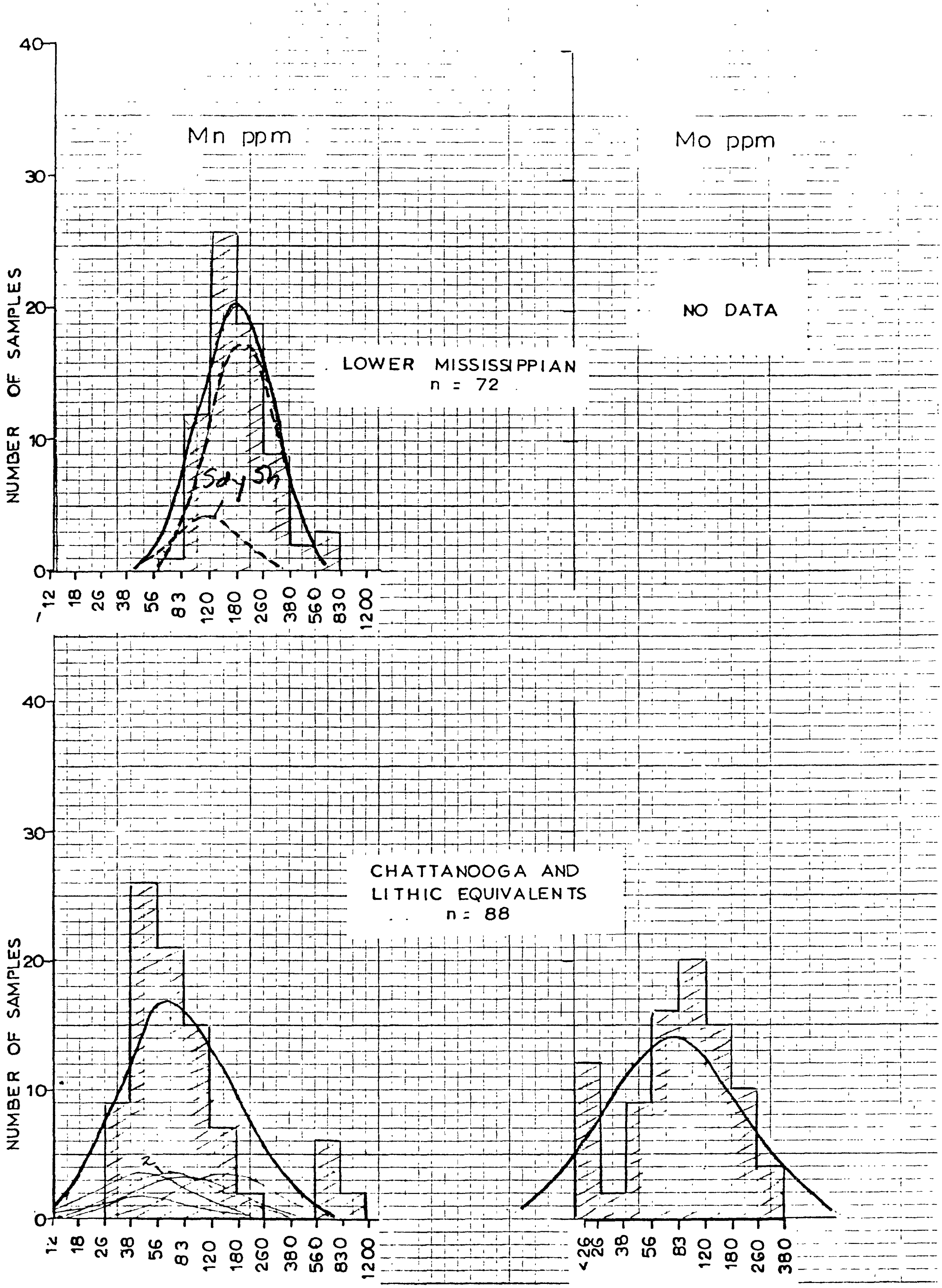

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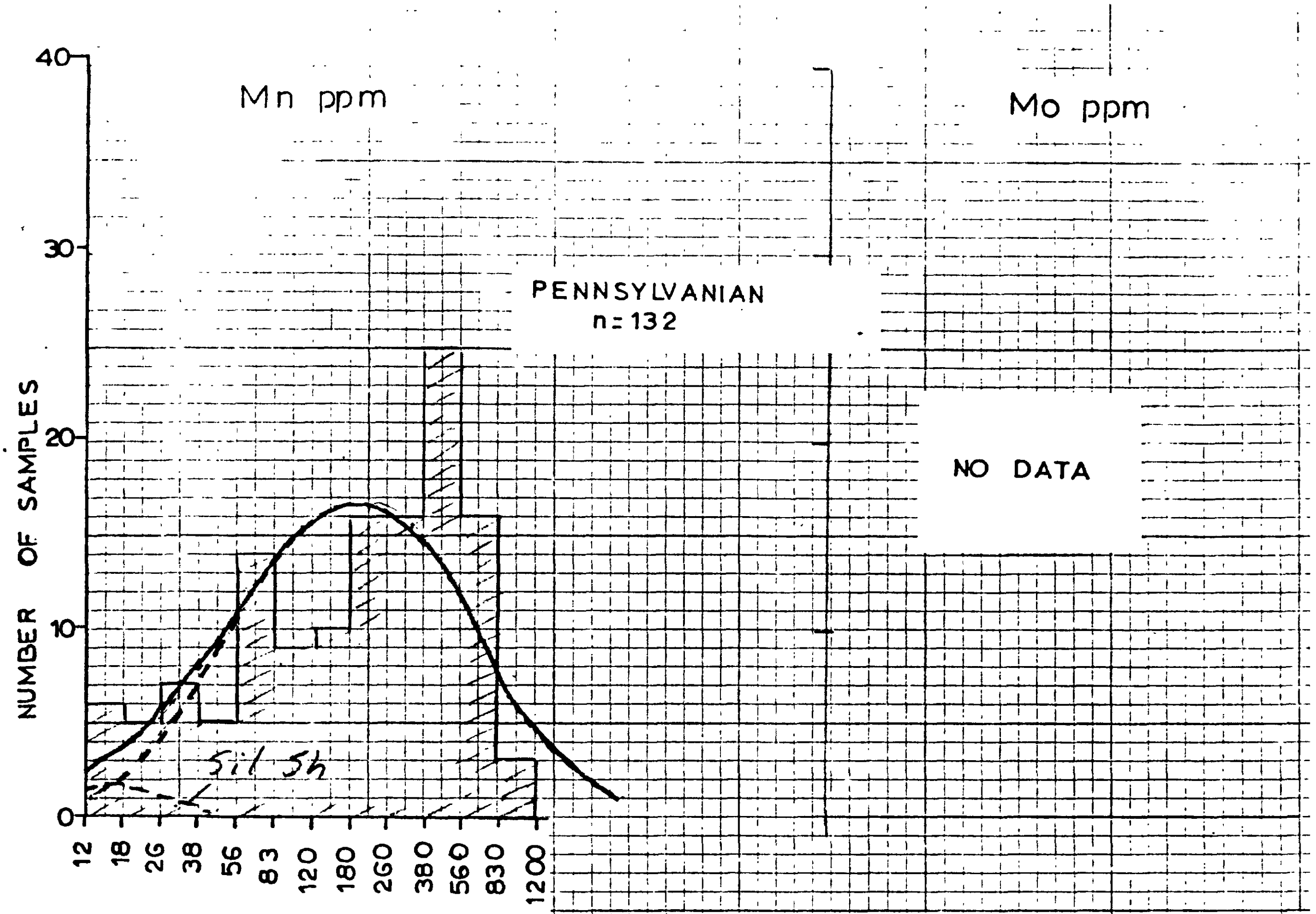

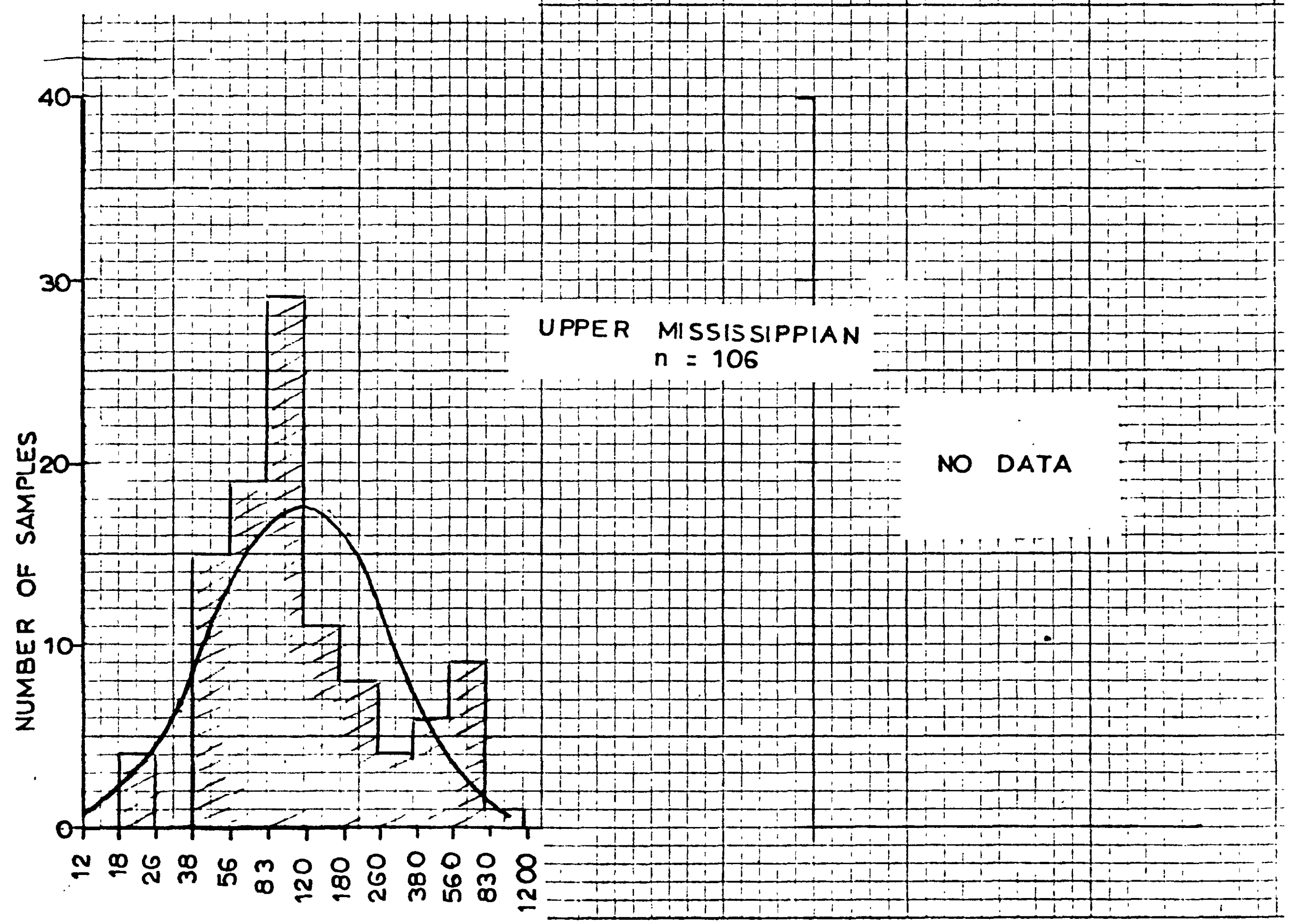

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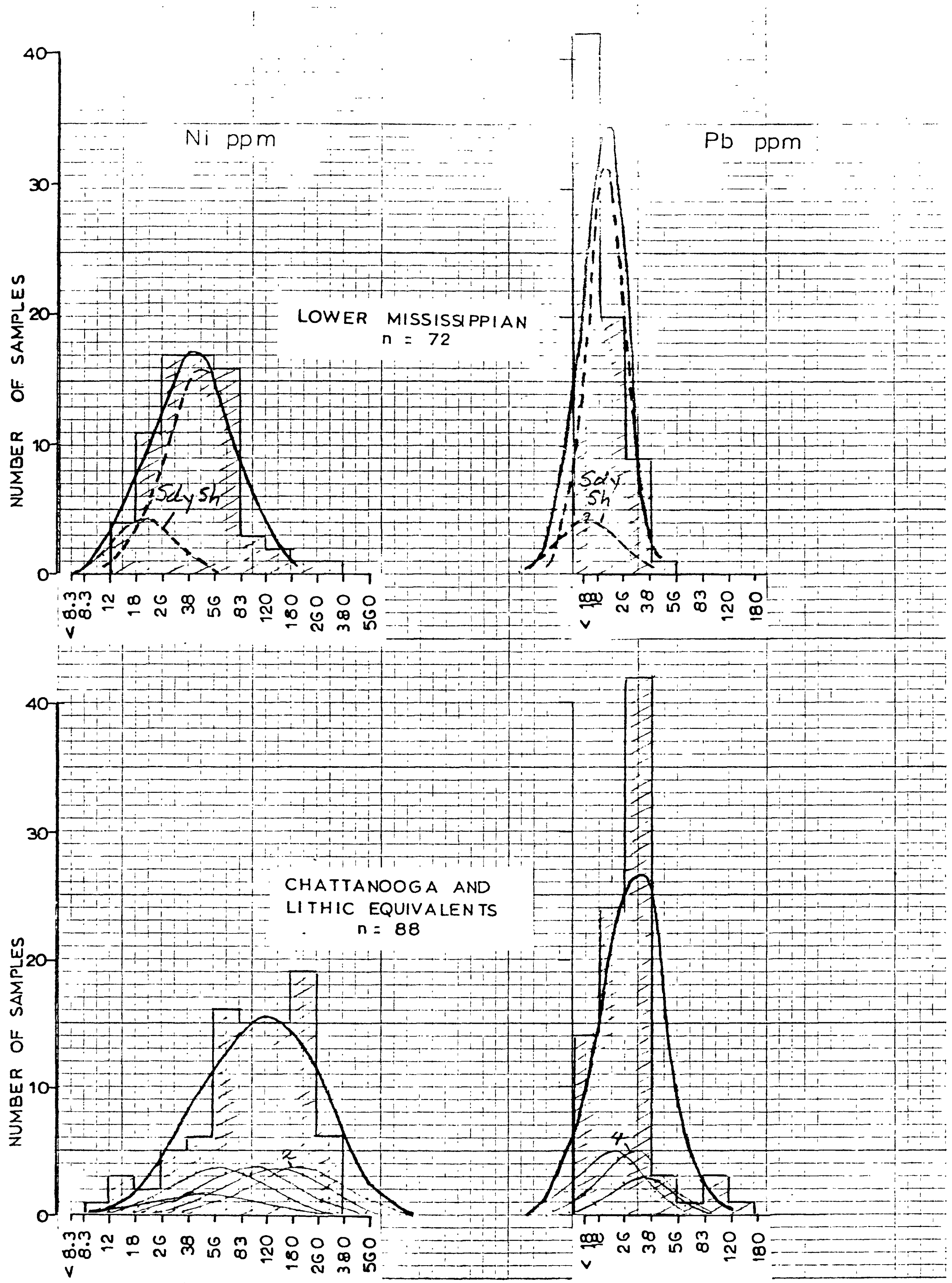

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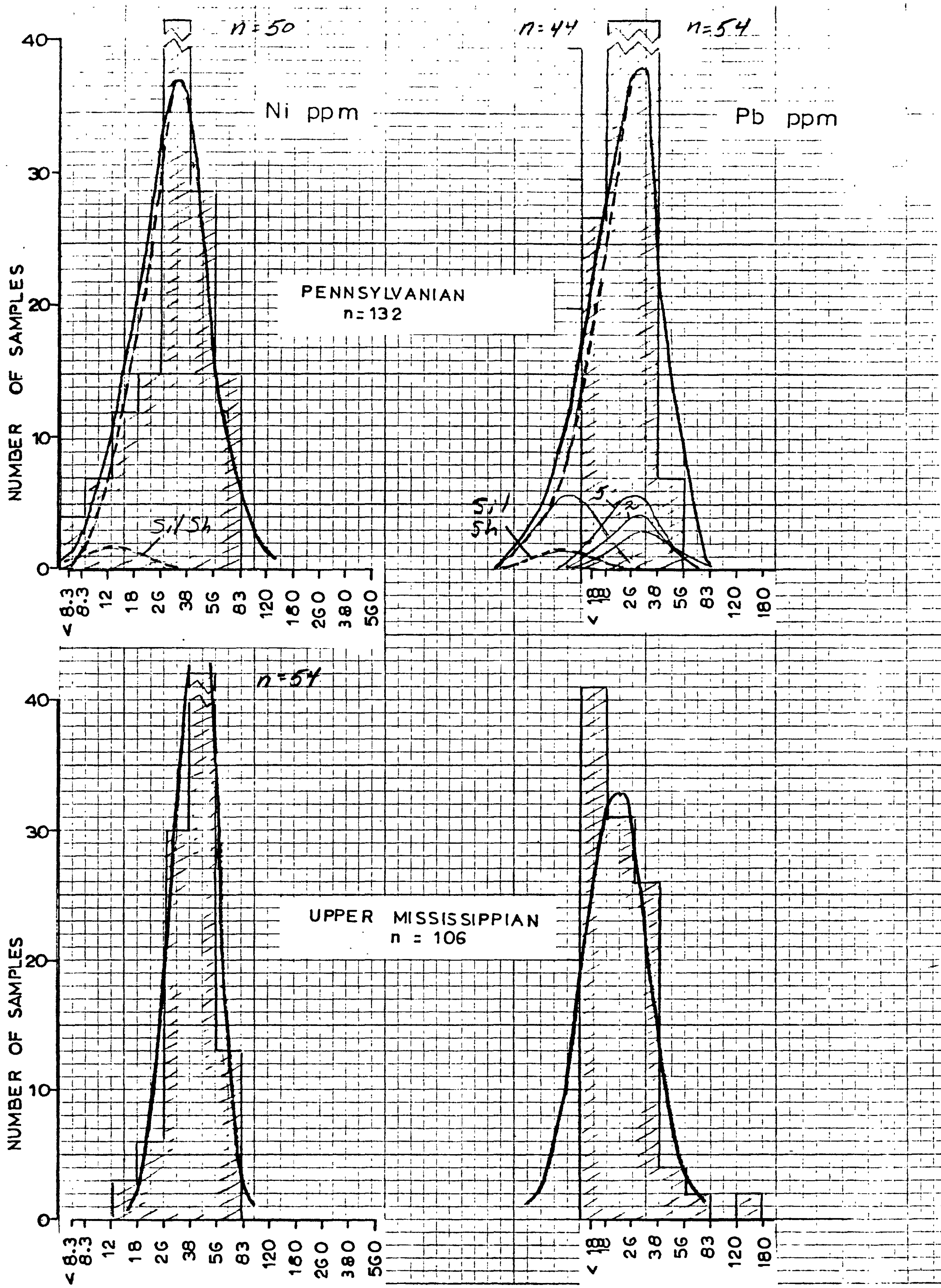

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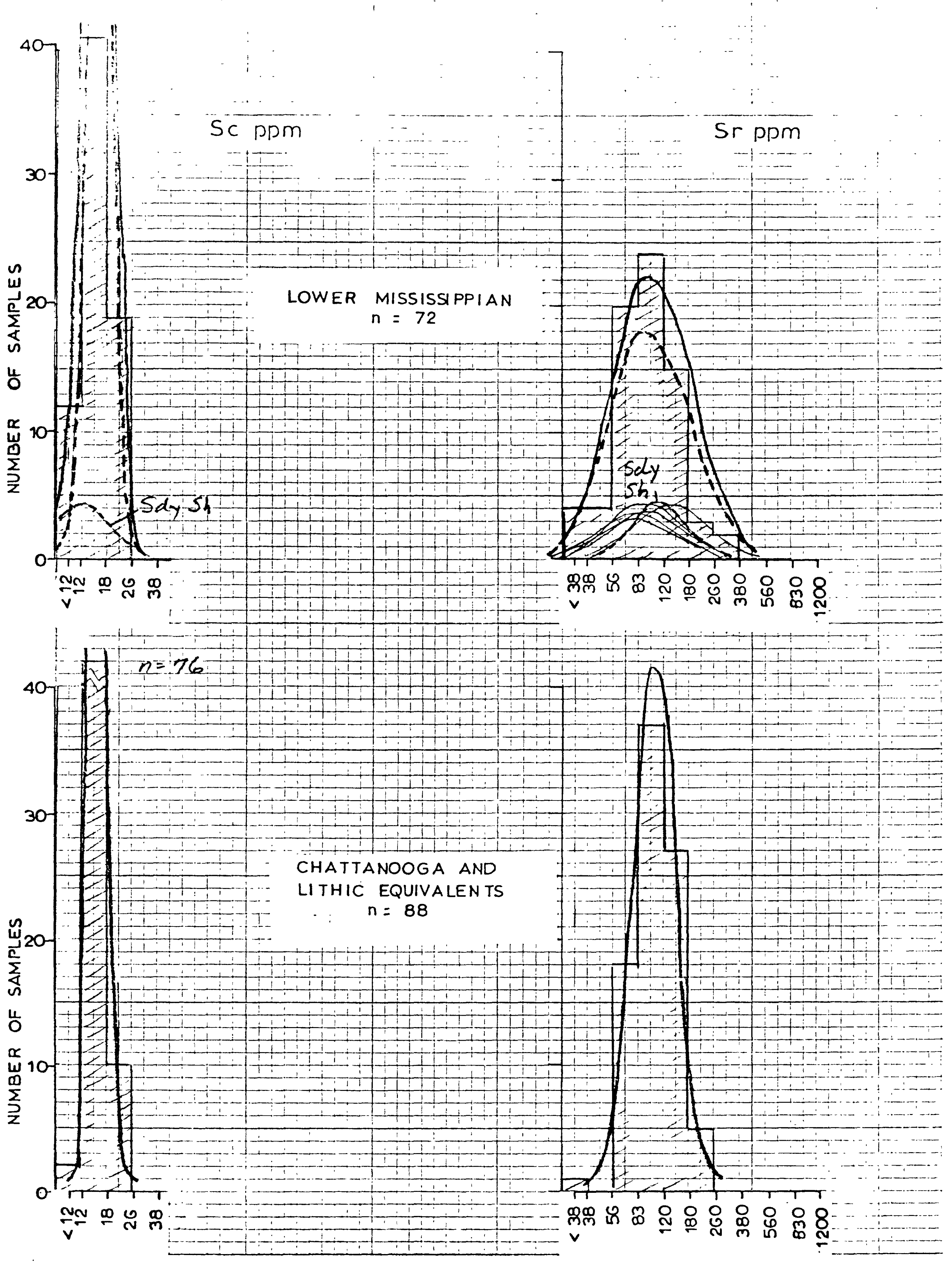

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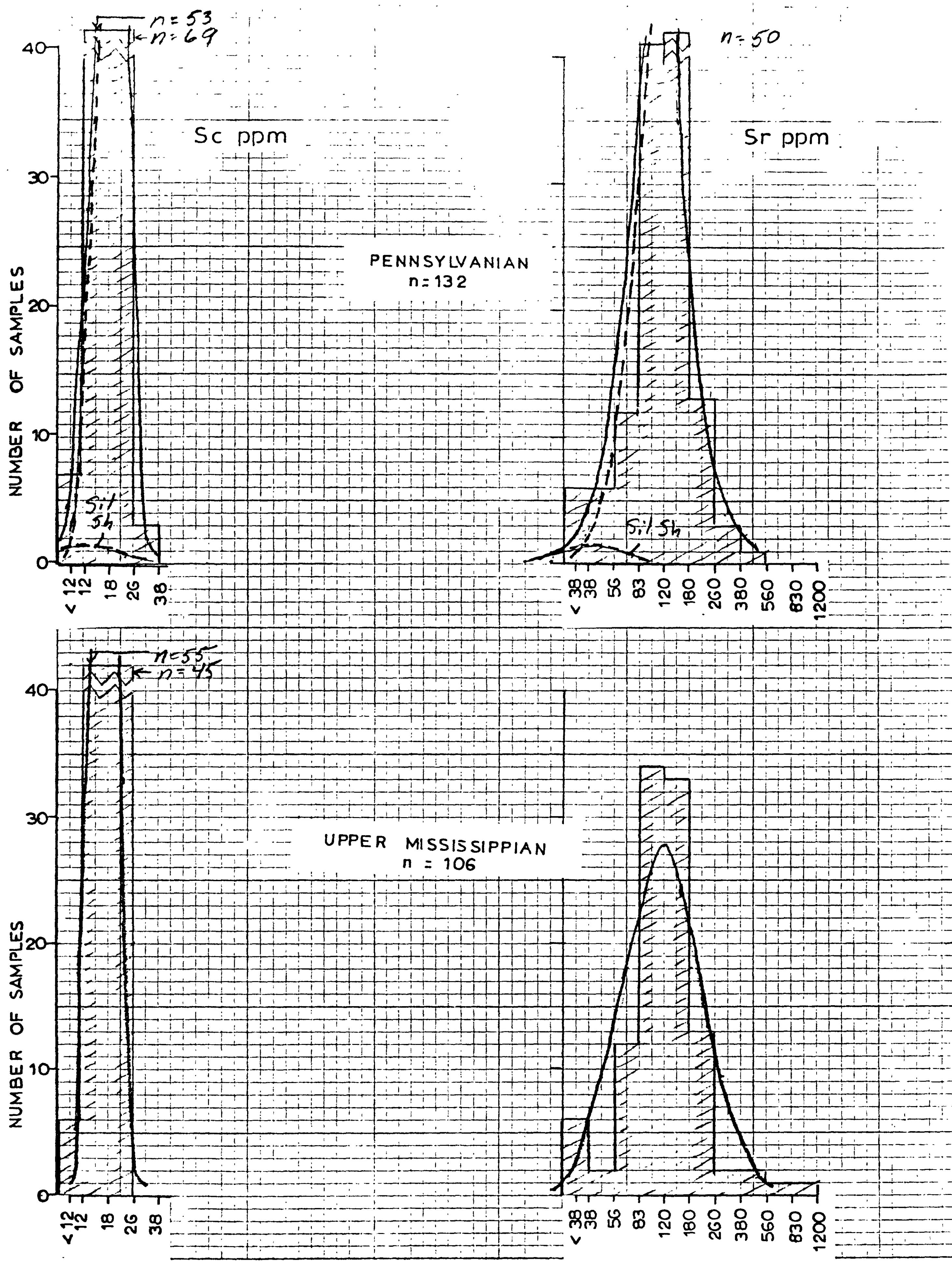

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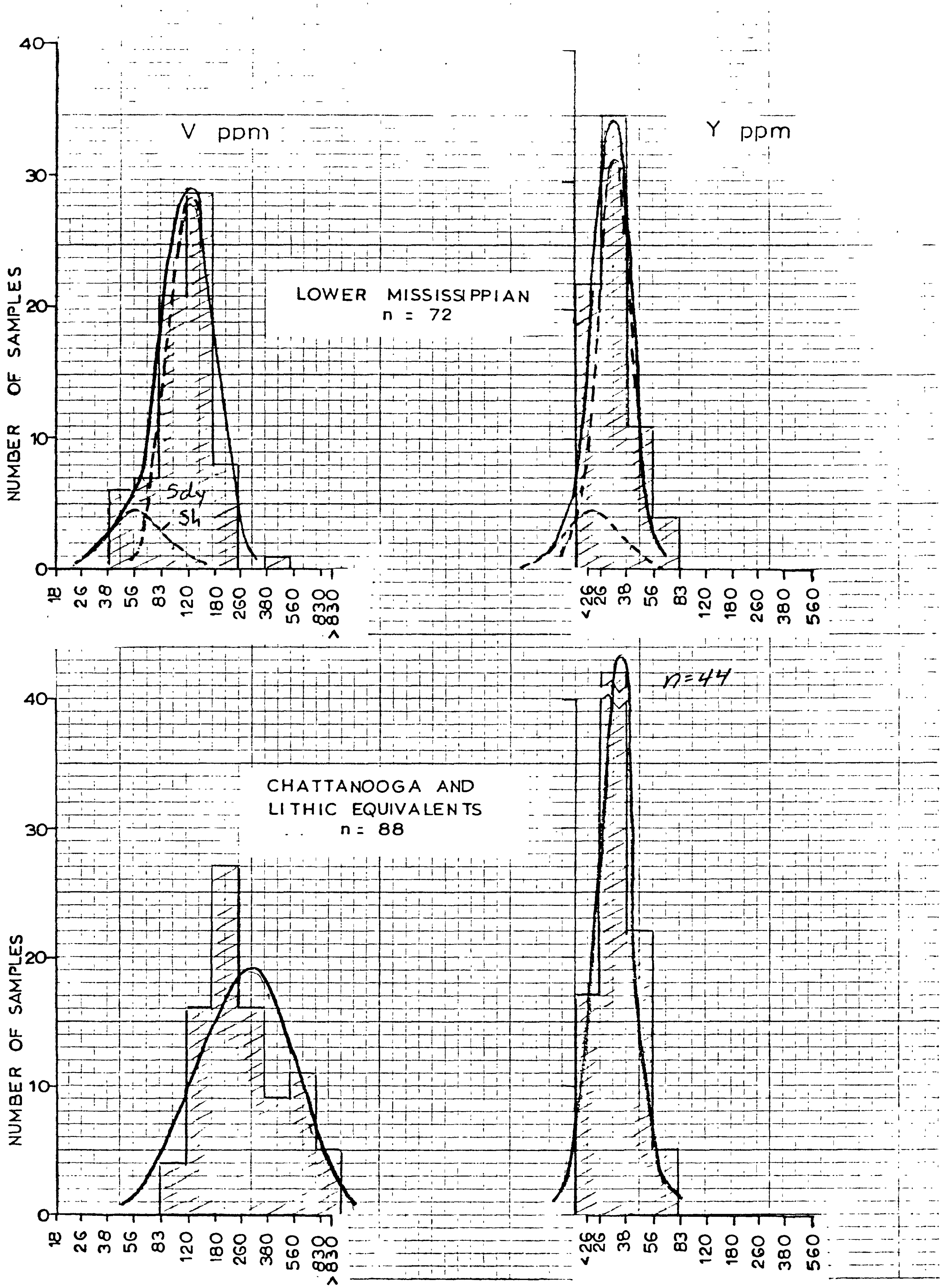

