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Geochemical analyses and summaries of Mississippian and Pennsylvanian sandstone 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 is the third and last in a series that summarizes results of a study of geochemical variability in Paleozoic rocks of Kentucky (cf. Connor, 1981a, b). The study was undertaken as a field experiment in geochemical sampling and was based on an attempt to collect rock samples 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. In addition, of the three conventional sedimentary rock types, sandstone is probably affected most by the weathering process. Limestone weathers by dissolution; thus, if an outcrop exists, the chances are good that it won't be deeply weathered. A nearly pure claystone, as a generally impervious material, also may not become deeply weathered in outcrop. Sandstone, on the other hand, particularly coarse or well-sorted sandstone with its easily leachable cements, may undergo great geochemical change but still remain a recognizable sandstone in outcrop. These difficulties notwithstanding, the data resulting from this study were used to identify 6 stratigraphic-geochemical subpopulations in the Mississippian and Pennsylvanian sandstone of Kentucky.

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, all sampling was restricted to those areas covered by mapped 7-1/2' quadrangles at the time of sample selection. In all, 145 samples of sandstone were collected from 16 formations.

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

STRATIGRAPHIC SETTING

Rocks of Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian age crop out in Kentucky (fig. 1), but only Mississippian and Pennsylvanian rocks contain substantial amounts of sandstone. Rocks of Osagean age (Lower Mississippian) in Kentucky are represented largely by the Borden and Fort Payne Formations (Sable, 1979). They constitute a heterogeneous assortment of interbedded limestone, dolomite, sandstone, shale, siltstone and chert. Deltaic clastics are dominant to the northeast (Borden Formation) and 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.

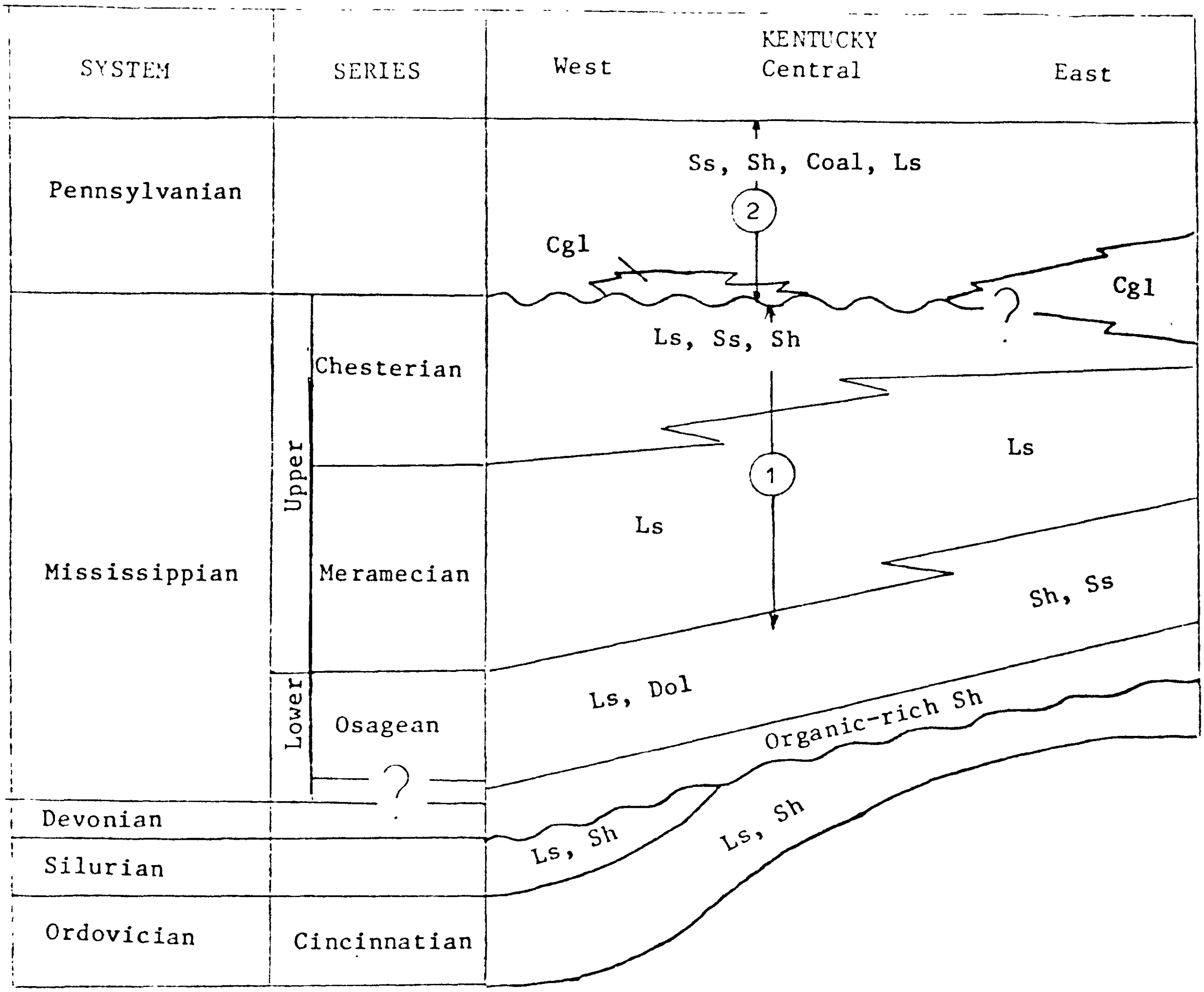


Figure 1.--Regional stratigraphic relations of Paleozoic rocks in Kentucky. Sampled sandstone units are numbered.