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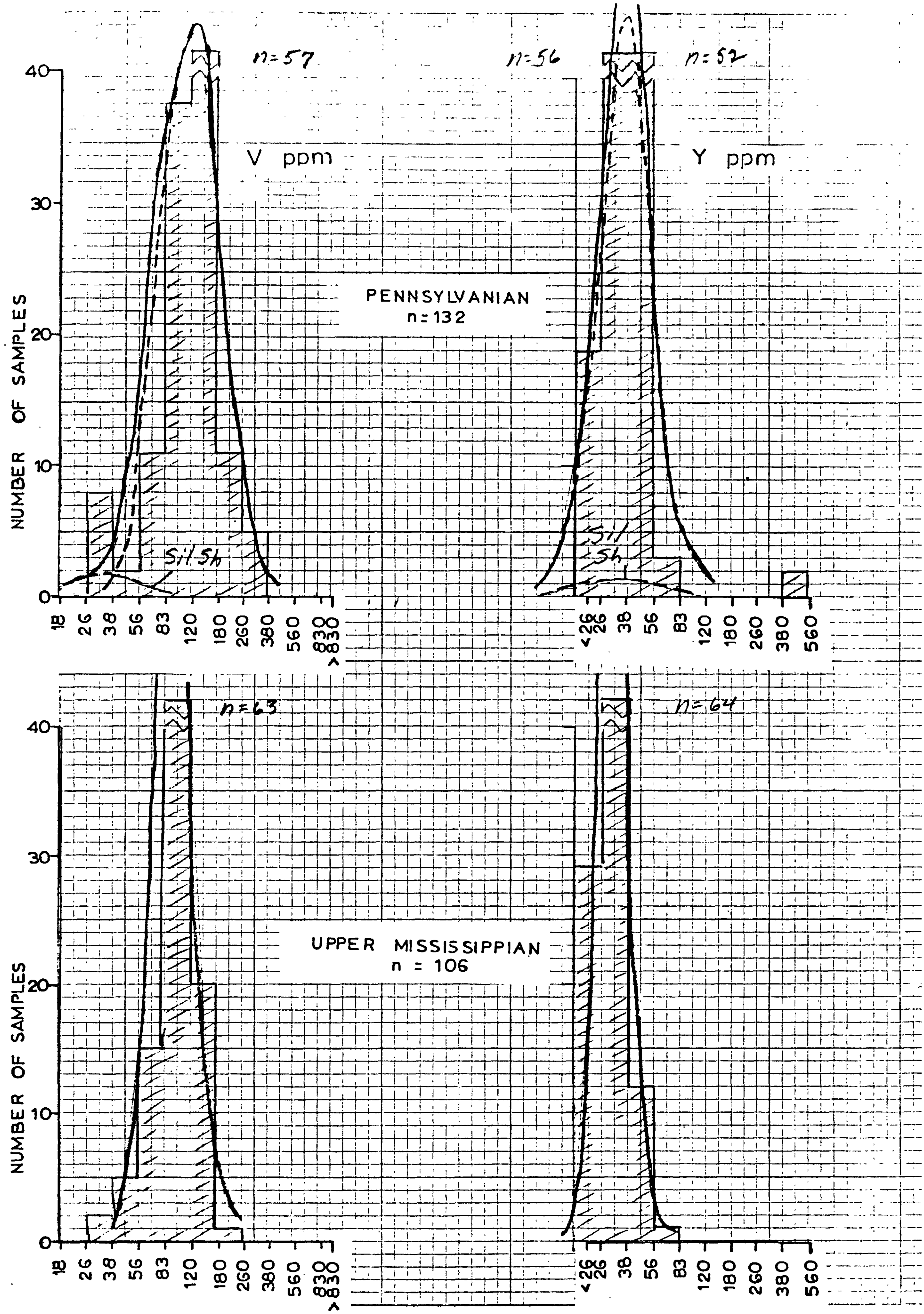

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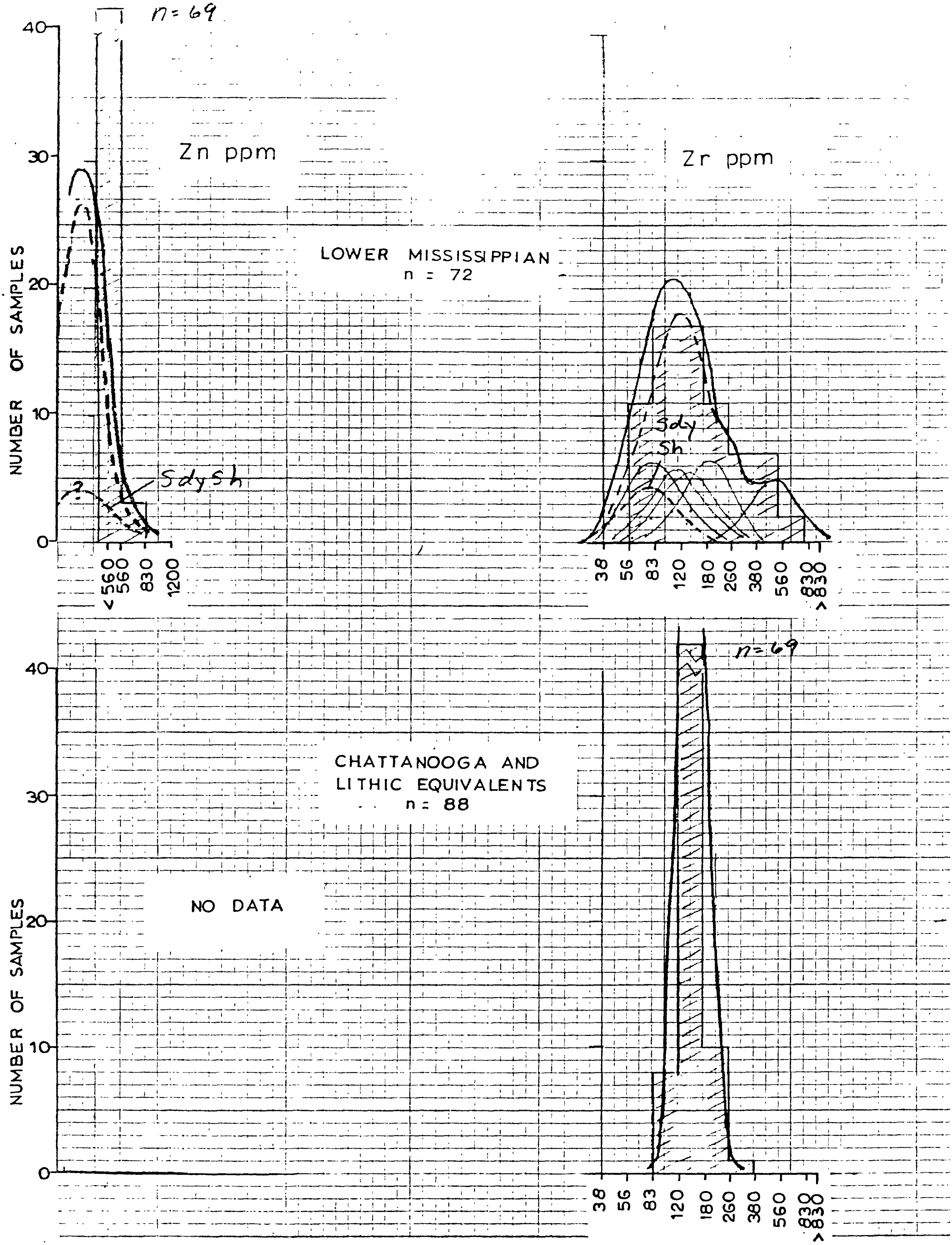

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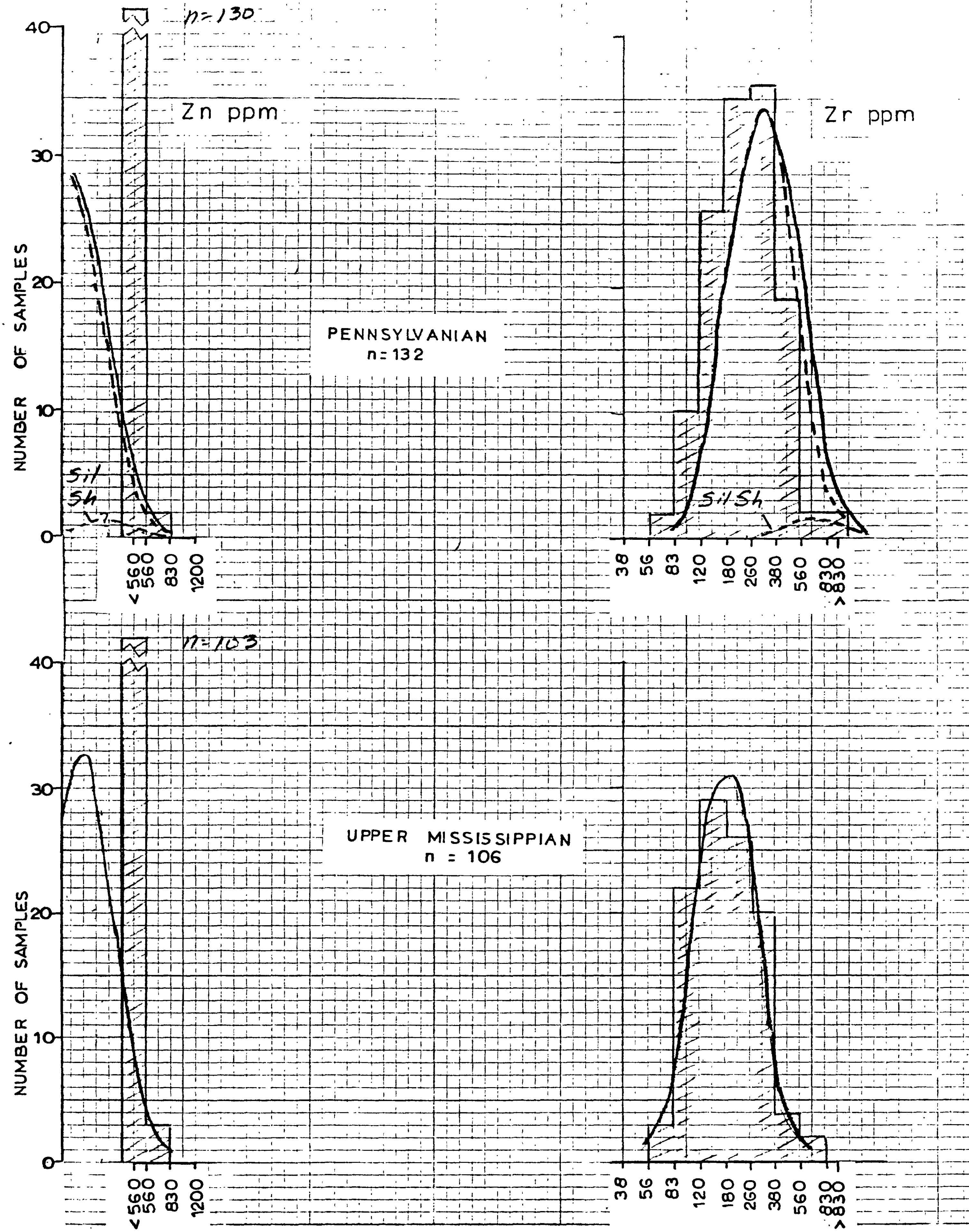

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Table 1A.--Chemical analyses of the Chattanooga, New Albany and Ohio Shales in Kentucky. [%, percent; ppm, parts per million; N, not detected; leaders (--) indicate no data; labels ending in "-S" are spectrographic determinations]

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%	P2O5%	MnO%
DSH-E111	38 22 30	83 30 00	121,417	63.3	12.2	.80	<.01	.30	3.1	4.9	1.60	.81	.05	.04
DSH-E111	38 22 30	83 30 00	121,286	63.9	12.2	.70	.10	.50	3.6	4.9	1.60	.83	.09	.03
DSH-E112	38 22 30	83 30 00	121,243	58.8	14.6	.90	.20	.60	3.1	6.7	1.70	.87	.06	.06
DSH-E112	38 22 30	83 30 00	121,530	58.6	14.9	.80	N	.25	3.4	6.4	2.00	.82	.05	<.01
DSH-E121	38 22 30	83 30 00	121,447	67.7	15.3	1.00	.50	.60	3.7	3.6	1.80	.86	.03	.04
DSH-E121	38 22 30	83 30 00	121,274	67.5	15.1	1.10	.30	.30	3.8	3.8	1.60	.92	.03	.03
DSH-E122	38 22 30	83 30 00	121,479	60.0	13.5	1.00	<.01	.20	3.6	6.1	2.40	.72	.03	.07
DSH-E122	38 22 30	83 30 00	121,193	59.1	13.7	1.10	.10	.30	3.5	6.6	2.20	.74	.07	.02
DSH-E211	38 37 30	83 30 00	121,557	58.6	13.5	.60	.20	.20	3.4	3.6	2.20	.85	.02	.06
DSH-E211	38 37 30	83 30 00	121,223	58.6	13.4	.80	.10	.60	3.5	1.8	2.10	.83	.05	.05
DSH-E212	38 37 30	83 30 00	121,486	62.2	14.0	1.00	<.01	.10	3.1	5.5	2.00	.80	.02	.08
DSH-E212	38 37 30	83 30 00	121,381	61.4	14.0	.70	.10	.30	3.5	6.0	1.80	.82	.09	.02
DSH-E221	38 37 30	83 30 00	121,214	48.8	13.5	.75	.15	.34	3.5	1.8	2.60	.55	.11	.07
DSH-E221	38 37 30	83 30 00	121,531	48.3	13.3	1.00	.30	.30	3.4	7.6	2.80	.70	.08	<.01
DSH-E222	38 37 30	83 30 00	121,308	48.1	12.3	.80	.60	.60	3.9	2.3	2.10	.71	.08	.05
DSH-E222	38 37 30	83 30 00	121,410	50.3	12.8	.82	.11	.23	3.3	4.1	2.40	.75	.18	.03
DSH-K111	37 07 30	85 07 30	121,201	52.5	13.6	1.20	.10	.40	3.9	7.3	1.40	.71	.11	.05
DSH-K111	37 07 30	85 07 30	121,181	52.5	13.7	1.20	<.01	.50	3.9	5.8	1.40	.74	.11	.05
DSH-K112	37 07 30	85 07 30	121,208	55.2	12.9	1.20	.20	.50	3.7	6.1	1.10	.71	.13	.07
DSH-K112	37 07 30	85 07 30	121,411	55.1	12.7	1.20	.11	.38	3.7	3.9	1.20	.77	.22	.02
DSH-K121	37 07 30	85 07 30	121,385	45.7	11.2	4.50	8.50	.50	3.2	2.2	.78	.55	.14	.11
DSH-K121	37 07 30	85 07 30	121,241	45.8	10.8	4.70	6.60	.60	3.0	2.5	.76	.55	.06	.11
DSH-K122	37 07 30	85 07 30	121,237	51.8	11.6	1.30	.20	.50	3.0	7.8	1.10	.70	.17	.09
DSH-K122	37 07 30	85 07 30	121,462	52.2	11.7	1.30	.60	.70	3.1	6.8	1.10	.69	.19	.04
DSH-K211	37 07 30	85 00 00	121,163	52.5	12.8	1.20	.15	.30	3.4	2.9	1.20	.71	.07	<.01
DSH-K211	37 07 30	85 00 00	121,171	52.5	12.8	1.00	.20	.30	3.1	6.9	1.10	.73	.07	.02
DSH-K212	37 07 30	85 00 00	121,415	53.2	12.6	.92	.10	.48	3.8	4.8	1.40	.71	.07	.04
DSH-K212	37 07 30	85 00 00	121,303	52.5	12.3	1.00	.40	.90	4.5	7.3	1.30	.81	.10	.05
DSH-K221	37 07 30	85 00 00	121,142	55.1	12.5	1.00	.50	.30	3.1	7.0	1.40	.78	.11	.05
DSH-K221	37 07 30	85 00 00	121,457	54.9	12.5	1.00	.30	.60	3.4	6.0	1.30	.78	.11	.04
DSH-K222	37 07 30	85 00 00	121,236	56.0	14.3	1.20	.30	.40	3.7	6.4	1.70	.82	.06	.06
DSH-K222	37 07 30	85 00 00	121,548	56.1	14.1	1.10	.15	.24	4.1	2.6	1.90	.80	.05	.06
DSH-L111	37 00 00	84 52 30	121,349	45.8	12.8	1.10	.40	.40	3.4	9.8	1.50	.75	.15	.03
DSH-L111	37 00 00	84 52 30	121,229	45.8	13.1	1.10	.30	.50	3.2	3.4	1.40	.72	.15	.09
DSH-L112	37 00 00	84 52 30	121,224	47.7	12.2	1.10	.20	.88	3.7	7.9	1.20	.71	.10	.05
DSH-L112	37 00 00	84 52 30	121,504	48.2	11.9	.98	.15	.44	3.4	8.4	1.20	.75	.16	.05
DSH-L121	37 00 00	84 52 30	121,328	42.6	11.0	1.20	.70	.80	3.6	4.4	1.20	.74	.11	<.01
DSH-L121	37 00 00	84 52 30	121,364	42.4	10.7	1.00	.50	.40	2.7	5.6	1.40	.61	.17	.05
DSH-L122	37 00 00	84 52 30	121,552	52.7	15.0	1.10	.10	.30	4.1	4.0	1.40	.84	.07	.02
DSH-L112	37 00 00	84 52 30	121,331	52.4	14.6	1.10	.40	.40	3.6	3.0	1.20	.81	.09	<.01
DSH-L211	37 22 30	84 22 30	121,413	55.3	11.9	.70	.10	.60	3.0	6.7	.90	.75	.15	.05
DSH-L211	37 22 30	84 22 30	121,218	55.0	11.9	.90	.10	.70	3.6	2.8	.77	.66	.14	.05
DSH-L212	37 22 30	84 22 30	121,464	55.4	10.6	.90	.55	.50	2.6	6.2	1.90	.65	.05	.04
DSH-L212	37 22 30	84 22 30	121,395	54.0	11.3	.70	1.00	.40	2.9	5.8	1.00	.68	.19	.05
DSH-L221	37 22 30	84 22 30	121,350	64.3	17.2	1.20	.20	.20	4.5	4.0	2.00	1.00	.06	.02

Table 1A.--Cont.

Sample	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	Mo ppm-S	Ni ppm-S	Pb ppm-S
DSH-E111	<.05	1.4	.41	30	100	310	N	65	26	68	36	N
DSH-E111	<.05	1.6	.45	36	110	400	N	77	30	73	44	21
DSH-E112	.05	2.8	.59	60	110	720	11	93	100	110	98	23
DSH-E112	<.05	3.0	.45	55	95	610	9	77	100	110	82	20
DSH-E121	<.05	2.1	.69	36	130	550	N	82	72	24	11	N
DSH-E121	<.05	1.4	.49	40	120	450	N	85	80	23	12	26
DSH-E122	<.05	4.0	.48	48	120	440	9	120	160	N	78	23
DSH-E122	.06	2.0	.37	44	100	370	N	120	150	N	70	N
DSH-E211	<.05	5.3	.44	48	140	460	22	60	210	78	84	23
DSH-E211	<.05	3.2	.42	50	130	420	23	60	210	63	77	29
DSH-E212	<.05	3.3	.51	47	150	680	9	79	180	72	60	23
DSH-E212	<.05	2.6	.42	47	160	600	10	71	160	54	50	23
DSH-E221	<.05	1.4	.28	36	98	300	N	100	130	86	70	N
DSH-E221	.05	2.6	.35	44	100	370	N	110	150	110	84	N
DSH-E222	<.05	1.4	.32	36	100	320	N	110	100	110	60	N
DSH-E222	<.05	2.0	.34	39	110	320	N	120	110	150	60	20
DSH-K111	<.05	5.1	.30	89	110	300	37	60	82	89	180	20
DSH-K111	<.05	6.8	.34	95	130	360	39	66	85	90	200	30
DSH-K112	.05	3.9	.41	91	100	1,000	23	73	100	270	250	30
DSH-K112	<.05	6.4	.39	100	120	1,100	19	71	100	250	230	30
DSH-K121	.24	5.2	.26	850	88	220	14	82	150	N	85	N
DSH-K121	8.70	2.8	.19	640	90	230	12	82	150	N	79	N
DSH-K122	<.05	2.9	.28	84	100	720	9	110	170	35	190	35
DSH-K122	<.05	6.2	.42	96	110	900	12	120	170	48	240	30
DSH-K211	<.05	3.8	.37	79	110	1,400	22	70	110	160	130	22
DSH-K211	<.05	3.0	.31	76	100	800	20	60	110	140	110	20
DSH-K212	.19	7.6	.35	70	110	540	43	60	100	110	220	33
DSH-K212	<.05	4.3	.38	60	100	430	43	60	93	96	220	30
DSH-K221	<.05	2.3	.40	53	110	1,600	18	67	130	230	210	N
DSH-K221	<.05	4.6	.49	60	110	3,200	18	67	120	280	250	27
DSH-K222	<.05	3.4	.41	57	130	2,600	19	70	180	120	110	21
DSH-K222	<.05	4.0	.51	60	130	3,100	16	78	160	140	110	28
DSH-L111	.05	6.7	.32	100	89	300	30	60	90	120	76	30
DSH-L111	<.05	6.0	.35	100	100	340	34	60	95	120	85	25
DSH-L112	<.05	9.6	.42	130	120	300	56	60	100	180	150	30
DSH-L112	<.05	6.3	.32	110	100	300	50	60	100	160	140	31
DSH-L121	<.05	5.8	.27	130	86	250	46	46	92	150	99	35
DSH-L121	.11	9.5	.27	130	90	270	48	53	97	180	110	30
DSH-L122	.10	10.0	.41	92	140	340	38	75	94	100	180	30
DSH-L112	<.05	4.5	.34	75	120	300	37	61	89	80	170	N
DSH-L211	<.05	5.4	.35	76	92	300	26	56	100	97	130	29
DSH-L211	<.05	4.6	.36	76	88	300	28	57	100	99	140	31
DSH-L212	<.05	10.0	.32	54	100	270	34	48	110	110	100	28
DSH-L212	<.05	5.4	.26	51	79	250	30	44	100	96	85	30
DSH-L221	<.05	6.1	.73	46	140	510	N	100	84	80	13	30

Table 1A.--Cont.

Sample	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S	T-C%	Orgnc C%	Crbnt C%	Hg ppm
DSH-E111	13	90	220	30	N	170	16	9.55	9.5	.06	.40
DSH-E111	17	120	240	32	N	180	23	9.49	9.5	.02	<.02
DSH-E112	20	120	470	33	N	170	30	10.10	10.0	.15	.12
DSH-E112	18	80	440	24	N	150	21	9.94	9.9	.07	.24
DSH-E121	17	120	180	28	N	170	20	3.26	3.2	.08	<.02
DSH-E121	19	130	170	30	N	170	29	3.44	3.4	.03	<.02
DSH-E122	17	80	460	30	N	160	22	9.82	9.8	.03	.35
DSH-E122	17	80	390	30	N	130	23	9.81	9.8	.05	.50
DSH-E211	14	100	160	N	N	140	28	8.50	8.3	.17	.26
DSH-E211	15	90	130	26	N	130	30	8.76	8.7	.05	.16
DSH-E212	15	130	260	24	N	160	23	7.91	7.9	.03	.18
DSH-E212	15	110	210	22	N	140	23	7.95	7.9	.09	.15
DSH-E221	17	60	>1,000	29	N	100	19	19.10	19.1	.04	.90
DSH-E221	19	80	>1,000	29	N	130	17	18.70	18.6	.08	.60
DSH-E222	17	170	>1,000	35	N	140	21	19.10	19.0	.06	.80
DSH-E222	15	150	>1,000	33	N	130	20	19.20	19.1	.08	.80
DSH-K111	15	80	220	29	N	120	25	10.10	10.1	.01	.30
DSH-K111	11	80	240	24	N	120	29	10.50	10.4	.07	.50
DSH-K112	17	110	560	46	N	170	25	12.60	12.5	.07	.75
DSH-K112	15	100	540	39	N	140	23	12.30	12.2	.07	.50
DSH-K121	15	100	110	31	N	110	18	11.00	8.9	2.10	.40
DSH-K121	17	120	120	34	N	110	20	10.80	8.0	2.76	.13
DSH-K122	16	120	540	45	N	130	22	17.70	17.5	.17	1.20
DSH-K122	15	120	780	48	920	160	19	17.70	17.7	.04	.80
DSH-K211	16	130	260	30	N	130	22	16.00	15.9	.13	1.00
DSH-K211	15	90	220	30	N	130	20	16.20	16.2	<.01	.90
DSH-K212	15	80	260	30	540	150	24	11.00	11.0	.02	.50
DSH-K212	17	90	260	38	N	130	25	11.40	11.3	.11	.65
DSH-K221	16	130	590	36	N	150	21	14.70	14.6	.06	1.00
DSH-K221	16	170	700	38	N	170	20	15.20	15.2	.03	.80
DSH-K222	17	110	460	27	N	150	24	11.90	11.9	.03	.45
DSH-K222	17	120	570	29	N	160	24	11.80	11.7	.07	.45
DSH-L111	17	110	170	57	N	120	24	17.80	17.6	.22	.80
DSH-L111	18	120	180	60	N	130	25	15.40	15.4	.05	1.00
DSH-L112	17	100	170	40	N	150	19	12.90	12.8	.05	1.00
DSH-L112	15	110	170	37	N	140	25	12.90	12.8	.06	.75
DSH-L121	15	90	160	44	N	120	20	16.30	16.2	.09	1.10
DSH-L121	15	100	180	43	N	130	20	17.60	17.5	.14	.90
DSH-L122	16	120	300	34	N	160	27	9.74	9.6	.18	.45
DSH-L112	17	110	260	30	N	110	24	8.68	8.5	.19	.75
DSH-L211	13	80	180	39	N	160	23	13.20	13.1	.14	.90
DSH-L211	15	80	180	39	N	160	23	13.20	13.1	.09	1.00
DSH-L212	12	60	140	20	N	140	19	10.40	10.4	.03	.35
DSH-L212	13	60	130	27	N	120	20	10.80	10.4	.44	.90
DSH-L221	20	140	350	37	N	190	32	1.83	1.7	.16	<.02

Table 1A.--Cont.

Sample	Ag ppm
DSH-E111	.2
DSH-E111	<.2
DSH-E112	.2
DSH-E112	.2
DSH-E121	<.2
DSH-E121	<.2
DSH-E122	.2
DSH-E122	.3
DSH-E211	<.2
DSH-E211	<.2
DSH-E212	<.2
DSH-E212	.2
DSH-E221	.6
DSH-E221	.6
DSH-E222	.6
DSH-E222	.6
DSH-K111	.3
DSH-K111	.3
DSH-K112	.3
DSH-K112	<.2
DSH-K121	.5
DSH-K121	.6
DSH-K122	.4
DSH-K122	<.2
DSH-K211	<.2
DSH-K211	.4
DSH-K212	<.2
DSH-K212	<.2
DSH-K221	.4
DSH-K221	<.2
DSH-K222	.2
DSH-K222	.3
DSH-L111	<.2
DSH-L111	<.2
DSH-L112	<.2
DSH-L112	<.2
DSH-L121	<.2
DSH-L121	.2
DSH-L122	.3
DSH-L112	<.2
DSH-L211	<.2
DSH-L211	<.2
DSH-L212	<.2
DSH-L212	<.2
DSH-L221	.3

Table 1A.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%	P2O5%	MnO%
DSH-L221	37 22 30	84 22 30	121,379	64.5	17.1	.90	.30	.30	4.3	3.7	1.70	.98	.12	.02
DSH-L222	37 22 30	84 22 30	121,166	61.3	16.3	1.00	.20	.20	3.3	3.7	2.30	.94	.04	<.01
DSH-L222	37 22 30	84 22 30	121,397	60.6	16.5	.90	.60	.30	4.4	4.5	2.40	.92	.19	.05
DSH-R111	36 37 30	86 07 30	121,225	57.1	13.4	2.30	1.90	.25	4.4	2.7	1.30	.66	.16	.10
DSH-R111	36 37 30	86 07 30	121,162	57.3	13.8	2.20	2.40	.10	3.8	2.5	1.40	.78	.19	.09
DSH-R112	36 37 30	86 07 30	121,132	46.7	11.6	3.00	2.40	.10	3.3	3.2	.97	.64	.12	.09
DSH-R112	36 37 30	86 07 30	121,522	47.0	11.8	2.80	2.70	.30	3.9	6.9	.73	.66	.12	.06
DSH-R121	36 37 30	86 07 30	121,253	55.0	13.0	1.40	.40	.30	3.5	5.9	1.10	.70	.16	.06
DSH-R121	36 37 30	86 07 30	121,339	54.7	12.9	1.50	.40	.40	4.1	5.9	1.20	.72	.15	.05
DSH-R122	36 37 30	86 07 30	121,456	51.2	13.4	1.90	.80	.20	4.0	6.9	.76	.76	.08	.07
DSH-R122	36 37 30	86 07 30	121,521	51.4	13.5	1.90	.90	.30	4.0	7.6	.91	.70	.09	<.01
DSH-R211	36 45 00	86 00 00	121,513	59.4	12.9	1.40	.40	.40	3.6	5.6	.87	.77	.10	.05
DSH-R211	36 45 00	86 00 00	121,153	58.9	12.9	1.20	.40	.40	3.7	2.9	.93	.86	.11	.05
DSH-R212	36 45 00	86 00 00	121,507	50.0	12.4	1.20	.55	.30	3.5	7.4	1.10	.69	.31	.02
DSH-R212	36 45 00	86 00 00	121,217	50.7	12.8	1.10	.40	.50	3.4	3.0	.86	.66	.27	.03
DSH-R221	36 45 00	86 00 00	121,312	63.9	15.3	1.30	.20	.60	5.3	4.4	1.60	1.00	.08	.13
DSH-R221	36 45 00	86 00 00	121,310	63.4	15.4	1.30	.30	.70	5.4	4.4	1.70	1.00	.08	.10
DSH-R222	36 45 00	86 00 00	121,369	59.5	15.2	1.00	.10	.30	4.3	5.5	1.90	.85	.25	.05
DSH-R222	36 45 00	86 00 00	121,345	58.3	14.8	1.40	.90	.60	4.3	5.1	2.00	.82	.08	.03
DSH-S111	36 45 00	85 15 00	121,493	54.3	13.3	.80	.16	.42	4.3	6.5	1.90	.85	.06	.05
DSH-S111	36 45 00	85 15 00	121,549	55.5	13.8	.82	.28	.46	4.2	3.0	1.80	.57	.04	.02
DSH-S112	36 45 00	85 15 00	121,200	57.1	13.8	.70	.10	.40	4.2	5.9	1.50	.86	.07	<.01
DSH-S112	36 45 00	85 15 00	121,408	56.6	12.8	.60	.30	.50	3.9	5.8	1.60	.95	.22	.03
DSH-S121	36 45 00	85 15 00	121,558	53.3	12.5	.93	.11	.34	3.8	3.5	1.00	.77	.18	.02
DSH-S121	36 45 00	85 15 00	121,418	53.2	12.6	.80	.10	.40	3.3	5.4	.94	.80	.07	.04
DSH-S122	36 45 00	85 15 00	121,399	45.9	11.1	.80	.70	.50	3.2	4.2	1.30	.72	.14	.05
DSH-S122	36 45 00	85 15 00	121,536	46.0	11.2	1.10	.40	.45	3.4	7.1	1.60	.67	.08	.02
DSH-S211	36 52 30	85 22 30	121,278	53.7	12.9	.90	.40	.50	3.5	2.8	.82	.75	.10	<.01
DSH-S211	36 52 30	85 22 30	121,325	54.0	13.3	.90	.40	.30	3.6	3.0	.76	.81	.12	.03
DSH-S212	36 52 30	85 22 30	121,396	46.1	12.1	.90	1.00	.70	3.8	4.6	1.30	.72	.12	.05
DSH-S212	36 52 30	85 22 30	121,444	46.5	11.9	1.20	.55	.48	3.6	7.1	1.40	.69	.13	.04
DSH-S221	36 52 30	85 22 30	121,366	51.5	12.6	.90	1.00	.60	3.8	4.4	1.20	.66	.12	<.01
DSH-S221	36 52 30	85 22 30	121,262	51.0	12.7	1.00	.30	.50	3.9	6.4	1.20	.75	.10	.06
DSH-S222	36 52 30	85 22 30	121,180	52.5	11.9	.90	.10	.70	3.8	6.8	1.40	.74	.08	.02
DSH-S222	36 52 30	85 22 30	121,343	51.9	12.0	.80	.20	.60	3.8	6.8	1.40	.75	.06	.03
DSH-P111	37 00 00	88 00 00	121,439	63.1	15.8	1.00	.10	.10	4.3	5.1	1.30	.72	.02	.05
DSH-P111	37 00 00	88 00 00	121,185	63.2	15.6	1.10	<.01	.30	4.0	5.0	1.30	.74	.07	.05
DSH-P112	37 00 00	88 00 00	121,272	62.4	16.0	1.10	.30	.30	4.1	4.3	1.10	.80	.08	.06
DSH-P112	37 00 00	88 00 00	121,560	63.0	15.8	.80	.30	.10	4.2	4.9	1.30	.75	.07	.09
DSH-P211	36 52 30	88 15 00	121,134	64.9	19.2	1.20	.10	.10	3.8	4.4	1.80	.99	.07	.05
DSH-P211	36 52 30	88 15 00	121,455	64.9	19.6	1.10	.20	.10	4.1	5.1	1.30	.99	.06	.04
DSH-P212	36 52 30	88 15 00	121,168	66.9	12.1	.80	.10	.10	2.2	4.4	.88	.59	.03	.05
DSH-P212	36 52 30	88 15 00	121,144	67.0	12.1	.80	.30	.10	2.2	4.5	1.00	.62	.03	.05

Table 1A.--Cont.

Sample	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	Mo ppm-S	Ni ppm-S	Pb ppm-S
DSH-L221	<.05	4.6	.55	49	140	550	N	100	81	69	13	30
DSH-L222	<.05	2.3	.42	49	150	390	N	84	120	41	30	N
DSH-L222	<.05	2.5	.44	48	120	380	N	88	93	44	29	22
DSH-R111	2.00	3.9	.37	760	110	320	8	96	180	N	300	N
DSH-R111	1.90	3.7	.38	630	110	340	9	90	180	N	260	N
DSH-R112	<.05	4.6	.37	750	96	260	16	93	220	82	260	24
DSH-R112	<.05	5.8	.36	800	83	240	14	92	210	81.	240	25
DSH-R121	.05	3.6	.32	110	120	300	20	76	120	140	300	120
DSH-R121	<.05	3.8	.36	100	110	300	24	81	120	190	320	130
DSH-R122	<.05	6.9	.43	190	100	350	17	84	290	52	180	41
DSH-R122	<.05	9.9	.50	220	110	360	19	94	310	60	210	29
DSH-R211	.08	8.5	.43	130	90	300	38	66	110	99	190	37
DSH-R211	.12	4.0	.38	120	81	290	36	63	100	86	170	28
DSH-R212	<.05	5.6	.36	82	99	250	8	150	190	53	240	110
DSH-R212	<.05	3.7	.32	91	100	240	N	160	190	45	230	96
DSH-R221	<.05	3.7	.68	860	130	360	27	110	190	N	140	22
DSH-R221	.05	4.0	.74	600	140	370	29	120	190	N	140	23
DSH-R222	<.05	4.4	.49	60	110	7,800	N	100	220	45	58	43
DSH-R222	.18	2.7	.36	55	81	5,500	N	95	180	35	48	28
DSH-S111	<.05	7.4	.61	33	110	1,800	N	70	41	150	29	29
DSH-S111	<.05	9.3	.71	37	120	2,200	N	76	43	190	31	30
DSH-S112	<.05	3.5	.42	40	99	990	26	63	230	100	150	23
DSH-S112	<.05	5.7	.54	44	110	890	26	70	230	110	170	20
DSH-S121	<.05	6.9	.47	70	110	910	23	73	120	330	290	N
DSH-S121	.05	4.5	.37	68	94	900	20	68	110	240	230	31
DSH-S122	<.05	9.4	.37	100	87	260	60	51	100	150	130	23
DSH-S122	.11	5.0	.26	110	69	240	53	60	110	110	120	27
DSH-S211	.08	4.2	.42	83	110	600	25	76	140	270	250	30
DSH-S211	.05	2.9	.32	76	97	460	22	74	130	240	210	24
DSH-S212	<.05	5.9	.31	140	89	280	38	60	100	190	95	28
DSH-S212	<.05	7.1	.33	150	93	360	37	60	100	190	97	35
DSH-S221	<.05	7.0	.35	60	110	630	45	60	100	160	260	29
DSH-S221	.05	8.3	.38	68	120	600	50	65	120	150	290	36
DSH-S222	<.05	5.9	.38	48	100	360	30	64	75	150	79	21
DSH-S222	<.05	5.2	.36	47	87	330	30	60	64	140	78	34
DSH-P111	<.05	3.5	.56	44	180	370	8	97	30	67	60	36
DSH-P111	<.05	2.4	.40	40	180	330	N	85	30	53	51	34
DSH-P112	<.05	2.3	.38	44	180	380	10	94	28	59	50	56
DSH-P112	.08	4.1	.44	45	170	370	N	100	30	61	53	31
DSH-P211	<.05	2.7	.62	75	230	360	N	120	42	N	20	20
DSH-P211	<.05	4.9	.90	70	240	400	N	110	36	N	20	30
DSH-P212	<.05	2.3	.22	34	120	230	20	55	150	75	69	30
DSH-P212	<.05	2.9	.25	36	130	270	20	60	150	78	77	40

Table 1A.--Cont.

Sample	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S	T-C%	Orgnc C%	Crbnt C%	Hg ppm
DSH-L221	18	130	300	30	N	160	33	1.84	1.7	.10	.11
DSH-L222	17	110	220	23	N	140	26	5.39	5.3	.06	<.02
DSH-L222	17	100	260	26	N	150	29	5.38	5.3	.11	.08
DSH-R111	18	80	140	35	N	170	22	7.68	7.0	.65	.15
DSH-R111	17	90	120	36	N	190	23	7.74	7.2	.59	.30
DSH-R112	17	90	640	33	N	140	20	16.70	15.9	.81	.45
DSH-R112	15	90	700	28	N	130	19	16.70	15.9	.76	1.00
DSH-R121	16	70	330	30	1,000	130	24	12.70	12.6	.06	.80
DSH-R121	18	60	440	36	610	150	23	11.50	11.5	.02	.85
DSH-R122	15	70	260	28	N	140	19	14.90	14.7	.22	1.10
DSH-R122	18	90	300	30	N	160	16	15.10	14.8	.34	.75
DSH-R211	14	90	220	38	N	190	21	7.72	7.6	.10	.15
DSH-R211	15	80	180	45	N	170	23	7.92	7.8	.14	.50
DSH-R212	17	30	910	44	N	150	17	18.70	18.6	.17	1.10
DSH-R212	16	60	760	41	N	130	21	18.60	18.6	.05	1.20
DSH-R221	19	110	180	58	N	210	25	3.09	2.9	.15	.04
DSH-R221	20	110	200	60	N	230	25	2.44	2.3	.18	<.02
DSH-R222	17	200	260	42	N	160	25	7.16	7.1	.08	.08
DSH-R222	17	200	200	38	N	150	24	6.50	6.4	.06	.08
DSH-S111	13	170	220	21	N	190	24	12.80	12.7	.10	.75
DSH-S111	17	200	240	25	N	180	26	12.50	12.4	.07	.40
DSH-S112	15	130	340	25	N	170	24	11.00	10.9	.10	.35
DSH-S112	16	130	370	27	N	190	24	11.00	10.9	.12	.40
DSH-S121	15	130	660	60	N	180	18	15.90	15.9	.02	.40
DSH-S121	15	120	530	56	N	150	22	16.10	16.1	.02	.75
DSH-S122	14	90	180	37	N	160	17	13.70	13.6	.10	.80
DSH-S122	13	90	180	39	N	130	20	13.50	13.3	.18	.40
DSH-S211	17	110	590	43	N	160	24	15.70	15.6	.06	1.00
DSH-S211	16	100	570	37	N	140	22	14.20	14.1	.12	.65
DSH-S212	15	120	190	41	N	150	24	14.10	14.0	.15	.04
DSH-S212	14	140	190	40	N	140	26	13.80	13.8	.03	.75
DSH-S221	15	130	280	35	N	170	20	10.50	10.4	.10	.45
DSH-S221	18	140	300	42	N	160	25	10.60	10.4	.25	.30
DSH-S222	14	130	200	22	N	150	22	11.70	11.7	.02	.45
DSH-S222	13	130	190	26	N	160	24	11.50	11.5	.03	.40
DSH-P111	14	100	230	22	N	160	23	5.29	5.2	.05	.04
DSH-P111	12	90	190	N	N	130	22	5.30	5.2	.09	.08
DSH-P112	17	140	200	28	N	130	30	5.39	5.3	.06	.03
DSH-P112	17	130	220	26	N	130	25	5.55	5.5	.05	.04
DSH-P211	20	210	210	29	N	210	29	.74	.7	.06	.24
DSH-P211	20	200	220	30	N	270	23	.33	.2	.11	<.02
DSH-P212	15	90	120	24	N	100	18	6.46	6.4	.08	.04
DSH-P212	15	110	130	24	N	100	20	6.38	6.3	.07	.04

Table 1A.--Cont.

Sample	Ag ppm
DSH-L221	--
DSH-L222	<.2
DSH-L222	.3
DSH-R111	.3
DSH-R111	.4
DSH-R112	.8
DSH-R112	.5
DSH-R121	.2
DSH-R121	<.2
DSH-R122	<.2
DSH-R122	.3
DSH-R211	.2
DSH-R211	<.2
DSH-R212	.3
DSH-R212	.5
DSH-R221	.3
DSH-R221	.2
DSH-R222	<.2
DSH-R222	.3
DSH-S111	.2
DSH-S111	.3
DSH-S112	.3
DSH-S112	<.2
DSH-S121	<.2
DSH-S121	<.2
DSH-S122	<.2
DSH-S122	.3
DSH-S211	.2
DSH-S211	<.2
DSH-S212	.2
DSH-S212	.3
DSH-S221	.2
DSH-S221	<.2
DSH-S222	<.2
DSH-S222	<.2
DSH-P111	<.2
DSH-P111	<.2
DSH-P112	<.2
DSH-P112	.2
DSH-P211	.4
DSH-P211	<.2
DSH-P212	.4
DSH-P212	.4

Table 18.--Chemical analyses of shale of Lower Mississippian age in Kentucky. [%, percent; ppm, parts per million; N, not detected; leaders (--) indicate no data; labels ending in "-S" are spectrographic determinations]

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
LMSHE111	38 30 00	83 00 00	121,187	73.3	11.9	3.70	1.50	1.20	.10	.70	2.7	2.8	1.00	.92
LMSHE111	38 30 00	83 00 00	121,524	73.6	11.8	3.60	1.60	1.10	.30	.60	2.9	2.5	.87	.95
LMSHE112	38 30 00	83 00 00	121,459	81.8	7.3	2.30	.96	.70	.70	1.20	1.5	2.1	.34	.69
LMSHE112	38 30 00	83 00 00	121,371	82.9	7.5	2.60	.86	.50	.10	.70	1.6	1.8	.39	.72
LMSHE121	38 30 00	83 00 00	121,280	69.7	11.6	8.70	.48	.80	.50	.80	2.2	2.7	1.30	.95
LMSHE121	38 30 00	83 00 00	121,165	69.1	11.4	8.70	.52	.80	.40	.60	2.0	3.7	1.40	.94
LMSHE122	38 30 00	83 00 00	121,388	80.0	8.1	3.30	.76	.50	.10	.40	1.6	3.5	.57	.82
LMSHE122	38 30 00	83 00 00	121,313	80.7	7.7	3.30	.64	.60	.10	.50	2.0	2.4	.46	.81
LMSHE211	38 23 00	83 15 00	124,180	82.2	9.2	2.10	.60	.52	.65	.57	1.2	1.6	.36	.82
LMSHE212	38 23 00	83 15 00	124,181	64.8	17.2	4.30	1.40	1.50	.54	.24	2.6	4.7	1.20	1.10
LMSHE221	38 23 00	83 07 30	124,182	75.3	7.1	3.40	.44	.55	4.00	.12	1.9	2.4	.55	.64
LMSHE222	38 23 00	83 07 30	124,183	75.9	10.8	3.00	1.10	.83	.59	.60	1.7	2.9	.77	.87
LMSHK111	37 07 30	85 07 30	121,483	64.2	4.7	1.00	.72	4.90	7.80	.50	.9	1.0	.43	.26
LMSHK111	37 07 30	85 07 30	121,454	64.5	5.0	.86	.76	5.00	8.70	.70	1.1	1.1	.22	.27
LMSHK112	37 07 30	85 07 30	121,503	72.6	5.5	1.10	.60	3.50	5.60	1.00	1.2	1.0	.36	.30
LMSHK112	37 07 30	85 07 30	121,344	70.6	5.4	1.20	.56	3.80	7.10	1.00	1.1	1.0	.46	.31
LMSHK121	37 07 30	85 07 30	121,470	63.9	10.8	3.00	.96	3.40	4.80	.40	2.7	3.0	1.30	.48
LMSHK121	37 07 30	85 07 30	121,506	64.2	10.8	2.90	1.00	3.40	4.90	.50	2.5	2.7	1.50	.50
LMSHK122	37 07 30	85 07 30	121,515	71.4	13.0	4.00	.56	1.50	.31	.31	3.0	2.4	2.00	.59
LMSHK122	37 07 30	85 07 30	121,244	71.3	12.8	3.90	.56	1.60	.60	.70	2.5	3.3	1.80	.61
LMSHK211	37 07 30	85 00 00	121,315	77.7	9.8	2.50	.96	.90	.10	1.10	2.4	2.1	.67	.74
LMSHK211	37 07 30	85 00 00	121,297	78.3	9.6	2.50	.96	.80	.30	1.00	2.5	2.5	.73	.74
LMSHK212	37 07 30	85 00 00	121,481	62.4	17.4	3.60	2.60	2.00	.50	1.00	3.8	3.7	1.80	.87
LMSHK212	37 07 30	85 00 00	121,373	61.9	17.2	4.20	2.20	1.90	.20	.80	4.1	4.4	1.60	.92
LMSHK221	37 07 30	85 00 00	121,279	69.9	14.6	2.60	1.90	1.60	.50	1.20	2.4	2.9	1.10	.95
LMSHK221	37 07 30	85 00 00	121,452	69.8	14.2	2.40	2.00	1.60	.30	1.40	2.7	3.0	1.40	.96
LMSHK222	37 07 30	85 00 00	121,246	66.1	4.0	1.00	.64	4.90	9.10	.60	.5	1.5	.49	.20
LMSHK222	37 07 30	85 00 00	121,431	67.3	3.8	1.10	.64	4.50	8.10	.30	.6	1.6	.61	.17
LMSHL111	37 00 00	84 52 30	121,445	65.1	16.4	3.20	2.20	2.10	.50	1.00	3.7	3.1	1.70	.91
LMSHL111	37 00 00	84 52 30	121,202	64.6	16.2	3.60	2.20	2.20	.30	.80	3.9	3.7	1.60	.86
LMSHL112	37 00 00	84 52 30	121,306	71.2	12.6	2.70	1.80	1.60	.40	1.20	3.4	3.1	1.10	.88
LMSHL112	37 00 00	84 52 30	121,177	71.7	13.0	2.70	1.90	1.70	.10	.10	2.7	3.3	1.30	.89
LMSHL121	37 00 00	84 52 30	121,161	73.3	9.1	1.10	1.80	2.40	2.90	.40	1.8	2.2	.69	.59
LMSHL121	37 00 00	84 52 30	121,406	73.5	8.8	1.70	1.40	2.40	2.40	.55	2.1	1.7	.69	.64
LMSHL122	37 00 00	84 52 30	121,475	69.1	14.5	2.90	2.00	1.80	<.01	.80	3.4	3.4	1.10	.85
LMSHL122	37 00 00	84 52 30	121,440	68.1	14.3	2.90	2.00	1.90	.40	1.30	3.1	2.8	1.50	.83
LMSHL211	37 30 00	84 15 00	121,183	79.8	9.5	2.00	1.20	1.00	.10	.10	1.8	2.4	.78	.78
LMSHL211	37 30 00	84 15 00	121,205	79.3	9.5	2.10	1.20	.90	.20	.90	2.1	2.3	.67	.76
LMSHL212	37 30 00	84 15 00	121,539	77.7	10.3	1.50	1.50	1.10	.40	.90	2.0	1.9	.93	.75
LMSHL212	37 30 00	84 15 00	121,123	77.8	10.4	1.50	1.70	1.20	.50	.80	1.8	2.1	1.10	.78
LMSHL221	37 30 00	84 15 00	121,275	68.1	15.3	3.50	1.40	1.50	.30	.90	3.1	3.4	1.20	1.00
LMSHL221	37 30 00	84 15 00	121,305	67.8	15.5	3.60	1.40	1.40	.40	.70	3.2	3.2	1.30	1.00
LMSHL222	37 30 00	84 15 00	121,150	65.9	16.9	2.90	1.80	1.80	<.01	.60	3.3	2.5	1.90	.91
LMSHL222	37 30 00	84 15 00	121,140	65.6	16.9	3.00	1.70	1.70	.40	.60	3.1	3.5	2.00	.91
LMSHR111	36 37 30	86 15 00	121,419	72.3	11.9	3.00	.96	1.60	.30	.40	3.4	3.3	1.70	.65

Table 1B.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	La ppm-S
LMSHE111	.07	.05	<.05	6.60	.760	130	90	480	9	75	25	N
LMSHE111	.03	<.01	<.05	5.50	.580	140	95	480	11	87	24	N
LMSHE112	.02	.07	.05	4.50	.490	110	68	290	9	38	7	N
LMSHE112	.17	.05	<.05	5.20	.470	130	73	300	8	51	8	N
LMSHE121	.08	.06	.11	8.60	.550	180	74	380	10	72	21	N
LMSHE121	.07	<.01	<.05	8.50	.520	160	70	370	10	81	19	N
LMSHE122	.11	.02	<.05	6.80	.670	86	96	360	16	50	8	N
LMSHE122	.03	.02	<.05	3.40	.450	77	76	330	17	52	10	N
LMSHE211	.04	.05	<.05	3.10	.640	180	94	370	8	58	19	N
LMSHE212	.10	.05	<.05	7.20	.750	160	130	550	16	96	28	N
LMSHE221	.07	.09	2.90	4.70	.420	440	74	350	10	48	3	N
LMSHE222	.07	.05	<.05	6.10	.590	280	88	480	11	60	13	N
LMSHK111	.04	.03	13.60	1.40	.100	140	N	130	N	43	6	N
LMSHK111	.05	.03	11.70	1.00	.090	130	N	130	N	29	N	N
LMSHK112	.06	.05	7.10	1.60	.130	150	N	170	N	27	4	N
LMSHK112	.07	.03	7.10	1.30	.120	120	N	160	N	35	N	N
LMSHK121	.06	.08	5.00	5.90	.240	230	83	330	10	72	24	N
LMSHK121	.05	.08	4.80	4.60	.220	250	74	330	8	77	21	N
LMSHK122	.04	.08	.05	3.70	.270	310	110	300	11	78	28	N
LMSHK122	.06	.08	.08	6.50	.390	370	130	380	18	85	30	N
LMSHK211	.06	.05	<.05	4.20	.580	140	100	300	12	60	12	N
LMSHK211	.04	.03	<.05	3.60	.520	140	100	300	9	56	12	N
LMSHK212	.04	.08	.05	7.00	.510	240	110	800	12	82	22	N
LMSHK212	.19	.05	<.05	7.40	.560	250	120	1,000	13	86	24	N
LMSHK221	.14	.06	<.05	5.70	.700	230	100	480	15	81	24	N
LMSHK221	.13	.07	<.05	6.30	.720	200	85	430	10	74	20	N
LMSHK222	.40	.09	.05	.88	.077	180	33	90	8	26	4	N
LMSHK222	.56	.04	10.20	.98	.076	200	N	80	8	26	7	N
LMSHL111	.05	.07	<.05	5.80	.440	260	110	820	16	77	20	N
LMSHL111	.07	.05	<.05	4.80	.440	250	110	750	16	85	18	N
LMSHL112	.06	<.01	<.05	5.90	.620	190	100	360	11	75	16	N
LMSHL112	.07	.05	<.05	5.00	.540	180	90	360	N	71	13	N
LMSHL121	.03	.07	2.80	3.30	.320	180	84	240	8	60	11	N
LMSHL121	.04	.03	3.10	3.30	.320	180	83	240	N	60	9	N
LMSHL122	.03	.05	<.05	6.20	.550	240	100	400	12	82	43	N
LMSHL122	.02	.07	<.05	5.30	.510	220	96	390	13	79	16	N
LMSHL211	.05	.05	<.05	3.50	.500	120	92	350	N	54	4	N
LMSHL211	.08	.05	<.05	3.40	.560	110	91	300	N	53	N	N
LMSHL212	.03	<.01	.18	6.00	.640	140	110	350	N	57	9	N
LMSHL212	.13	.05	<.05	4.30	.570	130	110	330	8	53	8	N
LMSHL221	.03	.08	.05	6.50	.750	270	120	470	15	90	20	N
LMSHL221	.05	.05	<.05	4.80	.700	370	110	480	17	93	18	N
LMSHL222	.03	.05	<.05	6.60	.650	200	130	440	13	86	18	N
LMSHL222	.03	.05	<.05	5.40	.520	190	120	420	12	87	22	N
LMSHR111	.11	.04	<.05	4.10	.350	190	100	300	17	100	22	N

Table 18.--Cont.

Sample	Mo ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S
LMSHE111	N	30	N	16	80	140	36	N	490	16
LMSHE111	N	33	20	16	110	140	40	N	450	20
LMSHE112	N	20	N	11	30	85	29	N	540	N
LMSHE112	N	20	N	11	50	90	26	N	590	N
LMSHE121	N	30	20	17	90	140	35	N	330	17
LMSHE121	N	28	25	16	90	120	33	N	380	18
LMSHE122	N	45	26	13	N	110	35	N	770	N
LMSHE122	N	42	25	13	40	100	30	N	510	N
LMSHE211	N	26	N	11	50	90	46	N	500	N
LMSHE212	N	59	N	22	130	390	38	N	240	23
LMSHE221	N	36	N	14	100	120	45	N	480	N
LMSHE222	N	30	N	13	120	150	30	N	430	11
LMSHK111	N	18	N	10	80	44	20	N	100	N
LMSHK111	N	17	N	10	70	41	N	N	54	N
LMSHK112	N	18	N	N	80	46	23	N	82	N
LMSHK112	N	19	N	11	70	40	20	N	75	N
LMSHK121	N	78	N	14	90	130	51	N	98	14
LMSHK121	N	74	20	14	110	150	50	N	97	17
LMSHK122	N	52	22	15	70	150	24	N	130	20
LMSHK122	N	60	30	20	70	170	27	600	130	26
LMSHK211	N	31	N	16	90	100	34	N	270	14
LMSHK211	N	30	N	16	80	100	37	N	260	15
LMSHK212	N	69	N	18	160	190	28	N	150	26
LMSHK212	N	71	24	20	180	190	30	N	160	30
LMSHK221	N	36	30	19	130	150	36	N	210	26
LMSHK221	N	30	N	17	120	140	34	N	240	21
LMSHK222	N	36	N	11	80	47	27	N	48	N
LMSHK222	N	30	N	N	60	48	25	N	59	N
LMSHL111	N	60	20	18	120	150	26	N	150	30
LMSHL111	N	60	N	19	130	140	28	N	140	30
LMSHL112	N	43	N	17	80	140	35	N	190	20
LMSHL112	N	40	N	16	80	130	30	N	170	20
LMSHL121	N	39	20	13	90	91	30	N	140	15
LMSHL121	N	36	26	15	80	93	30	N	150	17
LMSHL122	N	60	21	16	90	150	30	N	180	29
LMSHL122	N	49	20	17	90	150	30	N	180	26
LMSHL211	N	18	N	13	70	81	30	N	280	14
LMSHL211	N	18	N	14	70	76	23	N	310	13
LMSHL212	N	30	N	15	80	97	23	N	280	12
LMSHL212	N	30	N	13	90	87	29	N	300	13
LMSHL221	N	50	N	20	110	160	38	N	230	23
LMSHL221	N	51	27	20	130	160	39	N	220	27
LMSHL222	N	39	27	19	110	160	29	N	190	30
LMSHL222	N	39	N	18	100	160	30	N	170	27
LMSHR111	N	81	32	15	80	180	36	650	150	20

Table 1B.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
LMSHR111	36 37 30	86 15 00	121,268	73.2	11.7	2.90	.96	1.60	.50	.40	3.0	3.4	1.50	.66
LMSHR112	36 37 30	86 15 00	121,133	43.3	5.2	1.50	.68	6.80	18.10	.10	1.1	1.3	1.00	.22
LMSHR112	36 37 30	86 15 00	121,155	43.9	5.1	1.50	.56	6.40	18.00	.10	1.3	1.5	.80	.22
LMSHR121	36 37 30	86 15 00	121,510	66.9	15.4	4.80	.36	1.70	.50	.30	3.1	2.9	2.20	.70
LMSHR121	36 37 30	86 15 00	121,466	66.8	15.3	4.70	.36	1.60	.30	.40	3.6	3.9	2.10	.71
LMSHR122	36 37 30	86 15 00	121,514	58.8	9.3	2.10	.92	2.90	9.90	.13	3.0	2.3	1.30	.44
LMSHR122	36 37 30	86 15 00	121,238	58.3	9.5	2.10	.82	2.80	10.10	.40	2.4	2.4	1.30	.43
LMSHR211	36 37 30	86 00 00	121,354	66.8	14.5	4.40	.16	1.60	.60	.30	3.2	3.9	3.20	.70
LMSHR211	36 37 30	86 00 00	121,461	67.3	14.6	4.10	.44	1.70	.50	.25	3.5	3.2	3.00	.65
LMSHR212	36 37 30	86 00 00	121,368	69.5	14.2	2.90	.76	1.50	.30	.40	3.8	3.6	1.80	.91
LMSHR212	36 37 30	86 00 00	121,541	69.8	14.4	2.60	.88	1.50	.60	.40	3.4	2.2	2.10	.92
LMSHR221	36 37 30	86 00 00	121,400	62.9	13.4	1.60	.80	3.30	3.70	.70	3.4	1.8	1.80	.68
LMSHR221	36 37 30	86 00 00	121,458	62.8	13.4	1.50	.92	3.50	3.90	.30	3.4	3.0	1.60	.65
LMSHR222	36 37 30	86 00 00	121,528	70.6	14.7	1.30	1.10	1.80	.70	.50	3.6	2.6	1.80	.66
LMSHR222	36 37 30	86 00 00	121,271	70.9	15.4	1.40	1.10	1.70	.50	.30	3.6	3.0	1.70	.70
LMSHS111	36 45 00	85 07 30	121,421	65.1	16.2	4.00	1.60	1.80	.60	.90	4.2	2.9	1.90	.78
LMSHS111	36 45 00	85 07 30	121,527	64.9	16.2	3.70	1.80	1.70	.50	.60	4.0	3.7	1.90	.77
LMSHS112	36 45 00	85 07 30	121,468	56.0	8.0	1.80	1.00	1.40	14.10	.83	1.9	2.3	.63	.43
LMSHS112	36 45 00	85 07 30	121,378	56.8	8.4	2.20	.56	1.30	14.00	.50	1.7	2.1	.54	.45
LMSHS121	36 45 00	85 07 30	121,517	57.3	6.1	2.00	.56	4.80	12.00	.61	1.5	1.6	.68	.42
LMSHS121	36 45 00	85 07 30	121,358	57.4	6.0	1.80	.64	4.50	13.10	.60	1.1	1.4	.56	.59
LMSHS122	36 45 00	85 07 30	121,288	52.4	5.9	1.40	.66	6.90	12.00	.70	1.4	1.2	.69	.32
LMSHS122	36 45 00	85 07 30	121,154	53.1	5.4	1.10	.80	6.80	11.60	.40	1.1	1.6	.63	.32
LMSHS211	36 52 30	85 15 00	121,538	48.6	7.5	1.70	1.50	3.80	16.20	.36	1.8	1.7	.73	.41
LMSHS211	36 52 30	85 15 00	121,252	49.2	7.7	2.10	1.20	3.70	14.80	.50	1.6	2.0	.52	.43
LMSHS212	36 52 30	85 15 00	121,230	62.0	12.2	1.60	1.60	1.40	6.40	.70	2.8	2.8	.87	.55
LMSHS212	36 52 30	85 15 00	121,135	62.1	11.7	1.00	2.20	1.50	6.50	.40	2.5	2.8	1.00	.51
LMSHS221	36 52 30	85 15 00	121,340	45.5	6.2	2.80	.86	2.20	19.80	.60	1.1	1.9	.63	.40
LMSHS221	36 52 30	85 15 00	121,425	46.0	6.0	2.50	.86	2.20	19.90	.60	1.2	1.8	.55	.41
LMSHS222	36 52 30	85 15 00	121,357	62.0	8.7	2.30	1.30	2.80	8.50	.60	1.9	2.0	.74	.55
LMSHS222	36 52 30	85 15 00	121,450	63.4	8.5	1.90	1.60	3.00	7.70	.70	1.7	2.2	.72	.44

Table 13.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	La ppm-S
LMSHR111	.12	.06	<.05	3.80	.380	180	130	350	20	97	25	N
LMSHR112	.03	.22	19.50	.99	.086	1,600	N	100	14	33	11	N
LMSHR112	.03	.22	19.70	.87	.080	1,500	N	80	13	30	7	N
LMSHR121	.06	.08	.15	7.00	.360	100	110	330	N	110	23	N
LMSHR121	.09	.04	<.05	8.50	.410	130	130	370	10	130	24	N
LMSHR122	.21	.09	8.40	3.10	.180	620	66	230	13	54	8	N
LMSHR122	.27	.11	8.90	2.00	.160	500	63	220	11	48	8	N
LMSHR211	.03	.14	.05	4.60	.300	800	87	380	14	60	12	75
LMSHR211	<.01	.14	.08	7.30	.410	700	100	470	14	79	11	90
LMSHR212	.05	<.01	<.05	6.10	.700	180	140	360	25	70	31	71
LMSHR212	.04	.02	<.05	7.60	.810	190	150	420	30	76	35	83
LMSHR221	.15	.11	4.50	2.60	.300	300	100	300	22	64	48	N
LMSHR221	.05	.10	4.60	3.50	.380	300	100	340	25	70	55	N
LMSHR222	.03	.10	<.05	3.30	.350	130	120	340	8	60	30	N
LMSHR222	<.01	.06	<.05	2.70	.360	140	130	370	11	71	30	N
LMSHS111	.02	<.01	.08	6.90	.350	130	92	340	N	90	20	N
LMSHS111	.03	.02	.06	5.70	.380	130	100	370	N	100	24	N
LMSHS112	.07	.05	10.90	2.10	.150	120	N	200	8	61	13	N
LMSHS112	.14	.02	<.05	1.20	.110	97	N	170	8	50	14	N
LMSHS121	.08	.02	11.70	1.80	.130	120	N	130	N	48	9	N
LMSHS121	.07	.03	12.20	1.30	.110	100	N	140	9	43	11	N
LMSHS122	.09	.03	15.30	.79	.092	110	N	150	10	47	9	N
LMSHS122	.06	.05	15.60	.75	.093	100	N	140	N	42	7	N
LMSHS211	.09	<.01	14.80	4.50	.200	200	33	250	9	67	14	N
LMSHS211	.10	.09	15.10	2.00	.150	150	N	190	N	48	14	N
LMSHS212	.14	.08	5.10	2.30	.180	150	100	320	N	92	25	N
LMSHS212	.14	.05	5.00	2.30	.180	140	97	300	8	91	26	N
LMSHS221	.08	.05	17.00	1.10	.100	180	N	140	9	39	9	N
LMSHS221	.05	.07	17.10	3.50	.160	350	N	180	10	56	9	N
LMSHS222	.09	.03	8.50	2.70	.150	140	45	370	10	60	19	N
LMSHS222	.07	.07	7.40	3.50	.170	140	51	390	8	64	16	N

Table 1B.--Cont.

Sample	Mo ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S
LMSHR111	N	90	36	19	90	170	39	590	140	24
LMSHR112	N	48	N	13	120	46	28	N	52	11
LMSHR112	N	44	N	12	110	40	30	N	51	N
LMSHR121	N	53	20	19	N	200	41	N	120	22
LMSHR121	N	55	25	20	50	220	53	530	140	27
LMSHR122	N	71	N	16	120	110	22	N	84	15
LMSHR122	N	67	N	15	110	91	22	N	72	19
LMSHR211	N	100	21	19	80	110	69	N	110	24
LMSHR211	N	140	N	20	70	150	81	N	120	23
LMSHR212	N	220	30	19	80	170	57	N	200	20
LMSHR212	N	270	42	22	90	200	59	N	230	22
LMSHR221	N	120	N	17	80	140	26	N	110	20
LMSHR221	N	140	N	17	90	160	26	N	120	17
LMSHR222	N	71	N	17	N	150	N	N	120	20
LMSHR222	N	80	N	18	80	170	24	N	120	21
LMSHS111	N	69	23	17	100	190	N	N	110	23
LMSHS111	N	76	24	19	120	210	22	N	120	28
LMSHS112	N	30	N	12	200	90	N	N	89	15
LMSHS112	N	27	N	11	140	70	20	N	60	12
LMSHS121	N	24	21	11	120	77	N	N	88	N
LMSHS121	N	21	20	12	100	60	22	N	70	11
LMSHS122	N	21	N	14	120	60	30	N	60	12
LMSHS122	N	19	N	12	100	55	28	N	65	10
LMSHS211	N	41	23	16	260	110	29	N	100	11
LMSHS211	N	33	N	14	170	75	26	N	74	13
LMSHS212	N	45	N	16	160	120	29	N	81	23
LMSHS212	N	45	N	15	150	120	27	N	86	23
LMSHS221	N	18	N	14	180	52	27	N	84	10
LMSHS221	N	24	N	15	260	84	30	N	96	12
LMSHS222	N	34	22	13	130	83	25	N	83	15
LMSHS222	N	38	N	12	130	96	22	N	83	13

Table 1C.--Chemical analyses of shale of Upper Mississippian age in Kentucky. [%, percent; ppm, parts per million; N, not detected; leaders (--) indicate no data; labels ending in "-S" are spectrographic determinations]

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
UMSHE111	38 37 30	82 52 30	121,260	60.2	12.3	3.9	.48	3.20	4.60	.20	2.7	3.8	3.50	.61
UMSHE111	38 37 30	82 52 30	121,391	60.7	12.9	4.0	.48	3.30	4.30	.41	2.9	1.2	4.00	.64
UMSHE112	38 37 30	82 52 30	121,496	60.5	24.0	1.8	.28	1.00	<.10	.10	2.6	6.0	2.40	1.20
UMSHE112	38 37 30	82 52 30	121,487	62.0	22.8	1.7	.36	.90	<.10	.20	2.5	5.7	2.50	1.20
UMSHE121	38 37 30	82 52 30	121,436	46.4	11.3	4.0	.60	7.10	8.80	.22	2.9	2.3	3.10	.65
UMSHE121	38 37 30	82 52 30	121,167	45.9	11.4	3.7	.84	6.40	9.30	.20	2.5	3.8	3.00	.64
UMSHE122	38 37 30	82 52 30	121,333	49.6	18.3	8.6	.96	3.60	1.10	.50	6.2	2.7	4.80	.88
UMSHE122	38 37 30	82 52 30	121,213	49.7	18.2	8.5	1.00	3.90	.70	.55	5.9	5.7	4.80	.74
UMSHE211	37 30 00	83 15 00	121,559	51.9	13.7	2.8	.72	1.50	9.60	<.10	3.3	2.8	4.20	.63
UMSHE211	37 30 00	83 15 00	121,169	51.2	13.5	3.0	.59	1.70	9.90	<.10	3.4	2.7	4.10	.64
UMSHE212	37 30 00	83 15 00	121,490	64.9	13.8	2.5	1.70	2.00	2.90	.10	3.6	3.0	3.00	.75
UMSHE212	37 30 00	83 15 00	121,182	65.0	13.7	2.7	1.60	1.90	2.10	.20	3.5	3.6	3.00	.81
UMSHE221	37 30 00	83 15 00	121,519	70.9	14.0	2.7	.76	1.40	.30	.10	2.5	3.0	2.40	.82
UMSHE221	37 30 00	83 15 00	121,269	70.4	13.8	2.8	.72	1.40	.90	.30	3.0	3.3	2.20	.90
UMSHE222	37 30 00	83 15 00	121,401	74.9	11.8	2.2	.68	1.10	.41	.10	2.6	3.3	1.60	.85
UMSHE222	37 30 00	83 15 00	121,143	75.8	11.5	1.5	1.10	1.20	.50	<.10	2.2	2.8	1.70	.80
UMSHH111	37 22 30	88 22 30	121,380	58.9	20.0	4.1	.64	1.30	1.50	.30	4.9	2.9	3.60	.95
UMSHH111	37 22 30	88 22 30	121,428	58.8	19.8	3.9	.72	1.60	.10	.10	4.9	5.0	3.20	.91
UMSHH112	37 22 30	88 22 30	121,482	75.4	10.7	3.3	.32	1.10	.10	.10	1.6	3.0	2.60	.90
UMSHH112	37 22 30	88 22 30	121,141	74.5	10.7	3.3	.36	1.20	.60	.10	1.7	3.3	2.70	.88
UMSHH121	37 22 30	88 22 30	121,151	43.4	11.1	2.2	.56	1.40	18.80	.10	2.0	2.8	2.60	.55
UMSHH121	37 22 30	88 22 30	121,553	42.8	11.1	2.4	.48	1.30	18.90	.10	2.5	2.8	2.60	.57
UMSHH122	37 22 30	88 22 30	121,485	39.4	10.2	3.2	.52	1.10	21.70	.10	1.8	2.5	2.20	.47
UMSHH122	37 22 30	88 22 30	121,348	39.3	10.2	3.2	.44	1.40	21.10	.40	2.3	2.0	2.20	.51
UMSHH211	37 22 30	88 15 00	121,128	57.7	18.7	3.6	1.60	1.80	1.20	.10	4.7	4.0	4.20	.71
UMSHH211	37 22 30	88 15 00	121,394	57.7	18.5	4.6	.60	1.60	.20	.20	5.3	4.1	3.90	.72
UMSHH212	37 22 30	88 15 00	121,138	57.6	18.3	5.9	.56	2.00	1.00	<.10	4.5	3.8	4.00	.69
UMSHH212	37 22 30	88 15 00	121,351	57.0	18.2	5.7	.64	1.80	1.50	.20	5.2	4.8	3.60	.72
UMSHH221	37 22 30	88 15 00	121,289	57.7	21.7	2.6	.64	1.60	.50	.20	6.1	4.4	3.50	.91
UMSHH221	37 22 30	88 15 00	121,221	58.2	20.8	2.5	.68	1.60	.40	.40	5.4	5.0	3.80	.86
UMSHH222	37 22 30	88 15 00	121,156	62.6	17.3	5.1	.88	1.10	.40	<.10	3.3	4.2	3.50	.73
UMSHH222	37 22 30	88 15 00	121,491	63.5	17.2	5.5	.24	1.00	.10	.10	3.8	3.6	3.30	.72
UMSHJ111	37 22 30	86 00 00	121,255	47.0	18.0	2.5	1.70	1.90	9.30	.30	2.9	5.5	4.00	.77
UMSHJ111	37 22 30	86 00 00	121,488	47.0	18.0	2.8	1.50	2.00	8.80	<.10	2.9	1.4	4.30	.75
UMSHJ112	37 22 30	86 00 00	121,170	65.3	16.0	3.4	1.20	1.50	.60	.20	2.7	4.8	3.10	.96
UMSHJ112	37 22 30	86 00 00	121,232	66.4	15.8	3.4	1.20	1.30	.80	.20	2.7	4.2	2.80	.92
UMSHJ121	37 22 30	86 00 00	121,174	63.9	17.9	2.5	2.20	1.50	.70	.10	2.5	4.8	2.80	.91
UMSHJ121	37 22 30	86 00 00	121,296	64.1	18.0	2.8	1.90	1.40	.70	.10	2.7	4.1	2.40	.94
UMSHJ122	37 22 30	86 00 00	121,139	66.7	16.0	2.7	1.80	1.70	.50	.10	2.2	4.6	3.10	.83
UMSHJ122	37 22 30	86 00 00	121,192	65.2	16.0	2.8	1.70	1.40	.40	.30	2.8	5.0	2.90	.86
UMSHJ211	37 15 00	86 00 00	121,290	54.0	23.0	4.7	.40	1.60	1.00	.20	3.0	5.1	5.40	.81
UMSHJ211	37 15 00	86 00 00	121,535	54.9	22.8	5.0	.12	1.70	.80	.10	2.6	4.1	6.10	.87
UMSHJ212	37 15 00	86 00 00	121,498	59.0	18.7	5.3	.24	2.20	.40	.14	3.1	2.9	6.10	.80
UMSHJ212	37 15 00	86 00 00	121,346	57.9	18.0	4.7	.44	2.20	.50	.20	3.2	5.9	6.00	.77
UMSHJ221	37 15 00	86 00 00	121,434	76.5	12.1	2.0	.60	.92	.27	.18	2.2	2.6	1.80	.67

Table 1C.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	La ppm-S
UMSHE111	.10	.09	3.90	3.50	.28	370	60	260	11	62	13	N
UMSHE111	.10	.08	4.30	3.20	.22	330	40	200	11	60	14	N
UMSHE112	.04	.05	.10	2.60	.87	56	76	700	N	160	11	N
UMSHE112	.02	.05	<.05	3.10	.94	48	69	720	N	160	11	N
UMSHE121	.16	.10	11.50	6.80	.33	780	34	270	14	74	60	N
UMSHE121	.14	.05	11.50	3.00	.23	530	30	220	10	60	60	N
UMSHE122	.25	.05	<.05	6.90	.37	300	170	300	14	100	20	N
UMSHE122	.24	.07	<.05	7.00	.41	250	140	300	13	100	18	N
UMSHE211	.14	.06	7.00	10.00	.46	240	100	1,500	30	130	25	N
UMSHE211	.12	.05	6.80	2.50	.22	150	62	600	20	90	25	N
UMSHE212	.09	.05	1.60	8.90	.49	140	100	300	16	91	15	N
UMSHE212	.16	.02	1.70	4.50	.43	130	79	300	15	93	12	N
UMSHE221	.09	.05	.05	5.80	.60	100	90	300	9	110	7	N
UMSHE221	.11	.03	.18	3.50	.48	97	92	300	N	100	6	N
UMSHE222	.14	.03	.15	3.70	.62	120	99	290	8	97	10	N
UMSHE222	.08	.05	<.05	3.50	.60	120	99	300	N	100	12	N
UMSHH111	.31	.05	<.05	10.00	.66	84	110	300	16	130	19	N
UMSHH111	.09	.07	<.05	8.70	.63	78	100	300	14	110	19	N
UMSHH112	.03	.05	.06	5.00	.72	41	72	200	11	88	15	N
UMSHH112	.04	.05	<.05	3.40	.65	41	71	200	11	99	17	74
UMSHH121	.07	.07	14.20	1.60	.18	280	N	120	13	83	8	N
UMSHH121	.08	.06	14.20	5.60	.34	500	35	180	17	110	9	N
UMSHH122	.07	.10	16.70	6.40	.26	630	N	150	12	100	8	N
UMSHH122	.08	.05	16.20	1.70	.13	380	N	110	9	61	5	N
UMSHH211	.06	.05	.59	6.00	.34	120	120	120	10	110	N	N
UMSHH211	.11	.05	.58	6.90	.35	92	100	140	11	120	N	N
UMSHH212	.03	.02	.58	6.30	.33	100	110	130	12	110	4	N
UMSHH212	.09	.03	.42	6.50	.32	99	89	140	11	110	N	N
UMSHH221	.08	.05	<.05	3.00	.43	45	130	230	N	160	16	78
UMSHH221	.09	.05	<.05	2.90	.44	39	140	180	N	130	11	N
UMSHH222	.09	.12	<.05	4.90	.32	690	110	200	20	94	21	N
UMSHH222	.08	.13	<.05	3.60	.29	670	97	170	16	100	18	N
UMSHJ111	.10	.09	5.40	3.70	.34	250	60	190	15	110	18	N
UMSHJ111	.07	.08	6.00	6.20	.39	310	56	180	15	130	15	N
UMSHJ112	.08	.05	<.05	5.40	.69	75	80	240	12	120	10	N
UMSHJ112	.10	.06	<.05	4.40	.48	68	88	220	10	100	8	N
UMSHJ121	.10	.07	<.05	4.70	.53	72	74	240	9	130	8	N
UMSHJ121	.11	.05	<.05	3.60	.36	69	60	240	10	140	8	N
UMSHJ122	.08	.05	<.05	3.80	.44	60	70	240	19	120	18	N
UMSHJ122	.11	.02	<.05	3.50	.41	60	72	200	20	110	14	N
UMSHJ211	.07	.05	.05	3.90	.41	51	60	200	11	130	25	N
UMSHJ211	.05	<.01	<.05	3.30	.28	45	37	170	N	100	23	N
UMSHJ212	.03	.05	<.05	7.30	.46	110	78	200	N	120	20	N
UMSHJ212	.04	.03	.05	5.60	.38	94	50	200	N	100	18	N
UMSHJ221	.05	.07	<.05	3.50	.51	65	74	210	9	100	13	N

Table 1C.--Cont.

Sample	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S
UMSHE111	30	N	14	100	97	N	N	110	20
UMSHE111	26	N	12	80	83	N	N	93	20
UMSHE112	35	27	21	90	180	35	N	250	32
UMSHE112	35	30	22	80	190	37	N	270	30
UMSHE121	30	N	15	210	110	30	N	120	16
UMSHE121	26	N	15	170	78	28	N	100	20
UMSHE122	43	N	18	250	110	N	N	120	30
UMSHE122	46	N	19	240	110	20	N	120	30
UMSHE211	85	21	16	280	180	20	N	140	20
UMSHE211	53	22	13	150	90	N	N	120	24
UMSHE212	47	N	14	120	100	21	N	220	20
UMSHE212	42	N	18	130	100	27	N	180	24
UMSHE221	40	N	16	100	100	30	N	330	19
UMSHE221	38	N	17	100	94	30	N	310	20
UMSHE222	30	N	14	80	92	36	N	630	15
UMSHE222	34	N	15	90	90	37	N	500	17
UMSHH111	60	N	20	150	150	35	N	160	30
UMSHH111	57	N	18	150	130	35	N	140	28
UMSHH112	36	24	15	90	67	41	770	340	13
UMSHH112	37	25	16	100	60	42	N	330	17
UMSHH121	30	N	15	410	74	26	N	100	20
UMSHH121	37	22	19	960	120	29	N	140	16
UMSHH122	30	N	17	770	100	27	N	120	16
UMSHH122	20	N	15	390	54	25	N	80	16
UMSHH211	52	N	16	150	88	N	N	100	25
UMSHH211	49	N	16	140	100	N	N	100	28
UMSHH212	51	N	18	170	96	N	N	98	30
UMSHH212	47	N	19	190	100	N	N	100	28
UMSHH221	35	N	20	230	160	34	N	130	36
UMSHH221	30	N	19	170	130	30	N	130	30
UMSHH222	38	N	18	150	93	36	N	140	25
UMSHH222	35	20	15	150	100	32	N	230	25
UMSHJ111	45	20	19	190	110	30	N	100	28
UMSHJ111	47	N	20	200	140	29	N	110	25
UMSHJ112	51	24	20	90	110	36	N	280	25
UMSHJ112	42	N	17	90	94	30	N	250	22
UMSHJ121	48	23	18	80	110	60	N	360	30
UMSHJ121	45	24	17	100	100	31	N	240	30
UMSHJ122	50	34	18	110	100	30	N	230	26
UMSHJ122	47	23	16	100	100	27	N	220	21
UMSHJ211	58	23	20	100	120	39	N	120	28
UMSHJ211	43	20	14	70	99	25	N	97	27
UMSHJ212	32	24	17	90	160	N	N	160	28
UMSHJ212	30	20	18	80	120	N	N	120	24
UMSHJ221	30	22	14	30	60	22	N	450	12

Table 1C.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
UMSHJ221	37 15 00	86 00 00	121,448	76.3	11.3	2.0	.64	1.10	.50	.60	1.8	3.2	1.80	.71
UMSHJ222	37 15 00	86 00 00	121,547	81.3	8.7	1.6	.64	.70	.30	.20	1.9	1.9	1.20	.75
UMSHJ222	37 15 00	86 00 00	121,211	81.3	8.5	1.4	.80	.90	.30	.40	2.1	2.3	1.10	.66
UMSHL111	37 15 00	84 22 30	121,534	60.7	17.7	4.8	1.00	2.20	.60	.20	4.0	2.6	4.30	.95
UMSHL111	37 15 00	84 22 30	121,423	60.3	17.5	4.8	1.00	2.40	.90	.60	4.3	3.4	4.00	.91
UMSHL112	37 15 00	84 22 30	121,233	60.0	17.6	5.2	1.00	2.30	.60	.40	4.1	3.7	4.00	.95
UMSHL112	37 15 00	84 22 30	121,355	58.6	17.4	5.0	.90	2.20	.60	.20	4.3	4.9	4.20	.92
UMSHL121	37 15 00	84 22 30	121,293	63.2	17.6	4.1	.44	1.50	.70	.40	3.2	4.6	3.20	.91
UMSHL121	37 15 00	84 22 30	121,210	63.2	17.2	4.4	.40	1.60	.24	.30	2.5	5.6	3.40	.89
UMSHL122	37 15 00	84 22 30	121,460	59.2	20.4	4.5	.64	1.70	.20	.20	3.1	4.9	3.90	.86
UMSHL122	37 15 00	84 22 30	121,285	57.2	20.2	4.7	.68	1.80	.20	.20	4.0	5.5	3.80	.88
UMSHL211	37 30 00	84 07 30	121,240	55.6	16.5	4.2	.64	2.30	3.50	.50	3.6	5.3	4.80	.80
UMSHL211	37 30 00	84 07 30	121,219	55.3	16.4	4.2	.76	2.10	4.00	.20	3.9	3.2	4.60	.74
UMSHL212	37 30 00	84 07 30	121,254	66.4	14.5	3.7	.64	1.90	1.10	.30	2.9	4.1	3.30	.77
UMSHL212	37 30 00	84 07 30	121,270	66.1	14.8	3.8	.64	1.90	.80	.20	3.0	4.2	3.20	.77
UMSHL221	37 30 00	84 07 30	121,247	70.6	14.4	2.5	.60	1.40	.70	.50	2.1	3.9	2.20	.90
UMSHL221	37 30 00	84 07 30	121,264	69.7	14.2	2.5	.60	1.50	.80	.40	2.2	4.3	2.30	.90
UMSHL222	37 30 00	84 07 30	121,474	64.2	17.2	3.9	.44	1.70	<.10	.10	3.7	3.0	3.90	.90
UMSHL222	37 30 00	84 07 30	121,152	63.0	17.0	3.8	.48	1.80	<.10	.10	3.3	4.2	4.50	.94
UMSHQ111	36 52 30	87 15 00	121,239	57.3	17.8	4.7	.44	2.30	1.00	.40	2.4	6.0	6.60	.70
UMSHQ111	36 52 30	87 15 00	121,545	58.1	18.1	4.8	.56	2.20	.80	.20	2.6	4.3	6.80	.72
UMSHQ112	36 52 30	87 15 00	121,494	58.4	16.3	5.4	.40	2.10	1.10	.10	2.4	4.6	7.90	.48
UMSHQ112	36 52 30	87 15 00	121,263	57.6	16.0	5.6	.40	1.90	1.40	.10	2.2	5.5	7.20	.50
UMSHQ121	36 52 30	87 15 00	121,137	57.7	20.5	4.3	.32	1.60	.30	<.10	2.2	5.9	5.50	.91
UMSHQ121	36 52 30	87 15 00	121,131	57.3	20.5	4.5	.36	1.60	.20	<.10	2.5	2.8	5.60	.94
UMSHQ122	36 52 30	87 15 00	121,336	67.7	14.6	5.7	.20	1.00	.60	.20	1.6	2.5	4.30	.87
UMSHQ122	36 52 30	87 52 30	121,302	66.9	14.2	5.9	.20	.90	.40	.30	2.0	5.1	2.90	.96
UMSHQ211	36 52 30	87 30 00	121,402	43.9	16.4	4.0	.64	1.30	12.40	.30	2.3	4.5	4.50	.72
UMSHQ211	36 52 30	87 30 00	121,497	43.5	16.6	4.0	.68	1.60	12.00	.24	2.5	4.7	4.40	.68
UMSHQ212	36 52 30	87 30 00	121,235	59.0	18.9	4.3	.52	1.90	.70	.40	2.4	6.0	4.60	.95
UMSHQ212	36 52 30	87 30 00	121,176	58.8	18.7	4.1	.60	1.80	.40	.30	2.9	6.1	5.00	.97
UMSHQ221	36 52 30	87 30 00	121,216	73.0	15.1	1.1	.44	.70	.20	.30	1.7	4.1	2.40	.78
UMSHQ221	36 52 30	87 30 00	121,500	73.2	15.0	1.4	.16	.80	.30	.10	1.4	3.2	2.70	.80
UMSHQ222	36 52 30	87 30 00	121,499	72.7	15.6	1.0	.32	1.00	<.10	.10	1.4	3.3	2.70	.82
UMSHQ222	36 52 30	87 30 00	121,209	71.7	15.6	1.1	.36	.70	.30	.30	1.7	4.6	2.60	.78
UMSHR111	36 52 30	86 37 30	121,477	65.4	17.0	4.2	.36	1.10	.10	.10	2.6	4.6	3.50	.90
UMSHR111	36 52 30	86 37 30	121,403	64.7	16.8	3.7	.28	1.10	.10	.30	2.5	5.3	3.70	.98
UMSHR112	36 52 30	86 37 30	121,502	66.2	14.4	2.7	.92	1.70	2.30	.10	2.3	3.7	3.30	.75
UMSHR112	36 52 30	86 37 30	121,356	65.8	14.4	2.5	.84	1.60	3.10	.20	2.5	3.0	3.20	.82
UMSHR121	36 52 30	86 37 30	121,525	64.8	16.9	4.7	.44	1.50	.50	.20	2.9	3.2	3.70	.87
UMSHR121	36 52 30	86 37 30	121,257	65.0	16.3	4.4	.40	1.50	.60	.30	2.9	4.4	3.30	.85
UMSHR122	36 52 30	86 37 30	121,505	58.4	19.7	4.5	.52	1.90	.32	N	3.4	5.4	4.60	.92
UMSHR122	36 52 30	86 37 30	121,300	56.9	19.7	4.6	.48	2.00	.90	.50	4.3	5.1	4.20	.99
UMSHR211	36 52 30	86 30 00	121,526	67.7	15.1	4.7	.20	1.50	.30	.10	2.4	4.1	3.20	.67
UMSHR211	36 52 30	86 30 00	121,424	67.8	15.3	4.2	.32	1.50	.20	.22	2.5	4.1	2.90	.65

Table 1C.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	La ppm-S
UMSHJ221	<.01	.04	<.05	3.50	.44	60	64	220	N	100	11	N
UMSHJ222	.02	.06	.05	2.80	.66	110	90	260	9	93	9	N
UMSHJ222	.08	.07	<.05	1.80	.45	100	61	240	8	120	6	N
UMSHL111	.08	<.01	<.05	6.20	.41	51	47	200	10	140	24	N
UMSHL111	.08	.07	<.05	8.30	.60	150	66	280	14	96	38	N
UMSHL112	.09	.09	<.05	6.10	.57	150	89	300	11	100	30	N
UMSHL112	.08	.05	.08	7.80	.51	150	60	280	10	90	30	N
UMSHL121	.11	.05	.05	4.40	.51	150	86	280	17	110	24	N
UMSHL121	.12	.05	<.05	3.40	.42	120	60	220	11	95	19	N
UMSHL122	.11	.07	.05	3.60	.36	92	56	260	9	98	30	N
UMSHL122	.11	.03	<.05	3.90	.37	98	68	270	14	100	33	N
UMSHL211	.12	.09	1.90	4.70	.38	150	82	240	20	100	52	N
UMSHL211	.12	.05	2.20	4.80	.43	150	88	210	21	100	54	N
UMSHL212	.10	.06	.18	5.30	.44	92	93	260	N	94	6	N
UMSHL212	.09	.06	.28	3.60	.31	100	81	280	N	100	6	N
UMSHL221	.08	.06	<.05	4.10	.58	100	96	300	N	100	N	N
UMSHL221	.08	.03	<.05	2.90	.59	100	81	300	10	120	N	N
UMSHL222	.08	.03	<.05	8.30	.69	180	100	300	28	120	26	74
UMSHL222	.08	.07	<.05	3.30	.45	110	74	240	17	83	25	N
UMSHQ111	.09	.06	.05	4.90	.29	90	73	200	20	100	20	N
UMSHQ111	.06	.06	.11	6.90	.36	82	60	200	20	100	18	N
UMSHQ112	.49	.05	<.05	7.70	.23	70	70	140	12	95	15	N
UMSHQ112	.58	.02	.05	4.10	.21	66	60	180	14	93	15	N
UMSHQ121	.07	.05	<.05	4.20	.42	60	78	180	17	120	37	72
UMSHQ121	.07	.05	<.05	4.00	.51	63	77	190	18	130	38	80
UMSHQ122	.05	.02	.05	4.10	.45	37	60	120	10	110	20	N
UMSHQ122	.05	.03	<.05	3.20	.42	34	48	120	N	100	19	N
UMSHQ211	.14	.05	8.30	2.80	.19	420	N	200	10	90	15	N
UMSHQ211	.06	.08	8.80	6.10	.34	640	34	300	N	110	15	N
UMSHQ212	.06	.09	<.05	4.70	.47	420	95	230	14	100	26	N
UMSHQ212	.08	.10	<.05	4.40	.49	510	83	240	14	100	21	N
UMSHQ221	.07	<.01	<.05	.86	.39	20	52	140	N	100	13	N
UMSHQ221	.03	.05	.08	1.20	.43	21	60	150	N	130	12	N
UMSHQ222	.02	.03	<.05	1.20	.50	20	60	170	N	110	13	75
UMSHQ222	.07	.05	<.05	.80	.36	19	60	150	N	100	12	N
UMSHR111	.07	.05	<.05	7.80	.77	47	91	280	15	120	20	81
UMSHR111	.17	.03	<.05	5.90	.63	53	85	270	15	120	20	75
UMSHR112	.04	.05	1.40	5.50	.47	110	83	210	23	110	12	N
UMSHR112	.06	.03	.95	3.20	.38	110	75	210	20	100	30	N
UMSHR121	.05	<.01	<.05	8.60	.59	90	80	300	26	120	19	87
UMSHR121	.05	.02	<.05	5.90	.60	93	93	300	30	140	19	90
UMSHR122	.05	.08	.05	7.00	.52	77	82	240	23	140	22	90
UMSHR122	.09	.03	<.05	4.40	.47	75	90	230	24	130	22	80
UMSHR211	.06	<.01	<.05	7.00	.35	56	60	230	11	110	15	N
UMSHR211	.03	.04	<.05	6.70	.40	60	70	240	12	100	14	N

Table 1C.--Cont.

Sample	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S
UMSHJ221	30	N	12	30	60	23	N	370	11
UMSHJ222	36	20	13	N	50	30	600	720	N
UMSHJ222	33	N	13	40	45	33	N	480	10
UMSHL111	58	24	20	100	140	33	N	120	25
UMSHL111	46	N	18	110	110	27	N	190	21
UMSHL112	43	N	20	130	100	24	N	160	30
UMSHL112	40	N	20	120	97	25	N	160	24
UMSHL121	73	24	20	120	110	36	N	190	27
UMSHL121	60	28	17	80	100	30	N	160	21
UMSHL122	40	25	17	110	120	24	N	120	30
UMSHL122	46	22	20	120	120	30	N	120	30
UMSHL211	49	N	18	170	97	24	N	130	29
UMSHL211	49	N	18	150	100	27	N	140	24
UMSHL212	46	N	17	90	110	24	N	210	21
UMSHL212	47	26	17	120	100	24	N	150	26
UMSHL221	42	20	17	100	86	26	N	290	24
UMSHL221	47	N	20	120	110	36	N	330	23
UMSHL222	60	36	20	120	150	51	N	250	29
UMSHL222	48	N	18	90	90	42	N	200	20
UMSHQ111	54	25	18	160	94	24	N	90	30
UMSHQ111	55	30	20	170	110	26	N	100	22
UMSHQ112	30	23	14	180	110	24	N	86	20
UMSHQ112	30	26	19	200	100	27	N	83	26
UMSHQ121	53	30	20	100	120	33	N	150	28
UMSHQ121	54	38	21	120	130	36	N	150	30
UMSHQ122	21	23	18	70	90	31	N	290	19
UMSHQ122	20	26	18	70	90	30	N	290	20
UMSHQ211	30	N	16	200	79	26	N	82	27
UMSHQ211	42	N	18	290	120	26	N	100	23
UMSHQ212	57	N	19	130	100	27	N	140	30
UMSHQ212	60	24	18	120	110	29	N	150	25
UMSHQ221	16	28	16	70	79	30	N	220	16
UMSHQ221	17	27	16	80	97	30	N	220	19
UMSHQ222	19	22	16	80	97	33	N	270	15
UMSHQ222	17	30	16	60	76	30	N	190	19
UMSHR111	50	68	20	120	120	40	510	280	22
UMSHR111	47	56	19	120	110	45	N	200	26
UMSHR112	46	30	15	130	100	26	N	240	20
UMSHR112	43	30	18	140	88	27	N	380	24
UMSHR121	69	31	17	120	120	48	N	260	23
UMSHR121	75	27	19	120	110	51	N	260	25
UMSHR122	70	37	19	120	150	43	N	170	30
UMSHR122	68	30	18	110	120	42	N	170	30
UMSHR211	47	N	15	30	94	21	N	150	14
UMSHR211	48	25	16	70	100	29	N	200	18

Table 1C.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
UMSHR212	36 52 30	86 30 00	121,199	58.2	15.7	3.9	.72	2.80	2.30	.20	4.3	5.0	4.80	.86
UMSHR212	36 52 30	86 30 00	121,533	59.2	16.9	3.7	.88	2.70	2.10	.25	3.8	3.1	5.10	.90
UMSHR221	36 52 30	86 30 00	121,520	54.3	20.4	4.0	.64	2.20	1.90	.70	2.9	5.8	5.80	.85
UMSHR221	36 52 30	86 30 00	121,393	54.6	20.0	4.1	.64	2.00	1.70	.30	3.2	6.1	6.00	.90
UMSHR222	36 52 30	86 30 00	121,433	56.3	20.0	4.0	.64	2.10	.60	.40	3.3	5.2	5.70	.91
UMSHR222	36 52 30	86 30 00	121,189	56.5	19.8	4.0	.60	1.90	.50	.30	3.5	6.2	5.40	.94
UMSHS111	36 45 00	85 00 00	121,469	81.6	7.8	1.7	.24	1.10	.60	.70	1.8	2.3	1.50	.55
UMSHS111	36 45 00	85 00 00	121,307	82.4	7.5	1.5	.24	1.10	.40	.40	1.9	2.5	1.40	.58
UMSHS112	36 45 00	85 00 00	121,126	80.2	9.0	1.4	.28	1.50	.60	.20	2.0	2.1	2.40	.59
UMSHS112	36 45 00	85 00 00	121,439	81.1	8.9	1.1	.44	1.20	.30	.20	1.9	2.1	2.20	.58
UMSHS121	36 45 00	85 00 00	121,267	60.0	18.0	5.4	.40	2.10	.40	.20	3.9	4.3	3.90	1.10
UMSHS121	36 45 00	85 00 00	121,509	59.8	18.2	5.7	.52	2.20	.30	.20	3.6	2.7	4.40	1.20
UMSHS122	36 45 00	85 00 00	121,435	59.2	17.0	5.0	.80	2.60	3.00	.10	3.7	3.0	4.30	1.00
UMSHS122	36 45 00	85 00 00	121,324	61.2	17.7	5.0	.84	2.40	.60	.30	3.7	3.8	3.50	1.10
UMSHT111	36 37 30	84 30 00	121,372	59.2	17.9	4.0	1.60	2.30	.60	.60	4.3	4.8	3.10	.95
UMSHT111	36 37 30	84 30 00	121,320	58.9	17.9	4.0	1.60	2.60	.80	.30	3.9	3.7	2.90	.94
UMSHT112	36 37 30	84 30 00	121,495	54.4	17.8	11.4	<.10	1.60	<.10	.10	2.5	4.8	4.70	.90
UMSHT112	36 37 30	84 30 00	121,184	53.9	17.1	11.1	--	1.60	<.10	.30	2.6	6.7	4.70	.92
UMSHT121	36 37 30	84 30 00	121,376	56.9	18.3	4.2	2.50	3.20	1.20	.60	4.1	4.7	2.70	.90
UMSHT121	36 37 30	84 30 00	121,347	56.9	18.4	4.0	2.60	3.20	.90	.60	3.2	5.0	2.90	.92
UMSHT122	36 37 30	84 30 00	121,277	61.2	13.9	3.4	.92	3.20	3.20	.60	2.4	3.9	2.70	.77
UMSHT122	36 37 30	84 30 00	121,480	61.0	14.0	3.5	.96	3.00	3.30	.60	2.7	3.9	3.00	.75
UMSHT211	36 52 30	84 15 00	121,294	63.9	16.5	3.6	1.80	1.70	.70	.80	3.2	4.1	1.80	.88
UMSHT211	36 52 30	84 15 00	121,398	64.0	16.9	3.5	1.80	1.50	.40	.60	2.6	3.7	1.90	.90
UMSHT212	36 52 30	84 15 00	121,332	75.0	11.6	3.0	1.00	1.10	.40	1.20	2.0	2.8	.82	.88
UMSHT212	36 52 30	84 15 00	121,367	74.6	11.6	3.3	.88	1.00	.10	.70	1.8	3.7	.95	.85
UMSHT221	36 52 30	84 15 00	121,261	36.5	10.1	1.6	1.60	5.50	17.20	.24	1.6	2.9	1.50	.50
UMSHT221	36 52 30	84 15 00	121,407	36.4	9.8	1.7	1.60	5.80	18.30	.26	1.8	2.0	1.60	.61
UMSHT222	36 52 30	84 15 00	121,537	49.2	11.5	1.5	2.40	5.80	9.00	.13	2.4	2.8	1.90	.63
UMSHT222	36 52 30	84 15 00	121,341	48.5	11.0	2.2	1.60	6.00	11.20	.40	2.0	2.3	1.70	.61

Table 1C.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S	La ppm-S
UMSHR212	.06	.05	1.00	3.90	.49	190	100	250	N	110	14	N
UMSHR212	.04	.06	1.00	8.20	.70	260	100	280	9	130	24	N
UMSHR221	.05	.05	.40	7.40	.54	90	74	200	14	130	19	N
UMSHR221	.16	.03	.24	4.90	.38	75	60	190	12	110	17	N
UMSHR222	.07	<.01	.05	6.80	.55	110	88	210	18	150	22	71
UMSHR222	.10	.05	<.05	3.90	.45	95	80	200	16	130	19	N
UMSHS111	<.01	.05	<.05	1.70	.30	41	44	220	15	48	6	N
UMSHS111	.02	.03	.05	1.30	.30	41	35	240	14	71	7	N
UMSHS112	.04	.05	<.05	1.30	.32	54	59	250	11	60	15	N
UMSHS112	.03	<.01	<.05	1.50	.34	48	60	240	10	60	14	N
UMSHS121	.06	.02	<.05	5.90	.66	100	90	290	9	99	25	N
UMSHS121	.05	.08	.05	7.80	.64	100	77	280	8	100	24	N
UMSHS122	.08	.07	<.05	4.00	.66	120	67	290	10	100	18	N
UMSHS122	.08	.03	.05	4.30	.55	110	73	260	8	94	16	N
UMSHT111	.28	.05	<.05	5.70	.44	180	94	340	14	100	18	N
UMSHT111	.17	.05	.05	4.00	.46	160	79	310	15	94	16	N
UMSHT112	.36	.51	.05	5.60	.33	3,600	44	260	42	58	44	N
UMSHT112	.35	.61	.08	7.50	.38	4,600	54	330	51	72	51	N
UMSHT121	.29	.05	.34	4.00	.35	250	77	290	15	88	45	N
UMSHT121	.17	.05	.24	4.40	.35	210	53	260	16	93	38	N
UMSHT122	.28	.05	2.80	4.70	.40	640	77	300	18	84	29	N
UMSHT122	.22	.12	3.00	6.80	.41	760	64	290	16	82	24	N
UMSHT211	.15	.05	.05	3.80	.44	200	68	390	20	98	30	N
UMSHT211	.15	.05	<.05	9.50	.51	230	67	400	21	91	30	N
UMSHT212	.13	.03	<.05	4.00	.53	110	72	260	13	60	10	N
UMSHT212	.21	.05	<.05	6.80	.68	120	74	280	10	65	4	N
UMSHT221	.11	.14	19.60	1.30	.15	580	N	140	9	64	12	N
UMSHT221	.12	.09	18.80	2.10	.17	200	N	120	N	67	14	N
UMSHT222	.12	.18	11.90	4.30	.32	1,000	N	240	15	83	9	N
UMSHT222	.11	.08	12.30	1.50	.17	610	N	160	13	60	8	N

Table 10.--Cont.

Sample	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S	Ga ppm-S
UMSHR212	33	N	18	120	100	N	N	170	28
UMSHR212	38	N	20	130	120	N	N	210	24
UMSHR221	55	23	20	150	160	24	N	130	30
UMSHR221	52	24	17	120	110	23	N	110	30
UMSHR222	55	27	19	120	150	32	N	160	31
UMSHR222	49	24	19	120	130	30	N	130	28
UMSHS111	28	N	N	N	34	30	N	340	N
UMSHS111	30	N	11	50	37	30	N	300	11
UMSHS112	30	N	11	60	51	29	N	270	13
UMSHS112	30	N	10	30	51	22	N	270	N
UMSHS121	43	20	21	120	100	30	N	240	29
UMSHS121	42	22	20	120	110	26	N	230	26
UMSHS122	48	26	20	120	100	34	N	270	30
UMSHS122	45	20	19	110	96	30	N	240	25
UMSHT111	38	30	18	200	120	20	N	180	35
UMSHT111	37	21	20	180	130	25	N	180	28
UMSHT112	60	97	17	80	82	25	N	130	27
UMSHT112	71	100	19	90	100	29	600	140	30
UMSHT121	42	29	17	170	110	25	N	140	35
UMSHT121	41	22	18	170	110	30	N	120	27
UMSHT122	52	130	17	180	88	38	N	200	24
UMSHT122	52	150	15	160	90	36	600	210	20
UMSHT211	48	60	19	140	120	36	N	160	30
UMSHT211	49	40	17	120	110	30	N	180	23
UMSHT212	36	N	15	90	66	31	N	300	13
UMSHT212	38	20	15	90	74	37	N	320	15
UMSHT221	20	44	17	240	68	34	N	90	18
UMSHT221	22	43	14	250	72	28	N	100	16
UMSHT222	34	28	17	270	90	30	N	120	17
UMSHT222	25	30	14	180	60	30	N	88	19

Table 1D.--Chemical analyses of shale of Pennsylvanian age in Kentucky. [%, percent; ppm, parts per million; N, not detected; leaders (--) indicate no data; labels ending in "-S" are spectrographic determinations]

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
PSH-E1	37 30 00	83 15 00	118,665	54.1	24.8	3.90	.50	1.80	.10	.32	4.4	6.40	2.00	.92
PSH-E1	37 30 00	83 15 00	118,671	54.0	25.2	3.80	.54	1.90	.18	.38	4.5	6.40	1.90	.91
PSH-E112	37 30 00	83 15 00	121,295	51.2	25.2	7.60	.44	1.00	.30	.30	4.5	5.00	2.40	.88
PSH-E112	37 30 00	83 15 00	121,172	50.1	25.0	7.30	.76	1.00	.20	.20	3.8	5.20	2.60	.91
PSH-E2	37 30 00	83 15 00	118,676	65.6	15.8	4.80	1.40	1.80	.30	1.50	2.8	4.00	.65	.93
PSH-E2	37 30 00	83 15 00	118,693	66.2	10.4	12.00	.20	1.20	N	N	2.4	4.50	1.40	.71
PSH-E122	37 30 00	83 15 00	121,476	52.4	24.5	2.10	4.50	2.00	.30	.20	4.3	6.20	1.40	.85
PSH-E122	37 30 00	83 15 00	121,467	52.2	24.4	1.90	4.70	2.00	.50	.40	4.2	5.80	1.40	.86
PSH-E211	38 07 30	83 15 00	121,256	75.4	13.0	1.70	.80	.70	.30	.20	1.9	3.70	.62	.80
PSH-E211	38 07 30	83 15 00	121,463	75.8	13.0	1.60	.84	.80	.11	.10	1.7	4.10	.61	.83
PSH-E212	38 07 30	83 15 00	121,231	48.3	31.4	1.10	1.00	.50	.40	.20	.9	10.00	2.80	2.20
PSH-E212	38 07 30	83 15 00	121,546	49.0	30.5	1.50	.84	.50	.20	.20	.9	10.00	3.00	2.20
PSH-E221	38 07 30	83 15 00	121,426	64.8	19.0	2.50	.56	1.00	.10	.30	3.3	5.10	1.20	1.10
PSH-E221	38 07 30	83 15 00	121,298	64.8	20.0	2.70	.56	.90	.40	.30	3.3	4.40	1.30	1.20
PSH-E222	38 07 30	83 15 00	121,412	57.7	21.4	4.70	.52	1.20	.20	.50	4.1	5.60	1.80	1.10
PSH-E222	38 07 30	83 15 00	121,194	57.5	21.4	4.60	.60	1.60	N	.30	4.5	5.60	1.80	.94
PSH-F1	38 15 00	82 45 00	118,663	61.3	18.7	4.20	1.70	2.10	.32	1.10	3.2	4.80	1.20	1.00
PSH-F1	38 15 00	82 45 00	118,669	61.1	18.7	4.30	1.80	2.00	.32	.96	3.2	4.80	1.30	1.00
PSH-F112	38 15 00	82 45 00	121,215	61.5	17.6	6.40	.68	1.40	.24	.40	3.1	5.70	1.40	1.10
PSH-F112	38 15 00	82 45 00	121,145	62.2	17.4	6.40	.64	1.20	.40	.10	2.2	4.60	1.60	1.10
PSH-F2	38 15 00	82 45 00	118,678	63.9	18.7	2.60	1.60	2.20	.34	.15	3.1	5.20	.84	.98
PSH-F2	38 15 00	82 45 00	118,675	63.4	18.7	2.80	1.60	2.20	.50	.26	3.1	5.30	.84	.98
PSH-F122	38 15 00	82 45 00	121,414	72.6	16.5	1.00	.16	.20	.10	.30	1.3	5.00	1.40	1.10
PSH-F122	38 15 00	82 45 00	121,361	73.9	15.8	1.00	.14	.30	.10	.20	1.1	4.70	1.40	1.10
PSH-F211	38 15 00	82 37 30	121,390	50.6	21.9	5.50	.82	1.60	5.60	.40	3.8	4.70	3.80	.95
PSH-F211	38 15 00	82 37 30	121,429	51.6	24.6	5.50	.92	1.70	1.10	.20	3.8	5.00	4.00	.88
PSH-F212	38 15 00	82 37 30	121,360	52.4	20.2	11.50	.32	1.00	1.10	.20	3.0	4.40	3.50	.98
PSH-F212	38 15 00	82 37 30	121,234	51.0	20.4	11.90	.38	1.10	.80	.40	2.7	6.40	3.30	1.00
PSH-F221	38 15 00	82 37 30	121,330	58.0	21.5	5.40	.84	.90	.10	.50	4.6	5.50	1.30	1.00
PSH-F221	38 15 00	82 37 30	121,159	57.9	21.8	5.90	.56	1.00	.10	.20	3.1	3.90	3.70	.99
PSH-F222	38 15 00	82 37 30	121,146	56.7	22.8	3.60	1.70	1.40	.20	.20	3.1	6.40	2.00	.94
PSH-F222	38 15 00	82 37 30	121,449	56.9	21.3	3.90	1.40	1.60	.10	.30	3.4	7.30	2.10	.91
PSH-H111	37 15 00	88 07 30	121,273	73.2	13.3	3.00	.40	.80	.40	.20	3.1	3.00	1.20	1.00
PSH-H111	37 15 00	88 07 30	121,554	72.0	13.9	3.20	.36	.60	.30	.10	3.8	2.90	1.40	1.00
PSH-H112	37 15 00	88 07 30	121,318	69.6	15.3	2.30	.48	.80	.40	.40	4.4	2.90	1.50	1.00
PSH-H112	37 15 00	88 07 30	121,405	71.0	15.5	2.50	.30	.91	.23	.16	3.8	2.70	1.70	1.10
PSH-H121	37 15 00	88 07 30	121,352	88.0	4.9	1.60	N	.20	.20	.10	.7	1.90	.81	.57
PSH-H121	37 15 00	88 07 30	121,245	89.3	4.5	1.60	.16	.30	.20	.20	.4	1.40	.66	.57
PSH-H122	37 15 00	88 07 30	121,416	79.8	15.1	1.30	.12	.20	<.01	<.01	.9	1.10	.77	.67
PSH-H122	37 15 00	88 07 30	121,370	86.5	6.1	1.50	N	.30	.50	.10	1.0	1.30	.89	.80
PSH-H211	37 22 30	88 22 30	121,420	52.8	20.1	10.90	.40	1.20	.10	.10	3.9	6.00	2.20	.94
PSH-H211	37 22 30	88 22 30	121,321	53.2	20.4	9.90	.44	1.20	.50	.50	4.5	5.70	2.00	.94
PSH-H212	37 22 30	88 22 30	121,195	57.6	19.8	6.10	.96	1.10	.20	.20	3.9	6.40	2.00	.92
PSH-H212	37 22 30	88 22 30	121,127	57.9	20.7	6.10	.56	1.20	<.01	.10	3.3	5.50	2.60	.96
PSH-H221	37 22 30	88 22 30	121,148	76.2	13.5	1.20	.28	.80	.40	.20	2.7	2.50	1.00	1.00

Table 10.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Mg%-S	Ca%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Co ppm-S	Cr ppm-S
PSH-E1	.13	<.01	<.05	5.00	1.0	.03	.30	150	150	700	N	20	150
PSH-E1	.13	.02	<.05	2.00	.7	.05	.30	100	70	700	N	15	150
PSH-E112	.25	.05	<.05	3.70	--	--	.30	59	42	380	N	N	110
PSH-E112	.18	.05	<.05	7.20	--	--	.38	60	55	420	N	N	110
PSH-E2	.21	.11	<.05	5.00	.7	.15	.50	700	70	700	N	20	70
PSH-E2	.20	<.01	<.05	5.00	.7	.15	.50	500	70	700	N	15	70
PSH-E122	.13	.08	.76	10.00	--	--	.39	740	60	450	N	21	110
PSH-E122	.16	.07	.72	10.00	--	--	.40	660	60	430	N	20	110
PSH-E211	.03	.06	<.05	3.00	--	--	.55	110	67	370	N	11	90
PSH-E211	.05	.04	<.05	3.50	--	--	.68	110	62	340	N	8	64
PSH-E212	.05	.06	<.05	1.20	--	--	1.00	41	60	170	N	9	150
PSH-E212	.04	.06	<.05	3.20	--	--	>1.00	51	66	180	N	11	230
PSH-E221	.03	.07	.05	4.80	--	--	.84	130	72	460	N	N	100
PSH-E221	.06	.05	<.05	3.10	--	--	.80	120	74	490	N	N	100
PSH-E222	.27	.08	<.05	9.30	--	--	.59	550	54	590	N	19	98
PSH-E222	.13	.05	<.05	5.10	--	--	.51	440	60	580	N	20	99
PSH-F1	.17	.03	<.05	5.00	.7	.15	.30	300	70	700	N	30	70
PSH-F1	.18	.04	<.05	3.00	1.0	.15	.30	300	100	700	N	20	70
PSH-F112	.18	.10	<.05	6.30	--	--	.58	340	36	450	N	14	60
PSH-F112	.16	.09	<.05	5.10	--	--	.65	340	48	530	N	15	86
PSH-F2	.13	.03	<.05	3.00	1.0	.20	.30	200	50	700	N	15	100
PSH-F2	.14	.03	<.05	3.00	1.0	.20	.30	300	70	700	N	15	100
PSH-F122	.18	.05	<.05	.71	--	--	.60	23	51	210	N	N	60
PSH-F122	.03	.03	<.05	.94	--	--	.58	30	61	280	N	9	70
PSH-F211	.17	.05	.20	8.10	--	--	.38	170	36	400	N	15	110
PSH-F211	.25	.04	.18	9.00	--	--	.41	160	N	450	N	15	110
PSH-F212	.34	.08	.05	8.60	--	--	.38	360	N	290	N	18	83
PSH-F212	.41	.11	<.05	6.90	--	--	.37	340	40	300	N	17	89
PSH-F221	.11	.03	.05	4.50	--	--	.51	82	41	520	N	N	91
PSH-F221	.08	.05	<.05	5.60	--	--	.51	87	46	550	N	N	84
PSH-F222	.05	.05	<.05	4.60	--	--	.41	150	38	440	N	10	98
PSH-F222	.03	.04	<.05	5.90	--	--	.49	150	51	430	N	9	100
PSH-H111	.15	.08	<.05	4.60	--	--	.88	370	120	360	N	71	120
PSH-H111	.14	.06	.08	7.00	--	--	.98	360	120	380	N	70	120
PSH-H112	.05	.03	<.05	2.70	--	--	.68	64	110	300	N	11	120
PSH-H112	.11	.03	<.05	3.50	--	--	.85	60	130	300	N	10	120
PSH-H121	.03	.03	<.05	1.50	--	--	.40	17	90	120	N	N	41
PSH-H121	.02	.06	<.05	1.30	--	--	.37	18	76	130	N	N	44
PSH-H122	.02	.04	<.05	1.00	--	--	.54	15	90	120	N	N	64
PSH-H122	.21	.02	<.05	.90	--	--	.43	12	77	100	N	N	64
PSH-H211	.20	.17	<.05	8.30	--	--	.45	820	88	310	N	14	120
PSH-H211	.19	.13	<.05	4.60	--	--	.38	1,000	70	300	N	15	110
PSH-H212	.16	.07	.08	5.90	--	--	.46	490	91	310	N	14	130
PSH-H212	.15	.09	<.05	6.40	--	--	.52	490	98	330	N	17	130
PSH-H221	.04	.05	.05	1.40	--	--	.79	86	140	340	N	9	99

Table 1D.--Cont.

Sample	Cu ppm-S	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S
PSH-E1	50	70	20	50	30	30	200	300	30	N	100
PSH-E1	50	70	15	50	30	20	150	300	50	N	70
PSH-E112	44	N	N	32	26	20	110	150	23	N	93
PSH-E112	47	N	N	35	N	20	100	140	N	N	100
PSH-E2	30	70	20	50	50	15	150	150	50	N	300
PSH-E2	50	50	20	50	15	15	150	150	50	N	200
PSH-E122	40	N	N	65	24	19	140	170	22	N	110
PSH-E122	60	N	N	60	26	18	130	160	21	N	110
PSH-E211	22	N	N	42	32	17	100	81	35	600	250
PSH-E211	20	N	N	39	22	15	60	89	32	780	270
PSH-E212	20	N	30	60	44	20	70	97	43	N	250
PSH-E212	21	N	43	83	53	23	80	150	50	N	380
PSH-E221	19	N	N	30	N	20	120	140	42	N	290
PSH-E221	20	70	N	30	27	20	120	120	42	N	260
PSH-E222	35	N	N	44	25	18	140	150	40	N	150
PSH-E222	38	70	N	43	30	20	150	150	42	N	150
PSH-F1	50	70	20	70	30	20	100	200	50	N	200
PSH-F1	50	70	20	70	20	20	100	200	50	N	200
PSH-F112	42	N	N	34	20	17	90	86	43	N	290
PSH-F112	49	90	N	40	34	22	120	110	70	N	340
PSH-F2	20	50	15	30	20	15	100	150	30	N	200
PSH-F2	50	50	20	50	30	15	100	150	30	N	150
PSH-F122	13	N	N	16	28	16	30	82	33	N	360
PSH-F122	15	N	N	20	28	17	70	90	36	N	290
PSH-F211	60	N	N	49	36	19	150	160	24	N	100
PSH-F211	60	N	N	49	30	20	160	180	25	N	110
PSH-F212	100	N	N	70	35	20	180	130	68	680	120
PSH-F212	110	N	N	75	27	19	180	130	60	N	130
PSH-F221	29	N	N	18	29	21	110	140	35	N	180
PSH-F221	30	N	N	15	30	20	110	120	30	N	150
PSH-F222	28	N	N	30	27	18	100	130	25	N	140
PSH-F222	21	N	N	30	31	19	100	160	25	N	140
PSH-H111	38	130	N	60	N	24	180	120	470	N	420
PSH-H111	37	140	N	62	N	23	190	140	480	N	370
PSH-H112	16	71	N	32	N	19	140	140	40	N	310
PSH-H112	16	76	N	30	N	19	150	140	41	N	310
PSH-H121	N	N	N	12	N	12	40	34	28	N	520
PSH-H121	N	N	N	11	N	11	30	32	24	N	440
PSH-H122	5	N	N	10	20	11	40	37	30	N	680
PSH-H122	N	N	N	10	20	11	N	36	31	N	450
PSH-H211	29	N	N	73	23	20	170	140	34	N	140
PSH-H211	29	N	N	70	N	20	150	140	36	N	120
PSH-H212	34	N	N	60	N	20	170	140	37	N	150
PSH-H212	36	N	N	72	24	21	170	140	38	N	150
PSH-H221	13	N	N	26	N	19	120	94	39	N	340

Table 1D.--Cont.

Sample	Na%-S	K%-S	Ce ppm-S	Ga ppm-S	Yb ppm-S	T-C%	Orgnc C%	Crbnt C%
PSH-E1	1.0	5	150	70	3	.22	.2	.05
PSH-E1	.7	5	150	50	5	.24	.2	.06
PSH-E112	--	--	--	41	--	--	--	--
PSH-E112	--	--	--	37	--	--	--	--
PSH-E2	1.5	3	N	30	5	--	--	--
PSH-E2	1.5	3	N	30	5	--	--	--
PSH-E122	--	--	--	35	--	--	--	--
PSH-E122	--	--	--	36	--	--	--	--
PSH-E211	--	--	--	20	--	--	--	--
PSH-E211	--	--	--	17	--	--	--	--
PSH-E212	--	--	--	60	--	--	--	--
PSH-E212	--	--	--	60	--	--	--	--
PSH-E221	--	--	--	29	--	--	--	--
PSH-E221	--	--	--	30	--	--	--	--
PSH-E222	--	--	--	33	--	--	--	--
PSH-E222	--	--	--	37	--	--	--	--
PSH-F1	1.5	3	N	50	5	--	--	--
PSH-F1	1.5	3	N	50	5	--	--	--
PSH-F112	--	--	--	25	--	--	--	--
PSH-F112	--	--	--	39	--	--	--	--
PSH-F2	.7	3	N	50	3	--	--	--
PSH-F2	.7	3	N	50	3	--	--	--
PSH-F122	--	--	--	20	--	--	--	--
PSH-F122	--	--	--	22	--	--	--	--
PSH-F211	--	--	--	43	--	--	--	--
PSH-F211	--	--	--	38	--	--	--	--
PSH-F212	--	--	--	30	--	--	--	--
PSH-F212	--	--	--	34	--	--	--	--
PSH-F221	--	--	--	34	--	--	--	--
PSH-F221	--	--	--	38	--	--	--	--
PSH-F222	--	--	--	38	--	--	--	--
PSH-F222	--	--	--	37	--	--	--	--
PSH-H111	--	--	--	24	--	--	--	--
PSH-H111	--	--	--	20	--	--	--	--
PSH-H112	--	--	--	24	--	--	--	--
PSH-H112	--	--	--	26	--	--	--	--
PSH-H121	--	--	--	N	--	--	--	--
PSH-H121	--	--	--	N	--	--	--	--
PSH-H122	--	--	--	N	--	--	--	--
PSH-H122	--	--	--	N	--	--	--	--
PSH-H211	--	--	--	33	--	--	--	--
PSH-H211	--	--	--	30	--	--	--	--
PSH-H212	--	--	--	33	--	--	--	--
PSH-H212	--	--	--	34	--	--	--	--
PSH-H221	--	--	--	20	--	--	--	--

Table 1D.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
PSH-H221	37 22 30	88 22 30	121,311	75.4	13.2	1.10	.32	.60	.20	.40	3.6	3.10	.88	1.00
PSH-H222	37 22 30	88 22 30	121,363	89.4	4.8	.75	N	.20	.40	.15	1.1	1.00	.33	1.00
PSH-H222	37 22 30	88 22 30	121,164	90.3	4.6	.40	.20	.30	.30	.10	.9	.46	.43	.88
PSH-I211	37 22 30	87 30 00	121,179	60.0	19.1	6.10	.56	1.50	.10	.80	3.1	5.00	1.80	1.00
PSH-I211	37 22 30	87 30 00	121,327	58.9	19.7	6.10	.56	1.50	.80	1.30	4.0	3.90	1.60	1.00
PSH-I212	37 22 30	87 30 00	121,125	54.7	21.3	7.50	.56	1.80	.60	.50	2.9	6.10	2.40	.88
PSH-I212	37 22 30	87 30 00	121,386	55.1	20.8	6.90	.88	1.40	.40	.70	3.4	4.70	2.60	.90
PSH-I221	37 22 30	87 30 00	121,422	64.0	16.2	7.50	.32	1.10	.10	.80	2.3	5.00	1.30	.94
PSH-I221	37 22 30	87 30 00	121,353	64.7	16.1	6.90	.32	1.00	.30	.80	2.0	5.00	1.40	.95
PSH-I222	37 22 30	87 30 00	121,512	66.2	15.0	7.70	.32	1.10	.50	1.00	1.8	3.80	1.20	.90
PSH-I222	37 22 30	87 30 00	121,147	65.9	13.9	6.90	1.10	1.10	.40	.80	2.0	3.40	1.20	.96
PSH-J111	37 52 30	86 45 00	121,342	66.8	15.4	5.80	.28	1.20	1.00	.70	2.0	3.80	1.80	.85
PSH-J111	37 52 30	86 45 00	121,175	66.3	16.0	5.60	.32	1.00	.30	.40	1.8	5.30	1.90	.88
PSH-J112	37 52 30	86 45 00	121,276	75.7	11.2	4.40	.28	.60	.40	.80	1.1	3.50	.89	.75
PSH-J112	37 52 30	86 45 00	121,478	75.0	11.9	4.50	.32	.80	<.01	.60	1.3	3.10	.72	.75
PSH-J2	37.8833	86 45 00	118,679	59.6	23.4	1.60	.42	1.10	.22	.71	4.0	5.90	1.20	1.00
PSH-J2	37.8833	86 45 00	118,694	59.9	23.6	1.70	.38	1.20	.21	.62	4.2	5.50	1.20	1.00
PSH-J122	37 52 30	86 45 00	121,136	57.3	22.1	2.40	2.50	1.80	.30	.60	3.1	6.20	1.60	.96
PSH-J122	37 52 30	86 45 00	121,198	57.3	20.8	2.90	2.50	1.90	.10	.60	4.0	7.60	.33	.97
PSH-J211	37 07 30	86 15 00	121,377	73.5	15.4	1.60	.16	.60	.30	.20	2.0	4.10	.88	1.10
PSH-J211	37 07 30	86 15 00	121,556	73.6	15.2	1.50	.24	.40	.30	.10	2.3	3.70	1.10	1.10
PSH-J212	37 07 30	86 15 00	121,282	78.4	15.8	1.60	N	.30	.40	.40	.6	1.60	.33	.40
PSH-J212	37 07 30	86 15 00	121,334	88.3	6.4	1.40	N	.15	.27	.25	.6	1.50	.32	.52
PSH-J221	37 07 30	86 15 00	121,492	63.5	18.4	5.30	.24	.80	.10	<.01	2.6	4.80	2.30	.95
PSH-J221	37 07 30	86 15 00	121,190	62.7	18.0	5.40	.36	.80	.20	.30	2.6	5.50	2.20	1.10
PSH-J222	37 07 30	86 15 00	121,473	71.1	15.8	2.00	.48	.80	.30	.50	2.3	4.30	1.30	.95
PSH-J222	37 07 30	86 15 00	121,338	71.5	15.2	2.20	.28	.80	.40	.20	2.3	4.30	1.70	.95
PSH-L1	37 07 30	84 00 00	118,689	60.8	20.9	3.10	1.30	2.00	.10	.57	3.5	5.50	1.10	.98
PSH-L1	37 07 30	84 00 00	118,666	60.7	20.5	3.20	1.40	1.90	.16	.76	3.4	5.50	1.00	.98
PSH-L112	37 07 30	84 00 00	121,409	57.6	21.6	3.70	1.40	1.20	.20	.50	3.6	6.30	1.80	1.10
PSH-L112	37 07 30	84 00 00	121,204	57.4	21.4	4.00	1.40	1.80	<.01	.40	3.7	6.10	1.80	1.00
PSH-L2	37 07 30	84 00 00	118,690	63.1	17.5	5.40	1.10	1.80	.27	.57	3.1	4.80	1.20	.91
PSH-L2	37 07 30	84 00 00	118,664	64.2	16.7	5.30	1.10	1.70	.18	.66	2.9	5.00	1.20	.89
PSH-L122	37 07 30	84 00 00	121,291	64.3	17.1	4.60	1.10	1.30	.15	.80	3.2	4.80	1.30	.99
PSH-L122	37 07 30	84 00 00	121,427	65.1	16.7	4.50	1.20	1.30	.10	.70	2.5	4.80	1.00	1.00
PSH-L211	37 15 00	84 00 00	121,465	54.2	25.7	4.90	.48	1.10	N	.30	3.5	5.90	2.80	.99
PSH-L211	37 15 00	84 00 00	121,265	53.9	25.4	4.70	.44	.90	.20	.20	3.1	7.30	2.60	1.00
PSH-L212	37 15 00	84 00 00	121,314	74.5	12.9	3.30	.32	.70	.50	.65	1.8	3.00	.59	.81
PSH-L212	37 15 00	84 00 00	121,441	75.3	12.7	2.40	1.00	.80	.20	1.10	1.8	2.10	.71	.78
PSH-L221	37 15 00	84 00 00	121,292	70.3	13.9	5.80	.24	.30	.20	.20	2.5	4.20	1.20	.67
PSH-L221	37 15 00	84 00 00	121,301	68.8	14.7	6.50	.12	.50	.25	.30	2.7	4.00	1.30	.71
PSH-L222	37 15 00	84 00 00	121,173	62.6	19.4	4.60	.56	.80	.30	.10	2.5	5.30	2.30	1.10
PSH-L222	37 15 00	84 00 00	121,443	62.1	19.1	5.10	.28	.90	<.01	.30	2.9	5.30	2.30	1.10
PSH-M1	37 45 00	83 07 30	118,662	54.4	23.2	4.60	1.20	2.20	N	.36	4.8	5.80	1.60	.88
PSH-M1	37 45 00	83 07 30	118,668	54.9	23.2	4.50	1.30	2.10	<.01	.36	4.8	6.00	1.60	.88

Table 1D.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Mg%-S	Ca%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Co ppm-S	Cr ppm-S
PSH-H221	.04	.05	<.05	1.30	--	--	.83	85	140	300	N	N	100
PSH-H222	.12	.03	<.05	.54	--	--	.91	15	160	160	N	N	60
PSH-H222	.03	.05	<.05	.45	--	--	.78	12	130	150	N	N	58
PSH-I211	.12	.07	<.05	10.00	--	--	.63	460	60	680	N	11	95
PSH-I211	.11	.05	<.05	4.80	--	--	.60	380	37	490	N	12	87
PSH-I212	.10	.11	.05	7.10	--	--	.44	660	45	600	N	19	100
PSH-I212	.22	.08	<.05	6.30	--	--	.42	580	44	600	N	17	99
PSH-I221	.08	.14	<.05	9.50	--	--	.48	610	43	410	N	15	60
PSH-I221	.09	.08	<.05	5.80	--	--	.47	500	38	380	N	15	63
PSH-I222	.09	.13	<.05	6.70	--	--	.49	630	50	410	N	14	56
PSH-I222	.10	.07	<.05	8.50	--	--	.67	700	60	450	N	18	68
PSH-J111	.09	.05	.08	4.60	--	--	.43	200	50	360	N	15	78
PSH-J111	.08	.07	<.05	6.00	--	--	.48	200	56	420	N	9	71
PSH-J112	.06	.08	<.05	5.10	--	--	.41	180	40	340	N	13	60
PSH-J112	.06	.05	.05	4.50	--	--	.38	180	45	330	N	N	52
PSH-J2	.15	<.01	<.05	1.50	.5	.03	.50	70	70	1,000	N	5	70
PSH-J2	.14	<.01	<.05	2.00	.3	.03	.50	70	70	1,000	N	N	100
PSH-J122	.14	.05	<.05	5.70	--	--	.56	230	60	830	N	14	100
PSH-J122	.16	.05	<.05	3.60	--	--	.44	200	43	590	N	12	94
PSH-J211	.14	<.01	<.05	1.60	--	--	.78	30	60	300	N	N	120
PSH-J211	.05	.09	<.05	1.50	--	--	.60	34	60	300	N	N	110
PSH-J212	.03	.05	.05	1.00	--	--	.24	24	48	120	N	N	66
PSH-J212	.02	.05	<.05	.90	--	--	.25	20	48	90	N	N	59
PSH-J221	.05	.03	.05	5.90	--	--	.55	190	75	300	N	N	98
PSH-J221	.08	.05	<.05	4.30	--	--	.45	170	51	270	N	N	96
PSH-J222	.05	.05	<.05	3.30	--	--	.73	80	80	300	N	N	100
PSH-J222	.07	.03	.05	2.00	--	--	.54	56	60	260	N	N	100
PSH-L1	.13	.03	<.05	5.00	1.0	.05	.50	300	70	700	N	15	150
PSH-L1	.11	.03	<.05	5.00	1.0	.03	.30	300	100	700	N	15	100
PSH-L112	.13	.05	<.05	5.90	--	--	.46	200	42	450	N	N	100
PSH-L112	.22	.07	<.05	4.70	--	--	.49	190	42	470	N	9	110
PSH-L2	.17	.07	<.05	5.00	.7	.07	.30	500	70	500	N	20	70
PSH-L2	.15	.06	<.05	5.00	.5	.10	.20	500	70	700	N	20	100
PSH-L122	.13	.08	<.05	6.80	--	--	.72	520	58	400	N	19	110
PSH-L122	.13	.10	<.05	5.70	--	--	.60	500	60	380	N	17	100
PSH-L211	.06	.04	<.05	3.40	--	--	.41	55	35	320	N	N	120
PSH-L211	.06	.03	<.05	3.60	--	--	.43	66	42	340	N	N	120
PSH-L212	.15	.05	<.05	4.20	--	--	.64	200	59	330	N	12	98
PSH-L212	.13	.07	<.05	7.00	--	--	.67	240	75	300	N	11	83
PSH-L221	.15	.10	<.05	5.20	--	--	.33	480	47	270	N	26	81
PSH-L221	.15	.10	<.05	5.10	--	--	.32	400	37	250	N	23	60
PSH-L222	.10	.09	.05	6.00	--	--	.73	480	75	380	N	15	100
PSH-L222	.11	.11	<.05	5.10	--	--	.60	500	67	310	N	16	98
PSH-M1	.14	<.01	<.05	5.00	.7	.02	.30	150	100	700	N	10	100
PSH-M1	.14	.02	<.05	5.00	.7	.02	.20	150	100	700	N	10	70

Table 1D.--Cont.

Sample	Cu ppm-S	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S
PSH-H221	13	N	N	25	N	18	110	100	41	N	400
PSH-H222	6	N	N	12	N	15	50	36	50	N	>1,000
PSH-H222	N	N	N	10	N	12	40	30	44	N	840
PSH-I211	40	N	N	40	N	20	190	140	38	N	220
PSH-I211	36	N	N	36	22	20	170	140	38	N	240
PSH-I212	45	N	N	51	33	20	230	170	33	N	130
PSH-I212	38	N	N	47	36	19	230	170	32	N	130
PSH-I221	38	N	N	35	27	17	120	100	42	N	250
PSH-I221	39	N	N	37	30	18	120	100	35	N	260
PSH-I222	37	N	N	35	32	15	120	91	34	N	240
PSH-I222	38	N	N	44	33	20	140	100	43	N	290
PSH-J111	35	N	N	43	30	18	100	100	36	N	240
PSH-J111	32	N	N	35	30	17	110	100	29	550	230
PSH-J112	30	N	N	30	25	16	90	79	28	N	240
PSH-J112	24	N	N	29	33	14	80	79	26	N	340
PSH-J2	20	50	15	15	20	20	300	200	30	N	150
PSH-J2	30	50	20	20	N	20	500	200	30	N	100
PSH-J122	45	N	N	32	24	20	240	150	34	N	160
PSH-J122	38	N	N	28	26	19	210	140	30	N	140
PSH-J211	23	70	N	20	21	17	100	100	46	N	400
PSH-J211	25	85	N	20	27	19	110	92	49	N	380
PSH-J212	3	N	N	12	21	13	40	30	30	N	340
PSH-J212	3	N	N	N	N	10	N	25	23	N	280
PSH-J221	19	N	N	30	23	18	100	110	31	N	300
PSH-J221	16	N	N	28	20	18	90	110	30	N	220
PSH-J222	27	N	N	30	26	17	100	120	34	N	280
PSH-J222	14	N	N	29	20	17	100	100	34	N	270
PSH-L1	50	50	20	70	20	20	200	200	50	N	150
PSH-L1	50	70	20	50	30	20	200	300	50	N	150
PSH-L112	36	N	N	41	36	20	140	150	39	N	140
PSH-L112	40	74	N	44	36	23	160	160	42	N	150
PSH-L2	30	30	20	70	15	15	100	200	30	N	200
PSH-L2	30	50	15	50	20	15	150	150	30	N	150
PSH-L122	30	72	N	51	34	20	120	110	51	N	300
PSH-L122	27	71	N	47	34	19	120	120	42	N	310
PSH-L211	26	N	N	30	30	20	120	150	27	N	130
PSH-L211	30	N	N	30	35	22	130	160	30	N	130
PSH-L212	21	N	N	38	33	16	100	85	46	N	480
PSH-L212	20	N	N	36	20	14	80	79	36	N	450
PSH-L221	24	N	N	20	25	18	90	90	25	N	270
PSH-L221	21	N	N	19	N	16	70	78	20	N	190
PSH-L222	18	N	N	30	31	19	100	130	30	N	240
PSH-L222	20	N	N	25	30	18	90	120	29	N	210
PSH-M1	70	100	20	30	20	30	150	200	50	N	100
PSH-M1	50	70	15	30	20	20	150	200	30	N	70

Table 10.--Cont.

Sample	Na%-S	K%-S	Ce ppm-S	Ga ppm-S	Yb ppm-S	T-C%	Orgnc C%	Crbnt C%
PSH-H221	--	--	--	20	--	--	--	--
PSH-H222	--	--	--	N	--	--	--	--
PSH-H222	--	--	--	N	--	--	--	--
PSH-I211	--	--	--	30	--	--	--	--
PSH-I211	--	--	--	30	--	--	--	--
PSH-I212	--	--	--	37	--	--	--	--
PSH-I212	--	--	--	38	--	--	--	--
PSH-I221	--	--	--	24	--	--	--	--
PSH-I221	--	--	--	25	--	--	--	--
PSH-I222	--	--	--	22	--	--	--	--
PSH-I222	--	--	--	23	--	--	--	--
PSH-J111	--	--	--	19	--	--	--	--
PSH-J111	--	--	--	22	--	--	--	--
PSH-J112	--	--	--	16	--	--	--	--
PSH-J112	--	--	--	17	--	--	--	--
PSH-J2	1.0	5	N	50	3	--	--	--
PSH-J2	1.5	5	N	50	3	--	--	--
PSH-J122	--	--	--	42	--	--	--	--
PSH-J122	--	--	--	38	--	--	--	--
PSH-J211	--	--	--	19	--	--	--	--
PSH-J211	--	--	--	21	--	--	--	--
PSH-J212	--	--	--	N	--	--	--	--
PSH-J212	--	--	--	N	--	--	--	--
PSH-J221	--	--	--	25	--	--	--	--
PSH-J221	--	--	--	22	--	--	--	--
PSH-J222	--	--	--	21	--	--	--	--
PSH-J222	--	--	--	20	--	--	--	--
PSH-L1	1.5	5	N	70	5	--	--	--
PSH-L1	1.5	5	N	50	5	--	--	--
PSH-L112	--	--	--	34	--	--	--	--
PSH-L112	--	--	--	36	--	--	--	--
PSH-L2	1.0	3	N	50	5	--	--	--
PSH-L2	1.0	3	N	50	5	--	--	--
PSH-L122	--	--	--	30	--	--	--	--
PSH-L122	--	--	--	27	--	--	--	--
PSH-L211	--	--	--	37	--	--	--	--
PSH-L211	--	--	--	39	--	--	--	--
PSH-L212	--	--	--	20	--	--	--	--
PSH-L212	--	--	--	16	--	--	--	--
PSH-L221	--	--	--	23	--	--	--	--
PSH-L221	--	--	--	18	--	--	--	--
PSH-L222	--	--	--	30	--	--	--	--
PSH-L222	--	--	--	27	--	--	--	--
PSH-M1	1.0	5	150	70	5	1.15	1.1	.05
PSH-M1	1.0	5	N	50	3	1.16	1.1	.03

Table 10.--Cont.

Sample	LATITUDE	LONGITUD	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%	TiO2%
PSH-M112	37 45 00	83 07 30	121,484	77.4	12.9	1.10	.60	.60	.30	.40	1.8	3.40	.49	.92
PSH-M112	37 45 00	83 07 30	121,284	77.8	12.6	1.30	.48	.60	.30	.30	2.1	3.40	.50	.94
PSH-M2	37 45 00	83 07 30	118,688	70.2	14.7	2.70	.74	.80	.22	1.40	2.3	4.10	.91	.92
PSH-M2	37 45 00	83 07 30	118,674	69.3	14.9	3.10	.62	.90	.27	1.70	2.5	3.80	.88	.91
PSH-M122	37 45 00	83 07 30	121,191	77.1	13.5	1.50	.16	.20	.10	.30	1.7	3.80	.61	.92
PSH-M122	37 45 00	83 07 30	121,178	75.2	14.5	2.00	.16	.30	<.01	.20	1.6	4.20	.67	.94
PSH-M211	37 30 00	83 00 00	121,442	58.3	20.5	3.50	2.20	2.10	.40	1.00	4.2	4.50	1.30	.99
PSH-M211	37 30 00	83 00 00	121,242	58.2	20.7	3.30	2.30	2.10	.60	1.20	3.8	4.50	1.10	1.00
PSH-M212	37 30 00	83 00 00	121,319	64.2	19.6	2.70	.50	.70	.30	.60	4.3	4.80	.94	1.20
PSH-M212	37 30 00	83 00 00	121,540	64.9	19.8	2.90	.48	.80	.40	.35	3.3	4.50	1.20	1.20
PSH-M221	37 30 00	83 00 00	121,438	67.1	18.1	1.80	.84	.90	<.01	.10	3.1	4.50	1.30	1.10
PSH-M221	37 30 00	83 00 00	121,228	65.9	18.2	2.00	.92	1.10	.10	.50	3.7	5.20	1.20	1.10
PSH-M222	37 30 00	83 00 00	121,317	65.2	16.6	5.00	.88	.90	.10	1.10	3.4	4.50	.95	.99
PSH-M222	37 30 00	83 00 00	121,283	65.4	16.4	4.90	.88	1.20	.50	1.10	3.3	3.70	1.10	1.00
PSH-N111	37 30 00	82 07 30	121,158	56.7	20.5	6.20	1.70	1.60	.40	.30	3.6	5.20	1.30	.96
PSH-N111	37 30 00	82 07 30	121,322	56.4	20.8	7.00	1.30	1.60	.50	.20	3.7	5.20	1.20	.91
PSH-N112	37 30 00	82 07 30	121,316	60.4	17.7	3.00	2.00	1.50	.30	.70	3.7	4.50	1.20	.99
PSH-N112	37 30 00	82 07 30	121,529	60.4	18.6	3.20	1.80	1.50	.30	.40	3.1	4.50	1.50	.95
PSH-N121	37 30 00	82 07 30	121,392	58.4	20.6	3.10	1.70	1.50	1.70	.80	4.6	4.90	1.30	.90
PSH-N121	37 30 00	82 07 30	121,471	59.0	21.5	3.00	1.90	1.80	.20	.60	4.8	5.20	1.00	.87
PSH-N122	37 30 00	82 07 30	121,562	59.5	19.5	6.10	1.10	1.50	.30	.55	3.9	4.50	1.60	1.00
PSH-N122	37 30 00	82 07 30	121,542	59.8	19.3	5.80	1.10	1.70	.40	.55	3.6	4.40	1.60	1.00
PSH-N211	37 37 30	82 37 30	121,309	59.7	20.9	3.90	.98	1.40	.40	1.00	4.7	4.50	1.20	1.10
PSH-N211	37 37 30	82 37 30	121,188	60.0	20.3	3.90	1.00	1.40	.10	.80	3.9	5.20	1.40	1.20
PSH-N212	37 37 30	82 37 30	121,550	61.1	21.2	1.90	2.10	1.30	.20	.30	3.4	4.90	1.70	1.20
PSH-N212	37 37 30	82 37 30	121,335	60.4	20.7	1.80	2.10	1.60	.20	.20	3.4	6.30	1.60	1.50
PSH-N221	37 37 30	82 37 30	121,212	65.9	13.9	3.30	2.20	1.90	1.60	1.90	2.8	2.90	.43	.86
PSH-N221	37 37 30	82 37 30	121,544	66.9	14.2	2.10	3.00	1.70	1.40	1.60	2.4	2.80	.63	.92
PSH-N222	37 37 30	82 37 30	121,304	69.9	13.4	5.00	5.20	1.00	.40	1.80	2.8	3.10	.80	.94
PSH-N222	37 37 30	82 37 30	121,226	70.9	13.7	4.90	.52	1.20	.30	.18	2.7	3.20	.88	.83
PSH-T1	36 53 00	84 07 30	118,685	59.5	21.2	2.90	1.60	2.10	.16	.59	4.4	5.30	1.00	.96
PSH-T1	36 53 00	84 07 30	118,684	59.6	21.3	3.00	1.50	2.10	N	.51	4.2	5.20	1.00	.96
PSH-T112	36 52 30	84 07 30	121,206	51.3	26.0	6.00	.56	1.10	<.01	.30	3.7	6.80	3.10	.86
PSH-T112	36 52 30	84 07 30	121,543	52.5	26.4	5.80	.48	1.10	.20	.15	3.4	5.50	3.40	.87
PSH-T2	36 53 00	84 07 30	118,677	66.2	15.5	2.90	2.60	1.80	.40	1.60	3.0	3.80	.41	.89
PSH-T2	36 53 00	84 07 30	118,687	66.3	15.6	2.80	2.80	2.00	.33	1.50	3.0	4.00	.44	.89
PSH-T122	36 52 30	84 07 30	121,511	79.0	10.1	2.70	.76	.63	.15	1.10	1.9	2.00	.52	.75
PSH-T122	36 52 30	84 07 30	121,382	80.0	9.9	2.70	.72	.60	.20	1.10	1.7	1.90	.66	.77
PSH-T211	36 52 30	84 15 00	121,220	72.7	15.8	1.60	.24	.50	.20	.40	3.5	4.00	.90	1.10
PSH-T211	36 52 30	84 15 00	121,453	73.9	15.0	1.10	.52	.45	<.01	.10	1.9	4.20	1.00	1.00
PSH-T212	36 52 30	84 15 00	121,362	69.9	14.7	4.90	.24	.70	.30	.30	2.5	3.70	1.40	.95
PSH-T212	36 52 30	84 15 00	121,329	68.8	14.6	4.60	.72	.70	.50	.60	2.8	3.90	1.30	.99
PSH-T221	36 52 30	84 15 00	121,207	63.0	19.3	3.00	.68	.90	.10	.30	3.6	6.00	1.60	1.00
PSH-T221	36 52 30	84 15 00	121,249	62.4	19.9	3.10	.40	.80	.30	.40	2.8	5.60	1.50	1.10
PSH-T222	36 52 30	84 15 00	121,384	76.1	12.5	2.40	.24	.40	<.01	.20	1.8	3.70	.89	.85
PSH-T222	36 52 30	84 15 00	121,359	75.6	12.8	2.40	.28	.60	.40	.20	1.9	3.70	.81	.87

Table 10.--Cont.

Sample	P2O5%	MnO%	CO2%	Fe%-S	Mg%-S	Ca%-S	Ti%-S	Mn ppm-S	B ppm-S	Ba ppm-S	Be ppm-S	Co ppm-S	Cr ppm-S
PSH-M112	.03	.05	.05	2.20	--	--	.75	65	59	300	N	N	41
PSH-M112	.03	.03	<.05	1.80	--	--	.70	60	55	300	N	N	45
PSH-M2	.25	<.01	<.05	3.00	.3	.05	.30	100	70	700	N	5	70
PSH-M2	.20	.02	<.05	3.00	.3	.05	.50	100	50	700	N	N	150
PSH-M122	.06	<.01	<.05	1.00	--	--	.46	19	33	220	N	N	44
PSH-M122	.06	.05	<.05	.94	--	--	.44	16	30	230	N	N	37
PSH-M211	.18	.07	<.05	9.70	--	--	.64	370	60	690	N	11	100
PSH-M211	.17	.09	.05	8.60	--	--	.75	340	60	630	N	12	100
PSH-M212	.06	.03	<.05	3.10	--	--	.79	68	48	530	N	N	94
PSH-M212	.05	.10	.08	6.80	--	--	1.00	71	60	600	N	N	96
PSH-M221	.05	.04	.05	5.70	--	--	1.00	120	73	600	N	8	90
PSH-M221	.08	.05	<.05	3.40	--	--	.85	120	68	600	N	N	90
PSH-M222	.25	.07	<.05	6.40	--	--	.65	360	49	520	N	18	77
PSH-M222	.24	.05	.05	6.40	--	--	.69	380	51	500	N	20	81
PSH-N111	.16	.12	<.05	10.00	--	--	.56	840	46	570	N	15	84
PSH-N111	.18	.05	.08	6.00	--	--	.36	580	N	400	N	12	72
PSH-N112	.16	.13	<.05	4.60	--	--	.49	600	35	480	N	17	89
PSH-N112	.15	<.01	.08	8.70	--	--	.64	700	40	460	N	15	84
PSH-N121	.16	.08	.05	6.90	--	--	.46	410	30	600	N	14	90
PSH-N121	.02	.10	.05	5.30	--	--	.40	420	46	680	N	17	100
PSH-N122	.14	.02	.05	6.80	--	--	.58	850	50	550	N	19	88
PSH-N122	.14	.06	.05	8.20	--	--	.69	400	46	600	N	20	95
PSH-N211	1.40	.08	<.05	5.30	--	--	.72	360	49	600	N	14	99
PSH-N211	.16	.07	<.05	7.00	--	--	.88	410	61	720	N	12	100
PSH-N212	.03	.06	.05	4.80	--	--	.90	200	55	460	N	15	100
PSH-N212	.04	.05	.05	3.80	--	--	.77	190	48	430	N	14	100
PSH-N221	.22	.10	1.10	7.80	--	--	.66	520	53	450	N	14	60
PSH-N221	.22	.09	1.10	7.20	--	--	.71	640	56	550	N	12	69
PSH-N222	.23	.08	<.05	7.50	--	--	.77	480	47	480	N	15	60
PSH-N222	.21	.07	<.05	7.90	--	--	.65	470	60	470	N	13	68
PSH-T1	.17	.03	<.05	5.00	1.0	.05	.50	200	100	700	5	15	100
PSH-T1	.18	.03	<.05	3.00	1.0	.15	.50	200	70	500	N	10	70
PSH-T112	.12	.02	<.05	3.80	--	--	.34	110	39	300	N	N	110
PSH-T112	.10	.06	<.05	9.60	--	--	.44	130	42	420	N	N	130
PSH-T2	.21	.06	<.05	5.00	1.0	.20	.50	700	70	700	N	20	100
PSH-T2	.22	.07	<.05	5.00	.7	.20	.50	500	70	700	N	20	70
PSH-T122	.15	.05	.10	5.30	--	--	.49	320	54	300	N	N	35
PSH-T122	.19	.08	<.05	5.90	--	--	.58	430	60	330	N	9	45
PSH-T211	.07	.05	<.05	1.60	--	--	.69	30	76	300	N	N	140
PSH-T211	.03	.04	<.05	2.00	--	--	.88	29	70	300	N	N	110
PSH-T212	.26	.05	<.05	6.90	--	--	.67	30	78	360	N	N	100
PSH-T212	.20	.03	.05	4.40	--	--	.61	30	73	340	N	N	100
PSH-T221	.19	.05	.05	3.90	--	--	.80	41	79	600	N	N	130
PSH-T221	.16	.03	<.05	8.30	--	--	.76	820	60	430	N	19	90
PSH-T222	.13	.08	<.05	3.90	--	--	.64	390	67	300	N	17	90
PSH-T222	.05	.05	.12	3.60	--	--	.63	390	81	360	N	19	100

Table 1D.--Cont.

Sample	Cu ppm-S	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zn ppm-S	Zr ppm-S
PSH-M112	10	N	N	13	22	14	30	60	43	N	460
PSH-M112	12	N	N	15	N	16	60	60	36	N	380
PSH-M2	20	50	N	10	30	15	150	150	30	N	300
PSH-M2	20	30	15	7	N	15	150	150	20	N	300
PSH-M122	N	N	N	N	N	10	40	59	25	N	300
PSH-M122	3	N	N	N	N	12	N	58	22	N	240
PSH-M211	35	77	N	35	30	20	200	170	36	N	200
PSH-M211	41	76	N	39	26	22	170	170	39	N	200
PSH-M212	18	90	N	11	26	23	110	150	64	N	350
PSH-M212	22	95	N	17	31	24	110	160	62	N	380
PSH-M221	29	82	N	20	28	20	130	140	44	N	310
PSH-M221	30	94	N	20	29	21	160	130	47	N	370
PSH-M222	30	N	N	30	26	19	130	110	43	N	310
PSH-M222	30	73	N	33	23	20	130	120	50	N	330
PSH-N111	43	N	N	36	N	22	140	130	35	N	150
PSH-N111	40	N	N	30	20	17	110	100	26	N	120
PSH-N112	56	N	N	36	35	19	170	130	35	N	190
PSH-N112	43	70	N	36	23	19	160	130	35	N	230
PSH-N121	34	N	N	30	25	19	110	150	23	N	130
PSH-N121	38	N	N	34	30	20	140	160	23	N	130
PSH-N122	40	74	N	43	30	19	150	130	38	N	200
PSH-N122	41	80	N	50	39	19	170	150	44	N	200
PSH-N211	41	76	N	30	22	24	160	150	49	N	210
PSH-N211	45	84	N	32	27	22	150	170	55	N	210
PSH-N212	26	74	30	35	40	22	130	190	36	N	250
PSH-N212	34	N	N	32	45	22	120	160	33	N	210
PSH-N221	20	N	N	30	N	16	150	95	34	N	390
PSH-N221	21	N	N	30	27	15	200	110	43	N	440
PSH-N222	17	85	N	33	21	17	140	98	47	N	300
PSH-N222	17	73	N	34	22	18	140	96	48	N	320
PSH-T1	50	100	30	50	20	30	300	300	50	N	150
PSH-T1	70	100	50	30	20	20	300	300	50	N	150
PSH-T112	34	N	N	38	37	20	120	150	N	N	100
PSH-T112	34	N	N	45	34	23	170	210	22	N	120
PSH-T2	30	50	20	50	30	15	150	150	50	N	300
PSH-T2	50	50	20	50	20	15	200	200	30	N	200
PSH-T122	9	N	N	20	N	12	70	52	27	N	400
PSH-T122	12	N	N	19	N	12	90	53	30	N	430
PSH-T211	18	N	N	15	26	18	80	100	32	N	500
PSH-T211	15	N	N	14	24	18	70	97	39	N	590
PSH-T212	38	N	N	17	28	20	110	110	38	N	340
PSH-T212	37	N	N	15	30	19	100	110	38	N	320
PSH-T221	18	N	N	25	28	20	180	150	35	N	220
PSH-T221	40	80	N	37	24	20	160	110	40	N	280
PSH-T222	16	N	N	30	24	15	70	74	43	N	330
PSH-T222	17	N	N	34	33	17	100	85	49	N	390

Table 10.--Cont.

Sample	Na%-S	K%-S	Ce ppm-S	Ga ppm-S	Yb ppm-S	T-C%	Orgnc C%	Crbnt C%
PSH-M112	--	--	--	16	--	--	--	--
PSH-M112	--	--	--	17	--	--	--	--
PSH-M2	2.0	3	N	30	3	2.12	2.1	.05
PSH-M2	1.5	2	N	30	3	2.06	2.0	.05
PSH-M122	--	--	--	14	--	--	--	--
PSH-M122	--	--	--	12	--	--	--	--
PSH-M211	--	--	--	38	--	--	--	--
PSH-M211	--	--	--	36	--	--	--	--
PSH-M212	--	--	--	29	--	--	--	--
PSH-M212	--	--	--	27	--	--	--	--
PSH-M221	--	--	--	28	--	--	--	--
PSH-M221	--	--	--	30	--	--	--	--
PSH-M222	--	--	--	28	--	--	--	--
PSH-M222	--	--	--	27	--	--	--	--
PSH-N111	--	--	--	31	--	--	--	--
PSH-N111	--	--	--	30	--	--	--	--
PSH-N112	--	--	--	32	--	--	--	--
PSH-N112	--	--	--	25	--	--	--	--
PSH-N121	--	--	--	39	--	--	--	--
PSH-N121	--	--	--	41	--	--	--	--
PSH-N122	--	--	--	32	--	--	--	--
PSH-N122	--	--	--	35	--	--	--	--
PSH-N211	--	--	--	36	--	--	--	--
PSH-N211	--	--	--	35	--	--	--	--
PSH-N212	--	--	--	36	--	--	--	--
PSH-N212	--	--	--	36	--	--	--	--
PSH-N221	--	--	--	20	--	--	--	--
PSH-N221	--	--	--	26	--	--	--	--
PSH-N222	--	--	--	22	--	--	--	--
PSH-N222	--	--	--	22	--	--	--	--
PSH-T1	1.5	5	150	70	5	--	--	--
PSH-T1	1.5	7	150	70	5	--	--	--
PSH-T112	--	--	--	34	--	--	--	--
PSH-T112	--	--	--	30	--	--	--	--
PSH-T2	2.0	3	150	50	5	--	--	--
PSH-T2	2.0	5	N	50	5	--	--	--
PSH-T122	--	--	--	11	--	--	--	--
PSH-T122	--	--	--	15	--	--	--	--
PSH-T211	--	--	--	22	--	--	--	--
PSH-T211	--	--	--	20	--	--	--	--
PSH-T212	--	--	--	20	--	--	--	--
PSH-T212	--	--	--	20	--	--	--	--
PSH-T221	--	--	--	28	--	--	--	--
PSH-T221	--	--	--	37	--	--	--	--
PSH-T222	--	--	--	15	--	--	--	--
PSH-T222	--	--	--	20	--	--	--	--

Table 2.--Elements commonly looked for, but rarely or never detected, by direct-reader emission spectrographic analysis, and their approximate lower limits of determination in parts per million.

Element	Lower limit of determination
Ag	4
Au	20
B	30
Be	5
Bi	20
Cd	200
Ge	100
In	20
Mo	20
Nb	30
Pd	10
Re	70
Sb	300
Sn	20
Tl	50
W	500
Zn	500

Table 3.--Average modes for shale of Paleozoic age in Kentucky. [C, Chattanooga, Ohio and New Albany Shales; LM, Lower Mississippian; UM, Upper Mississippian; ℙ, Pennsylvanian; Number of thin sections on which each mode is based is shown in parentheses]

Rock Unit	Framework grains: Silt (sand)	Framework grains: Rock fragments 2/	Framework grains: Feldspar	Matrix	Cement	Muscovite	Pyrite	Other 1/
Shale:								
C (39)	11%	3/ 6%	<1%	80%	4/<1%	<1%	3%	<1%
LM (32)	16	5	1	74	2	<1	<1	2
UM (52)	12	5/ 6	4	75	<1	<1	<1	2
ℙ (62)	17	8	3	66	1	1	<1	3
Sandy shale:								
LM (6)	27	6	1	37	4/ 22	<1	<1	5
Siliceous shale:								
ℙ (2)	51	13	14	10	7	2	<1	3

1/ Mostly hematite in C, LM and UM; both organic material and hematite in ℙ.
2/ Mostly clay pellets with subordinate phyllitic or schistose fragments.
3/ Includes 3.2% *Tasmanites*.
4/ Rhombic dolomite.
5/ Includes 0.9% fossil fragments.

Table 4A.--Sampling sites for rocks of the Chattanooga, New Albany and Ohio Shales. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Briensburg	DSH-P211	2 km E of Bethel Church	6.1 m below top of Chattanooga	Organic-free (Oxidized?)
	DSH-P212	do	do	Organic-poor
Eddyville	DSH-P111	SE edge of Vista Ridge Park (now under waters of reservoir)	2.1 m below top of Chattanooga	
	DSH-P112	do	1.8 m below top of Chattanooga	Weathered?
Petroleum	DSH-R111	In Trammel Ck., 2.7 km NW of Maple Grove Church	4.6 m above base of Chattanooga	Sandy
	DSH-R112	do	6.1 m above base of Chattanooga	Silty
	DSH-R121	1.4 km E of Mt. Union School	At top of Chattanooga	Splintery
	DSH-R122	do	1.5 m above base of Chattanooga	Flinty
Austin	DSH-R211	E end of Long Reach, Barren River Valley	5.5 m below top of Chattanooga	Silty, gypsum coatings
	DSH-R212	do	0.6 m below top of Chattanooga	do
	DSH-R221	2.2 km E of Maynard	4.6 m below top of Chattanooga	Gypsum coatings
	DSH-R222	do	3 m below top of Chattanooga	do

Table 4A.--Cont.

Quadrangle	Sample No. DSH-	Sample site	Stratigraphic Position	Remarks
Breeding	DSH-S211	In Strange Branch	3 m above base of Chattanooga	Silty, gypsum veins
	DSH-S212	do	6.1 m above base of Chattanooga	do
	DSH-S221	2 km up Garret Ck.	2 m below top of Chattanooga	Pyritic, gypsum
	DSH-S222	do	4.6 m above base of Chattanooga	Paper shale, silty
Burksville	DSH-S111	1.6 km SE of Howards Bottom School	2.1 m above base of Chattanooga	Hematitic, silty
	DSH-S112	do	4.6 m above base of Chattanooga	
	DSH-S121	0.8 km N of Salem Church	5.5 m above base of Chattanooga	Pyritic, gypsum veins
	DSH-S122	do	1.5 m above base of Chattanooga	do
Knifely	DSH-K111	0.3 km S of Evans Cemetery	3 m above base of Chattanooga	do
	DSH-K112	0.4 km S of Evans Cemetery	9.1 m above base of Chattanooga	Paper shale
	DSH-K121	0.8 km S of Neatsville	1.5 m(?) above base of Chattanooga	Dolomitic, pyrite
	DSH-K122	do	11 m above base of Chattanooga	Pyritic
Dunnville	DSH-K211	2.8 km up Damron Ck., W side	6.1 m above base of Chattanooga	
	DSH-K212	do	1.5 m above base of Chattanooga	do
	DSH-K221	1.3 km up Luttrell Ck., E side	0.9 m below top of Chattanooga	
	DSH-K222	do	1.8 m below top of Chattanooga	

Table 4A.--Cont.

Quadrangle	Sample No. DSH-	Sample site	Stratigraphic Position	Remarks
Eli	DSH-L111	S end of Floyd Ridge	1.5 m above base of Chattanooga	Silty
	DSH-L112	do	3 m above base of Chattanooga	do
	DSH-L121	S end of Brown Ridge	2.1 m above base of Chattanooga	do
	DSH-L122	do	3.4 m above base of Chattanooga	
Brodhead	DSH-L211	At Old Moss Cemetery	2.7 m above base of New Albany	Pyritic, silty
	DSH-L212	do	6.7 m above base of New Albany	
	DSH-L221	Near mouth of Hamilton Valley	6.1 m below top of New Albany	Gray shale
	DSH-L222	do	7.6 m below top of New Albany	do
Burtonville	DSH-E111	1.7 km E of Wallingford, on Spring Rd.	52 m above base of Ohio	Fissile
	DSH-E112	do	46 m above base of Ohio	do
	DSH-E121	Above Powder Lick Branch	9.1 m above base of Ohio	Brown, jarositic(?)
	DSH-E122	do	40 m above base of Ohio	
Manchester Islands	DSH-E211	W side, Sulphur Knob	24 m above base of Ohio	
	DSH-E212	do	18 m above base of Ohio	
	DSH-E221	SW side, Big Brier Knob	40 m above base of Ohio	Paper shale
	DSH-E222	do	41 m above base of Ohio Sh	do

Table 48.--Sampling sites for shale of Lower Mississippian age in Kentucky. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Adolphus	LMSHR111	1.2 km NE of Hinton Cemetery in Little Trammel Creek	35 m above base of Fort Payne	Claystone, weathered
	LMSHR112	do	18 m above base of Fort Payne	Dolomite, cherty
	LMSHR121	On road E of Oak Grove Church	23 m above base of Fort Payne	Claystone, weathered(?)
	LMSHR122	do	9 m above base of Fort Payne	Claystone
Holland	LMSHR211	1 km SE of Maysville School in Rhoden Creek	4.6 m above base of Fort Payne	Claystone, weathered(?)
	LMSHR212	do	1.5 m above base of Fort Payne	Claystone
	LMSHR221	1.5 km E of Oak Forest in Long Creek	4.6 m above base of Fort Payne	do
	LMSHR222	do	do	do
Amandaville	LMSHS211	2.8 km N of Spack Chapel	24 m above base of Fort Payne	Claystone, silty
	LMSHS212	do	6.1 m above base of Fort Payne	Claystone, pyritic
	LMSHS221	On S flank of of Collins Branch	34 m above base of Fort Payne	Siltstone, sandy
	LMSHS222	do	9.1 m above base of Fort Payne	Claystone, black

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Wolf Creek Dam	LMSHS111	At upper end of Lick Creek	do	Claystone
	LMSHS112	Near ridgetop, S of Lick Creek	61 m above base of Fort Payne	Siltstone, sandy
	LMSHS121	On NE flank of Billy Ridge	69 m above base of Fort Payne	do
	LMSHS122	do	65 m above base of Fort Payne	do
Knifely	LMSHK111	0.8 km N of Purdy	78 m above base of Fort Payne	do
	LMSHK112	do	81 m above base of Fort Payne	do
	LMSHK121	0.5 km W of Bottom District School	61 m above base of Fort Payne	Claystone, silty
	LMSHK122	0.7 km W of Bottom District School	43 m above base of Fort Payne	Claystone
Dunnville	LMSHK211	3.1 km NW of Millerfield School	34 m above base of Borden	Claystone, silty
	LMSHK212	do	6.1 m above base of Borden	Claystone
	LMSHK221	0.9 km N of Wilson School	43 m above base of Borden	Claystone, silty
	LMSHK222	0.6 km N of Wilson School	64 m above base of Borden	Carbonate, cherty
Eli	LMSHL111	2.4 km SE of Beasley School	2.4 m above base of Fort Payne	Claystone
	LMSHL112	do	35 m above base of Fort Payne	Claystone, silty
	LMSHL121	0.4 km S of New Pt. Pleasant Ch.	30 m above base of Fort Payne	Claystone, cherty, pyritic
	LMSHL122	do	27 m above base of Fort Payne	Claystone

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Berea	LMSHL211	0.6 km S of Silver Creek Cemetery	94 m above base of Borden	Claystone, silty, weathered
	LMSHL212	do	73 m above base of Borden	Claystone, silty
	LMSHL221	1.6 km N of Macedonia Church	29 m above base of Borden	do
	LMSHL222	do	34 m above base of Borden	do
Head of Grassy	LMSHE211	Hilltop S of Mouth of Long Lick	98 m above base of Borden	Siltstone, weathered
	LMSHE212	At mouth of Clark Branch	24 m above base of Borden	Claystone
Wesleyville	LMSHE221	0.2 km W of Stafford Hill School	12 m below top of Borden	Shale, sandy
	LMSHE222	1.8 km W of Stafford Hill School	73 m above base of Borden	Claystone
Brushart	LMSHE111	Across from mouth of Hackworth Hollow	12 m(?) above base of Borden	Claystone, silty
	LMSHE112	0.7 km E of Veach Cemetery	21 m below top of Borden	do
	LMSHE121	1.9 km N of Rexton	6.1 m(?) above base of Borden	Claystone, fragmental, Fe-stained, silty
	LMSHE122	2.2 km N of Rexton	40 m(?) below top of Borden	do

Table 4C.--Sampling sites for shale of Upper Mississippian age. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Shetlerville	UMSHH111	0.4 km W of Carrsville	3 m below top of Kincaid	Claystone
	UMSHH112	0.2 km W of Carrsville	1 m below top of Chlore ls	Claystone, silty
	UMSHH121	1.6 km S of Carrsville	3 m above base of Golconda	Claystone, fossiliferous
	UMSHH122	do	do	do
Rosiclare	UMSHH211	4.2 km SE of Carrsville	3 m below top of Renault	Claystone
	UMSHH212	do	do	do
	UMSHH221	0.8 km E of Carrsville	At top of Paint Creek	do
	UMSHH222	do	do	Claystone, carbonaceous
Honey Grove	UMSHQ111	At Pleasant Hill Church	At base of Waltersburg	do
	UMSHQ112	do	3 m above base of Waltersburg	do
	UMSHQ121	At Britmart	15 m above base of Big Clifty Sandstone Member (Golconda)	Claystone
	UMSHQ122	do	18 m above base of Big Clifty Sandstone Member (Golconda)	Soil
Pleasant Green Hill	UMSHQ211	2.7 km SE of Palestine Church	7.6 m above base of Hardinsburg	Claystone, fossiliferous
	UMSHQ212	do	12 m above base of Hardinsburg	Claystone
	UMSHQ221	0.4 km N of Boyd Cemetery	7.6 m above base of Tar Springs	Shale, sandy, weathered
	UMSHQ222	do	do	do

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
South Union	UMSHR111	1.1 km N of Felts Cemetery	3 m below top of Big Clifty Sandstone Member (Golconda)	Claystone, sandy
	UMSHR112	0.8 km NE of Felts Cemetery	9.1 m above base of Big Clifty Sandstone Member (Golconda)	do
	UMSHR121	At head of Epperson Hollow	7.6 m above base of Big Clifty Sandstone Member (Golconda)	Claystone, silty, weathered
	UMSHR122	do	do	Claystone
Rockfield	UMSHR211	0.7 km E of Blue Level	9.1 m above base of Big Clifty Sandstone Member (Golconda)	Claystone, sandy, weathered
	UMSHR212	do	2 m below top of Girkin	Soil
	UMSHR221	0.5 km E of Cedar Grove Church	At top of Girkin	Claystone
	UMSHR222	do	6.1 m above base of Big Clifty Sandstone Member (Golconda)	do
Millerstown	UMSHJ111	1.7 km N of Little Flock Church	At base(?) of Big Clifty Sandstone Member (Golconda)	Claystone, fossiliferous
	UMSHJ112	do	12 m(?) above base of Big Clifty Sandstone Member (Golconda)	Claystone, silty
	UMSHJ121	0.2 km SW of Lacon	3 m above base of Big Clifty Sandstone Member (Golconda)	Shale, sandy
	UMSHJ122	do	6 m above base of Big Clifty Sandstone Member (Golconda)	do

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Cub Run	UMSHJ211	0.4 km NE of Lines Mills	At base(?) of upper member of Girkin	Claystone, weathered
	UMSHJ212	do	do	Soil
	UMSHJ221	2.2 km NE of Cherry Spring Church	At base of Big Clifty Sandstone Member (Golconda)	Shale, sandy
	UMSHJ222	do	do	Graywacke, lithic
Cumberland City	UMSHS111	1.2 km E of Narvel	1.5 m above base Bangor	Siltstone, argillaceous
	UMSHS112	do	3.1 m above base of Bangor	do
	UMSHS121	2.2 km W of Nora	At top(?) of Bangor	Claystone
	UMSHS122	do	6 m(?) above base of Pennington	do
Barthell	UMSHT111	At mouth of Coffey Hollow	24 m below top of Pennington	do
	UMSHT112	0.5 km up Coffey Hollow	At top of Pennington	Paleosol(?)
	UMSHT121	0.8 km NW of Paint Cliff	27 m below top of Pennington	Claystone
	UMSHT122	0.5 km W of Paint Cliff	15 m below top of Pennington	Claystone, silty
Sawyer	UMSHT211	At mouth of Ned Branch	6 m below top of Pennington	do
	UMSHT212	do	3 m below top of Pennington	Siltstone, argillaceous
	UMSHT221	At mouth of Goodin Branch	do	Dolomite, argillaceous
	UMSHT222	do	4.3 m below top of Pennington	Claystone, calcareous

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Maretburg	UMSHL111	Below Backbone Ridge	7 m(?) below top of Pennington	Claystone, weathered
	UMSHL112	do	do	do
	UMSHL121	1.3 km NE of Freedom School	1.5 m below top of Pennington	Claystone
	UMSHL122	do	At top of Pennington	do
Bighill	UMSHL211	0.8 km W of Morrill	9.1 m below top of Newman	Soil
	UMSHL212	0.8 km NW of Morrill	9 m(?) above base of Pennington	Claystone, silty
	UMSHL221	0.2 km NW of Bighill School	5.2 m above base of Pennington	do
	UMSHL222	do	3.2 m above base of Pennington	do
Wrigley	UMSHE211	In quarry, at mouth of Oakley Cave Branch	12 m(?) below top of Pennington(?)	Soil
	UMSHE212	do	16 m(?) below top of Pennington(?)	Claystone, sandy
	UMSHE221	At Leisure	4.5 m below top of Pennington(?)	Claystone, silty
	UMSHE222	do	6 m below top of Pennington(?)	Siltstone, argillaceous
Portsmouth	UMSHE111	At head of Siloam Branch	At top of Pennington	Claystone, sandy, weathered
	UMSHE112	do	do	Claystone, weathered
	UMSHE121	In quarry, 1.9 km N of Valley View School	3.5 m(?) below top Pennington	Claystone, dolomitic, weathered
	UMSHE122	do	6 m below top of Pennington	Paleosol(?)

Table 4D.--Sampling sites for shale of Pennsylvanian age. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Shetlerville	PSH-H211	2.7 km W of Carrsville	5 m above base of Grindstaff Sandstone Member (Tradewater)	Claystone, black
	PSH-H212	do	do	do
	PSH-H221	1.4 km W of Carrsville	3 m below base of Gentry Coal (Caseyville)	Graywacke
	PSH-H222	1.3 km W of Carrsville	3 m above top of Gentry Coal (Caseyville)	Siltstone, silicified
Salem	PSH-H111	0.2 km S of Glendale Church	23 m above base of Caseyville	Graywacke, carbonaceous
	PSH-H112	do	50 m above base of Caseyville	Graywacke
	PSH-H121	0.2 km S of Corn School	60 m(?) above base of Caseyville	Sandstone, silty
	PSH-H122	do	do	Siltstone, sandy, weathered(?)
Slaughters	PSH-I211	0.5 km SW of Bailey Cemetery	320 m above base of No. 9 Coal (Breathitt)	Claystone
	PSH-I212	0.3 km SW of Bailey Cemetery	315 m above base of No. 9 Coal (Breathitt)	do
	PSH-I221	0.7 km NW of Slaughters	330 m above base of No. 9 Coal (Breathitt)	Siltstone, weathered
	PSH-I222	do	do	Claystone

Table 4D.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Tell City	PSH-J111	1 km NW of Adair	15 m below Lead Creek Limestone of Crider (1913)	Siltstone, argillaceous
	PSH-J112	do	do	Siltstone, sandy
	PSH-J2	0.8 km S of Poplar Grove Church	1 m above Lewisport Coal (Tradewater)	Claystone
	PSH-J122	1 km S of Poplar Grove Church	do	Claystone, pyritic
Brownsville	PSH-J211	1.5 km S of Brownsville	12 m above base of Caseyville	Claystone, silty
	PSH-J212	do	13 m above base of Caseyville	Sandstone, silty
	PSH-J221	1.2 km S of Lindsayville	30 m above base of Caseyville	Claystone, silty, carbonaceous
	PSH-J222	do	do	do
Sawyer	PSH-T211	At head of Dutch Branch	At top of Shale Member D (Lee)	Claystone, silty
	PSH-T212	do	6 m below top of Shale Member D (Lee)	Claystone, iron-stained, silty
	PSH-T221	1.2 km N of Baldrock	At top of Shale Member H (Lee)	Claystone, carbonaceous
	PSH-T222	1 km N of Baldrock	3 m below top of Shale Member H (Lee)	Claystone, silty

Table 4D.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Vox	PSH-T1	1.3 km E of Corinth School	1m above Blue Gem Coal (Breathitt)	Claystone
	PSH-T112	1 km E of Corintn School	30 m below Blue Gem Coal (Breathitt)	Claystone, weathered
	PSH-T2	1.4 km NW of Barton Chapel	3 m below base of Corbin Sandstone Member (Lee)	Siltstone, sandy
	PSH-T122	1.5 km NW of Barton Chapel	10 m below base of Corbin Sandstone Member (Lee)	Sandstone, silty
London	PSH-L1	0.9 km NE of Macedonia School	35 m above Lily Coal (Breathitt)	Claystone
	PSH-L112	do	do	do
	PSH-L2	0.8 km NW of McWhorter	16 m below horizon(?) of Lily Coal (Breathitt)	Claystone, silty
	PSH-L122	1 km N of McWhorter	On horizon(?) of Lily Coal (Breathitt)	Siltstone, argillaceous
Parrot	PSH-L211	1.6 km SW of Dabolt	100 m(?) above top of Pennington	Claystone (C-zone soil?)
	PSH-L212	1.9 km SW of	110 m(?) above top of Pennington	Siltstone, argillaceous, carbonaceous
	PSH-L221	0.5 km NW of Cornette	70 m(?) above top of Pennington	Claystone, sandy
	PSH-L222	0.6 km W of Cornette	100 m(?) above top of Pennington	Claystone (C-zone soil ?)

Table 4D.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Tiptop	PSH-M211	12 km up Wolfpen Branch	2 m above base of Magoffin Member (Breathitt)	Claystone, carbonaceous
	PSH-M212	do	At base(?) of Magoffin Member (Breathitt)	Siltstone, carbonaceous
	PSH-M221	1.9 km NE of Evanston	At top(?) of Peach Orchard Coal Zone (Breathitt)	Claystone
	PSH-M222	2.2 km NE of Evanston	7 m above Prater Coal(Breathitt)	Siltstone, coaly
White Oak	PSH-M1	0.3 km NW of Rock House School	At top(?) of Fire Clay Coal (Breathitt)	Claystone, iron-stained
	PSH-M112	0.5 km N of Rock House School	5 m(?) above Fire Clay Coal (Breathitt)	Siltstone, sandy, coaly
	PSH-M2	1 km S of Bloomington	3 m below base of Magoffin Member (Breathitt)	do
	PSH-M122	0.7 km S of Bloomington	15 m below Fire Clay Coal (Breathitt)	Graywacke
Lancer	PSH-N211	0.7 km SW of Dewey Dam	15 m below base of Magoffin Member (Breathitt)	Claystone, carbonaceous
	PSH-N212	0.8 km SW of Dewey Dam	At top(?) of Fire Clay Rider Coal (Breathitt)	do
	PSH-N221	0.5 km NW of Mayo Cemetery	At top(?) of Upper Elkhorn No. 3 Coal (Breathitt)	Siltstone, argillaceous
	PSH-N222	0.3 km NW of Mayo Cemetery	5 m above Upper Elkhorn No. 3 Coal (Breathitt)	Siltstone, carbonaceous, weathered(?)

Table 4D.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Matewan	PSH-N111	0.6 km SE of Christ Temple Church	3 m above Lower Thacker Coal (Breathitt)	Claystone
	PSH-N112	0.8 km SE of Christ Temple Church	At top of Lower Thacker Coal (Breathitt)	Siltstone, argillaceous
	PSH-N121	At head of May Fork	At top(?) of Hamlin Coal (Breathitt)	Claystone, carbonaceous
	PSH-N122	do	12 m above Williamson Coal (Breathitt)	Claystone, carbonaceous, weathered(?)
Wrigley	PSH-E1	3.1 km W of Blairs Mills	27 m above base of Breathitt	Claystone
	PSH-E112	do	26 m above base of Breathitt	Claystone, black
	PSH-E2	1.1 km NW of Wrigley	9 m above base of Breathitt	Siltstone, carbonaceous
	PSH-E122	do	At base(?) of Breathitt	Claystone, black
Haldeman	PSH-E211	0.8 km NW of Christian Cemetery	3 m above top of Olive Hill Clay Bed of Crider (1913)	Siltstone, argillaceous
	PSH-E212	1 km NW of Christian Cemetery	From Olive Hill Clay bed of Crider (1913)	Claystone, fossiliferous, carbonaceous, pyritic
	PSH-E221	1.7 km S of Ditney School	30 m above base of Breathitt	Claystone, silty
	PSH-E222	1.5 km S of Ditney School	do	Claystone

Table 4D.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Rush	PSH-F1	At head of Upper Stinson Creek	7 m above Princess No. 7 Coal (Breathitt)	Siltstone, sandy
	PSH-F112	1 km N of Williams Creek	At top(?) of Princess No. 7 Coal (Breathitt)	Siltstone, argillaceous
	PSH-F2	0.7 km SW of Denton	10m above Princess No. 7 Coal (Breathitt)	Claystone, silty
	PSH-F122	1 km W of Denton in RR cut	Beneath Princess No. 3(?) Coal (Breathitt)	Claystone, fossiliferous, carbonaceous, sandy
Boltsfork	PSH-F211	At head of Friendship Creek	18 m above Ames(?) Limestone Member (Conemaugh)	Claystone (Paleosol?)
	PSH-F212	do	26 m above Ames(?) Limestone Member (Conemaugh)	do
	PSH-F221	1.5 km N of Garner	12 m below top of Breathitt	Claystone
	PSH-F222	do	1 m above Princess No. 7 Coal (Breathitt)	do

Table 5A.--Components of geochemical variance for rocks of the organic-rich Chattanooga, New Albany, and Ohio Shales in Kentucky. [Components given as percentages of total logarithmic variance, Total V(Log X); *, component significantly different from zero at the 0.05 probability level; see text for explanation of v(m)]

	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(D)	v(m)1/
Oxides:							
SiO_2 2/	41.6	14%	32%*	21%	33%*	<1	<1.0
Al_2O_3	.0038	17	<1	31	51*	1	<1.0
MgO	.0276	29	20*	14	28*	9	<1.0
CaO	.2192	15*	<1	22	38*	25	<1.0
Na_2O	.0664	31	13*	11*	<1	45	<1.0
K_2O	.0047	2	<1	29	46*	23	<1.0
H_2O+	.0296	<1	<1	2	24	75	<1.0
TiO_2	.0040	<1	<1	25	52*	22	<1.0
P_2O_5	.0742	32*	<1	9	10	49	4.8
Elements:							
B	.0122	40*	<1	18	30*	12	2.2
Ba	.1032	6	<1	25	64*	3	<1.0
C, Org	.1040	19*	12	8	57*	4	1.2
C, CO_3	.2119	4	<1	18	33*	44	<1.0
Co	.1344	25*	<1	26	47*	3	1.0
Cr	.0172	27*	<1	22	46*	4	1.2
Cu	.0649	27*	15	<1	57*	1	1.3
Fe	.0516	46*	<1	5	14*	35	8.8
Ga	.0059	<1	<1	38*	28*	34	<1.0
Hg	.3342	15	4	37*	16*	28	<1.0
Mn	.1365	37*	5	16	41*	1	3.2
Mo	.1428	22	<1	38*	38*	2	<1.0
Ni	.1349	35*	<1	13	51*	1	1.8
Pb	.0470	20*	<1	24	37*	18	1.7
Sc	.0032	3	<1	18	40*	38	<1.0
Sr	.0251	12*	<1	28	48*	12	<1.0
V	.1003	11	<1	28	58*	2	<1.0
Y	.0155	11*	8	20	46*	16	<1.0
Zr	.0079	<1	14	<1	64*	22	<1.0

1/ v(m) is slightly biased to the high side because of an imbalance in the sample design due to sample rejection.

2/ Computed on untransformed data.

Table 53.--Components of geochemical variance for shale of Lower Mississippian age in Kentucky. [Components given as percentages of total logarithmic variance, Total V(Log X); *, component significantly different from zero at the 0.05 probability level; see text for explanation of v(m)]

	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(D)	v(m) 1/
Oxides:							
SiO2 2/	67.05	40%*	<1%	<1%	60%*	<1%	5.4
Al2O3	.0153	7	9	<1	84*	<1	<1.0
Fe2O3	.0396	8	<1	27	60*	5	<1.0
FeO	.0648	42*	2	<1	49*	8	5.7
MgO	.0661	43*	9	<1	48*	1	4.1
CaO	.5118	18*	27*	<1	44*	12	<1.0
Na2O	.0841	5	22*	<1	10	63	<1.0
K2O	.0192	23*	18	<1	52*	7	1.5
H2O+	.0144	<1	<1	<1	66*	34	<1.0
TiO2	.0128	14	42*	<1	42*	2	<1.0
P2O5	.1397	<1	42*	<1	12	45	<1.0
Elements:							
B	.0327	18*	15*	<1	61*	6	1.2
Ba	.0212	2	<1	<1	91*	6	<1.0
Co	.0389	24*	<1	10	49*	17	2.5
Cr	.0146	1	<1	<1	88*	11	<1.0
Cu	.0885	9	<1	16	69*	7	<1.0
Mn	.0554	7	5	<1	86*	3	<1.0
Ni	.0661	43	20*	3	32*	2	2.9
Sc	.0066	19	<1	5	60*	15	2.0
Sr	.0664	20*	7	<1	52*	21	1.7
V	.0241	<1	12	<1	81*	7	<1.0
Y	.0282	12	<1	44*	35*	9	<1.0
Zr	.0817	71*	13*	<1	15*	2	8.6

1/ v(m) is slightly biased to the high side because of an imbalance in the sample design due to sample rejection.
2/ Computed on untransformed data.

Table 5C.--Components of geochemical variance for shale of Upper Mississippian age in Kentucky. [Components given as percentages of total logarithmic variance, Total V(Log X); *, component significantly different from zero at the 0.05 probability level; see text for explanation of v(m)]

	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(D)	v(m) 1/
Oxides:							
SiO_2 2/	117.68	<1%	<1%	77%*	23%*	<1%	<1.0
Al_2O_3	.0131	<1	<1	56*	44*	<1	<1.0
Fe_2O_3	.0412	<1	<1	74*	23*	3	<1.0
FeO	.0766	24*	3/ 21	23*	18*	16	1.2
MgO	.0410	4	<1	68*	26*	3	<1.0
CaO	.4947	<1	<1	44*	45*	11	<1.0
Na_2O	.0941	26*	<1	5	11	57	4.0
K_2O	.0194	<1	29*	19	43*	9	<1.0
H_2O+	.0204	3/ 11	4	14*	3/ 17	54	<1.0
TiO_2	.0107	3	<1	60*	34*	2	<1.0
P_2O_5	.0948	16*	13 3/	5	31*	35	1.2
Elements:							
B	.0412	<1	23	47*	20*	11	<1.0
Ba	.0217	39*	<1	17	34*	11	4.3
Co	.0355	2	27*	<1	54*	16	<1.0
Cr	.0115	29*	<1	2	44*	24	3.9
Cu	.0929	<1	15	34*	45*	6	<1.0
Ga	.0248	<1	1	63*	20*	16	<1.0
Mn	.2204	16	<1	49*	32*	3	<1.0
Ni	.0218	13	<1	54*	25*	8	<1.0
Sc	.0076	8	<1	51*	17*	25	<1.0
Sr	.0769	3/ 19	<1	65*	3/ 4	12	1.1
V	.0184	3/ 10	<1	3/ 31	38*	22	<1.0
Y	.0161	<1	3	3/ 36	44*	17	<1.0
Zr	.0451	1	6	46*	37*	10	<1.0

1/ v(m) is slightly biased to the high side because of an imbalance in the sample design due to sample rejection.
2/ Computed on untransformed data.
3/ Significant at the 0.1 probability level.

Table 50.--Components of geochemical variance for shale of Pennsylvanian age in Kentucky. [Components given as percentages of total logarithmic variance, Total V(Log X); *, component significantly different from zero at the 0.05 probability level; see text for explanation of v(m)]

	Total v(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(D)	v(m)1/
Oxides:							
SiO2 2/	68.91	<1%	6%	24%	68%*	2%	<1.0
Al2O3	.0151	3	<1	3/ 29	50*	18	<1.0
Fe2O3	.0662	5	<1	33*	58*	4	<1.0
FeO	.1513	11	22*	3	47*	17	<1.0
MgO	.0718	<1	28*	7	59*	6	<1.0
CaO	.1061	10*	<1	1	16	72	1.5
Na2O	.1206	11*	3/ 15	2	26*	46	<1.0
K2O	.0408	<1	<1	54*	40*	6	<1.0
H2O+	.0236	1	2	36*	55*	7	<1.0
TiO2	.0082	<1	12	<1	82*	7	<1.0
P2O5	.1116	<1	14	<1	53*	33	<1.0
Elements:							
B	.0246	34*	4	<1	40*	22	4.2
Ba	.0388	<1	26*	13	56*	5	<1.0
Co	.1314	14*	<1	14	57*	15	1.2
Cr	.0176	6	<1	16	56*	20	<1.0
Cu	.0859	<1	11	22	58*	8	<1.0
Ga	.0411	<1	7	13	75*	5	<1.0
Mn	.2357	12	<1	51*	30*	7	<1.0
Ni	.0600	3/ 14	7	40*	33*	7	<1.0
Pb	.0359	15*	<1	8	24*	53	1.8
Sc	.0093	<1	<1	53*	30*	17	<1.0
Sr	.0555	<1	11	28*	49*	12	<1.0
V	.0378	<1	<1	3/ 28	67*	5	<1.0
Y	.0404	<1	18	<1	74*	9	<1.0
Zr	.0496	<1	28*	17	48*	7	<1.0

1/ v(m) is slightly biased to the high side because of an imbalance in the sample design due to sample rejection.
2/ Computed on untransformed data.
3/ Significant at the 0.1 probability level.

Table 6A.--Summary geochemical statistics for the organic-rich Chattanooga, New Albany, and Ohio Shales in Kentucky. [Data are in parts per million except where noted as percent (%); GM, geometric mean; GD, geometric deviation; GE, geometric error; Ratio, number of analyses in which constituent was determined to total number of analyses; leaders (--) indicate insufficient data]

Part I. Statewide summary

Oxides:	GM	GD	GE	Ratio
SiO2, % 1/	55.0	6.2	<0.6	88:88
Al2O3, %	13	1.13	1.01	88:88
MgO, %	1.1	1.45	1.12	88:88
CaO, %	.28	2.84	1.71	82:88
Na2O, %	.35	1.74	1.49	86:88
K2O, %	3.6	1.16	1.08	88:88
H2O+, %	4.8	1.46	1.41	88:88
TiO2, %	.76	1.15	1.07	88:88
P2O5,	890	1.81	1.55	88:88
Elements:				
Ag	.21	1.78	1.56	47:47
B	110	1.25	1.09	88:88
Ba	480	2.07	1.14	88:88
C, Org., %	9.3	2.06	1.16	88:88
C, CO3,	860	2.78	2.02	87:88
Co	12	3.23	1.16	66:88
Cr	77	1.31	1.06	88:88
Cu	110	1.72	1.06	88:88
Fe	4.2	1.64	1.36	88:88
Ga	23	1.17	1.11	88:88
Hg	.28	4.24	2.02	81:88
Mn	81	2.27	1.09	88:88
Mo	76	2.62	1.13	78:88
Ni	100	2.26	1.09	88:88
Pb	25	1.75	1.24	74:88
Sc	16	1.13	1.08	88:88
Sr	110	1.37	1.13	88:88
V 2/	290	1.96	1.11	84:88
Y	32	1.35	1.12	86:88
Zn 2/3/	<200	--	--	4:88
Zr	150	1.20	1.20	88:88

Table 6A.--Cont.

Part II. Medians by areas (quadrangle pairs)
[The number of samples in each area is given in parentheses]

	GD	Briensbury-Eddyville (8)	Petroleum-Austin (16)	Breeding-Burksville (16)	Knifely-Dunnville (16)	Eli-Brodhead (16)	Manchester Islands-Burtonville (16)
CaO, %	2.70	0.15	0.47	0.30	0.20	0.30	0.11
P2O5, %	1.68	.07	.14	.10	.11	.13	.055
B	1.22	180	110	100	110	100	110
C, Org.%	1.95	5.3	9.7	13	12	12	9.7
Co	2.08	<8	17	28	19	32	<9
Cr	1.29	96	94	65	70	60	84
Cu	1.65	33	190	110	115	96	120
Fe, %	1.47	2.6	4.0	5.9	4.2	5.9	2.3
Mn	1.96	44	160	68	82	76	44
Ni	1.98	52	220	140	200	100	65
Pb	1.56	33	29	29	28	30	21
Sr	1.41	120	90	130	110	110	110
Y	1.31	25	37	37	33	37	30

1/ Computed on untransformed data.
2/ Erickson (1966) reports up to 1000 parts per million each of V and Zn in the Sunbury Shale (an organic rich Mississippian shale similar to the Chattanooga and lying above it) in the Friendship quadrangle of northeastern Kentucky.
3/ 920 ppm Zn measured in sample DSH-K122 (Chattanooga Shale, Knifely quadrangle); 1000 ppm Zn measured in sample DSH-R121 (Chattanooga Shale, Petroleum quadrangle).

Table 6B.--Summary statistics for shale, siltstone, and sandy shale of Lower Mississippian age in Kentucky. [Data are in parts per million except where noted as percent (%); GM, geometric mean; GD, geometric deviation; GE, geometric error; M, median; Ratio, number of analyses in which constituent was determined to total number of analyses; leaders (--) indicate insufficient data]

Part I. Statewide summary

	Shale and Siltstone 1/				Sandy Shale	
Oxides:	GM	GD	GE	Ratio	M	Ratio
SiO2, % 2/	69	7.4	0.4	60:60	57	12:12
Al2O3, %	12	1.30	1.02	60:60	6.0	12:12
Fe2O3, %	2.7	1.54	1.11	60:60	1.8	12:12
FeO, %	1.1	1.74	1.17	60:60	.69	12:12
MgO, %	1.5	1.67	1.07	60:60	4.1	12:12
CaO, %	.65	4.37	1.76	58:60	12	12:12
Na2O, %	.53	1.83	1.70	60:60	.60	12:12
K2O, %	2.6	1.35	1.09	60:60	1.2	12:12
H2O+, %	2.7	1.28	1.18	60:60	1.5	12:12
TiO2, %	.73	1.28	1.04	60:60	.36	12:12
P2O5,	570	2.07	1.78	58:60	700	12:12
CO2, %	3/ .05	--	3.44	31:60	13	12:12
Elements:						
B	92	1.37	1.11	59:60	<30	0:12
Ba	370	1.35	1.09	60:60	150	12:12
Co	11	1.49	1.20	50:60	<8	6:12
Cr	71	1.28	1.09	60:60	43	12:12
Cu	17	1.84	1.20	59:60	9	10:12
Ga	18	1.45	1.11	54:60	10	7:12
La	46	1.33	1.13	4:60	<70	0:12
Mn	190	1.62	1.10	60:60	120	12:12
Mo	<20	--	--	0:60	<20	0:12
Ni	4/ 49	1.75	1.09	60:60	20	12:12
Pb	19	1.35	1.28	28:60	<20	2:12
Sc	16	1.19	1.08	60:60	12	11:12
Sr	86	1.58	1.31	57:60	110	12:12
V	130	1.37	1.10	60:60	57	12:12
Y	32	1.36	1.12	58:60	22	9:12
Zn	300	1.42	1.45	4:60	<500	0:12
Zr	180	1.81	1.10	60:60	78	12:12

Table 68.--Cont.

Part II. Medians by areas (quadrangle pairs)
[The number of samples in each area is given in parentheses]

Shale + siltstone:

	GD	Adolphus-Holland (14)	Amandaville-Wolf Creek Dam (16)	Knifely-Dunnville (14)	Eli-Berea (16)	Head of Grassy-Wesleyville-Brushart (12)
SiO2, 2/	6.3	67	62	68	70	75
FeO, %	1.56	.81	1.6	.96	1.8	.81
CaO, %	4.44	.55	7.1	.50	.40	.45
MgO, %	1.56	1.7	2.3	1.8	1.7	.75
K2O, %	1.32	3.4	2.2	2.5	3.1	2.0
B	1.46	100	74	100	110	82
Co	1.49	14	<8	11	12	10
Sr	1.70	80	140	90	90	85
Zr	1.43	120	85	140	190	490

1/ Samples R112 and K222 (Adolphus and Dunnville quadrangles, respectively) were excluded from the summary because they are normative carbonates.
2/ Computed on untransformed data.
3/ Primary mode; the distribution is bimodal with a secondary mode at 5%.
4/ Samples R211, R212, and R221 (Holland quadrangle) ranged from 100-270 ppm Ni.

Table 6C.--Summary geochemical statistics for shale of Upper Mississippian age in Kentucky. [Data are in parts per million except where noted as percent (%); GM, geometric mean; GD, geometric deviation; GE, geometric error; Ratio, number of analyses in which constituent was determined to total number of analyses; leaders (--) indicate insufficient data]

Part I. Statewide summary

	Shale				Paleosols(?)	
	GM	GD	GE	Ratio	UMSHT112	UMSHE122
Oxides:						
SiO_2 % 1/	62.0	9.4	0.3	106:106	54.0	50.0
Al_2O_3 %	15	1.29	1.02	106:106	18	18
Fe_2O_3 %	3.3	1.53	1.08	106:106	11	8.6
FeO %	.65	1.86	1.29	106:106	<.10	.98
MgO %	1.7	1.54	1.09	106:106	1.6	3.8
CaO %	.74	4.13	1.70	99:106	<.10	.90
Na_2O %	.21	2.01	1.71	97:106	.20	.53
K_2O %	2.8	1.36	1.10	106:106	2.6	6.1
H_2O+ %	3.8	1.38	1.27	106:106	5.8	4.2
TiO_2 %	.80	1.22	1.04	106:106	.92	.81
P_2O_5 %	.081	1.99	1.52	102:106	.36	.25
CO_2 % 2/	.040	--	--	51:106	.07	<.05
Elements:						
B	68	1.45	1.16	98:106	49	160
Ba	230	1.35	1.12	106:106	300	300
Co	12	1.48	1.19	88:106	47	14
Cr	100	1.26	1.13	106:106	65	100
Cu	15	1.91	1.19	99:106	48	19
Ga	22	1.38	1.16	101:106	29	30
La	54	1.25	1.24	13:106	<70	<70
Mn	120	2.41	1.19	106:106	4100	280
Ni	41	1.36	1.10	106:106	66	45
Pb	21	1.64	1.23	63:106	98	<20
Sc	17	1.18	1.10	103:106	18	19
Sr	120	1.79	1.24	102:106	85	250
V	98	1.35	1.16	106:106	91	110
Y	30	1.27	1.13	98:106	27	<20
Zn	210	1.65	1.68	4:106	<500	<500
Zr	180	1.62	1.16	106:106	140	120

Table 6C.--Cont.

Part II. Medians by areas (quadrangle pairs)
[The number of samples in each area is given in parentheses]

Shale:

	GD	Shetlerville-Rosiclare (16	Pleasant Green Hill-Honey Grove (14)	South Union-Rockfield (14)	Cub Run-Millerstown (14)	Cumberland City (8)	Barthell-Sawyer (14)	Maretburg-Bighill (14)	Wrigley-Portsmouth (12)
FeO %	1.75	0.64	0.38	0.50	1.2	0.42	1.6	0.64	0.74
Na2O %	1.84	.10	.27	.30	.20	.25	.60	.25	.20
P2O5 %	1.91	.08	.07	.06	.08	.05	.16	.09	.10
Ba	1.30	180	190	230	220	260	290	280	300
Cr	1.23	110	100	120	120	83	86	100	95

1/ Computed on untransformed data.
2/ CO2 is bimodal due to the erratic distribution of carbonate minerals. There is a primary mode at <0.05% and a minor secondary mode at 12%.

Table 6D.--Summary geochemical statistics for shale of Pennsylvanian age in Kentucky. [Data are in parts per million except where noted as percent (%); GM, geometric mean; GD, geometric deviation; GE, geometric error; Ratio, number of analyses in which constituent was determined to total number of analyses; M, Median; leaders (--) indicate insufficient data]

Part I. Statewide summary

	Shale				Siliceous Shale		Paleosols(?)	
	GM	GD	GE	Ratio	M	Ratio	PSH-F211	PSH-F212
Oxides:								
SiO_2 % 1/	64.0	8.2	1.2	128:128	89.0	4:4	51.0	52.0
Al_2O_3 %	17	1.30	1.13	128:128	4.7	4:4	23	20
Fe_2O_3 %	3.4	1.76	1.13	128:128	1.2	4:4	5.5	12
FeO %	.66	2.41	1.45	125:128	<.1	2:4	.87	.35
MgO %	1.0	1.79	1.16	128:128	.25	4:4	1.6	1.0
CaO %	.22	2.10	1.89	112:128	.25	4:4	.95	3.4
Na_2O %	.39	2.20	1.72	125:128	.12	4:4	.3	.3
K_2O %	2.8	1.53	1.12	128:128	.8	4:4	3.8	2.8
H_2O+ %	4.4	1.42	1.10	128:128	1.2	4:4	4.9	5.4
TiO_2 %	.96	1.20	1.06	128:128	.73	4:4	.92	.99
P_2O_5 %	.11	2.00	1.56	128:128	.03	4:4	.21	.37
CO_2 %	<.05	--	--	33:128	<.05	0:4	.19	<.05
Elements:								
B	60	1.39	1.18	127:128	110	4:4	<30	<30
Ba	420	1.55	1.11	128:128	140	4:4	430	290
Be	<5	--	--	1:128	<5	0:4	<5	<5
Co	9.1	2.26	1.38	89:128	<5	0:4	15	18
Cr	89	1.35	1.15	128:128	51	4:4	110	86
Cu	26	1.89	1.21	126:128	<3	0:4	60	110
Ga	29	1.56	1.11	124:128	<10	0:4	40	<32
La	25	2.68	1.44	50:128	<30	0:4	<30	<30
Mn	190	2.96	1.34	128:128	16	4:4	160	350
Nb	8.5	1.89	1.34	24:128	<15	0:4	<15	<15
Ni	31	1.72	1.16	125:128	12	4:4	49	72
Pb	24	1.44	1.37	106:128	<15	0:4	33	31
Sc	18	1.21	1.10	128:128	12	4:4	20	20
Sr	120	1.62	1.21	125:128	40	4:4	150	180
V	120	1.53	1.10	128:128	33	4:4	170	130
Y	2/ 37	1.53	1.14	126:128	36	4:4	25	64
Zn	140	1.87	1.39	3:128	<500	0:4	<500	<500
Zr	230	1.59	1.15	128:128	680	4:4	110	130

Table 6D.--Cont.

Part II. Medians by areas (quadrangle pairs)
[The number of samples in each area is given in parentheses]

Shale:

	GD	Shetlerville-Salem (16)	Slaughters (8)	Tell City-Brownsville (16)	Sawyer-Vox (16)	London-Parrot (16)	Tiptop-White Oak (16)	Lancer-Matewan (16)	Wrigley-Haldeman (16)	Rush-Boltsfork (12)
CaO %	2.04	0.27	0.40	0.30	0.20	0.19	0.25	0.35	0.20	0.22
Na2O %	2.13	.13	.80	.45	.35	.53	.45	.57	.30	.28
B	1.34	104	45	58	60	60	60	47	64	50
Co	2.17	13	15	<5	<5	13	<5	15	13	12
Pb	1.50	<15	31	23	25	30	25	26	26	28

1/ Computed on untransformed data.
2/ Sample PSH-H111 (Caseyville Formation, Salem quadrangle) contained 480 ppm Y.