In south-central Kentucky, the upper part of the Borden-Fort Payne interval and the overlying Warsaw Limestone contain a number of thin, geographically restricted sandstone bodies, including the Knifely Sandstone Member of the Fort Payne (Kepferle and Lewis, 1974) and the Science Hill Sandstone Member of the Warsaw Limestone (Lewis and Taylor, 1979). 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 overlying Salem-Warsaw interval of west-central Kentucky (Sable and others, 1966).

Overlying the Borden-Fort Payne interval is a highly variable thickness of nearly pure limestone, mostly of Meramecian age, which in turn is overlain by a sequence of interbedded limestone, sandstone and shale, mostly Chesterian in age. Together, these rocks, which comprise nearly all of the Upper Mississippian System 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.

Meramecian rocks mark the peak of the Mississippian transgression; they consist of light- to dark-gray, finely to coarsely crystalline, cherty, fossiliferous limestone. The overlying Chester thins rapidly from 300 m in the middle of the Illinois Basin to less than 150 m near the Cincinnati Arch (fig. 2) about 100 km to the east. This thinning reflects both slower deposition and pre-Pennsylvanian erosion. These 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 includes, in part, the Pennington Formation, and in south-central Kentucky, it includes the Hartsel Sandstone.

The Pennsylvanian rocks comprise a heterogeneous assortment of interbedded, poorly sorted sandstone, shale, siltstone, claystone, coal, conglomerate, and carbonate. They 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, finely crystalline 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 and 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, 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). The trace elements were determined in Denver, Colo., by a direct-reading emission spectrographic method described in Havens and Myers (1973).

The geochemical analyses are listed in tables 1A-1C. All samples were analyzed in duplicate. Thus in table 1A, the first two rows (sample M-S211) are replicate analyses of a single sample; the next two rows (sample M-S212) are replicate analyses of another sample; and so forth. Trace elements commonly looked for but rarely detected are listed in table 2 along with their approximate lower limits of determination. Thin-section modes, based on 100 points per section, were counted on all samples. Average modes are listed in table 3.

SAMPLING DESIGN

The same sampling design was used in the study of both the Mississippian and Pennsylvanian sandstones. It 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. For each stratigraphic unit (Mississippian or Pennsylvanian), the State was arbitrarily divided into one-degree areas, and two mapped 7-1/2' quadrangles were selected randomly within each one-degree area, if possible. For some one-degree areas, only two quadrangles were available for sampling. 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 stratigraphic unit. In each locality, two random samples of 2-4 kg were taken from outcrop.

Ten samples of Mississippian sandstone and 23 samples of Pennsylvanian sandstone were collected from float blocks in localities lacking outcrop. Because sample design was deemed of primary importance in this study, problems of outcrop availability were subordinated, in part, to the requirements of geographic location. In practice, float block samples were no more weathered on average than outcrop samples.

Following collection, samples of the Mississippian from the Cane Valley, Russell Springs, and Amandaville quadrangles (fig. 2) were placed into a separate stratigraphic category. They were collected near the Fort Payne-Warsaw contact (near the Lower-Upper Mississippian boundary) and, thus, lie stratigraphically far below the other Mississippian sandstone samples, most of which were of Chesterian age. The lower group of samples were deposited before the peak of Mississippian trangression whereas the upper, larger group were deposited following that peak. Because 8 of the 12 lower samples were collected from the Knifely Sandstone Member of the Fort Payne, they will be referred to here collectively as the Knifely and associated sandstones. Moderate amounts of sandstone also crop out near the base of the Lower Mississippian in northeastern

Kentucky (the Berea Sandstone and the Farmers Member of the Borden Formation) but no samples of these were collected due to lack of mapping at the time of collection.

The sampled quadrangles are listed in figure 2, and the sampling sites are described in tables 4A-4C. The quadrangle pairs in each one-degree area for the Upper Mississippian and Pennsylvanian units are identified in Part II of tables 6B and 6C. Because of lack of suitably spaced outcrops, one pair of 7-1/2' quadrangles for the Upper Mississippian unit (Cumberland City and Barthell) came from different one-degree areas.

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 3. The theoretical frequency distribution of a distance between two points in a rectangle was based on work of Ghosh (1951). The planned frequency distribution is based on distances between sample pairs (or locality pairs) as picked in the office using randomization procedures. The actual frequency distribution is based on the distances between sample (locality) pairs that actually occurred in the field. In general the planned distances are slightly less than the theoretical distances, but the actual distances between samples are much less than either the planned or theoretical. 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:		
Mississippian	.27	.072
Pennsylvanian	.27	.21
Between localities:		
Mississippian	6.4	4.1
Pennsylvanian	6.4	4.8
Between quadrangles:		
Mississippian	53	29
Pennsylvanian	53	34

Commonly, a randomly picked locality lacked outcrop. In such a case, samples were collected as close as possible to the randomly picked locality. The average error in distance between the planned and actual sampling site, both geographically and stratigraphically, is diagrammed in figure 4.

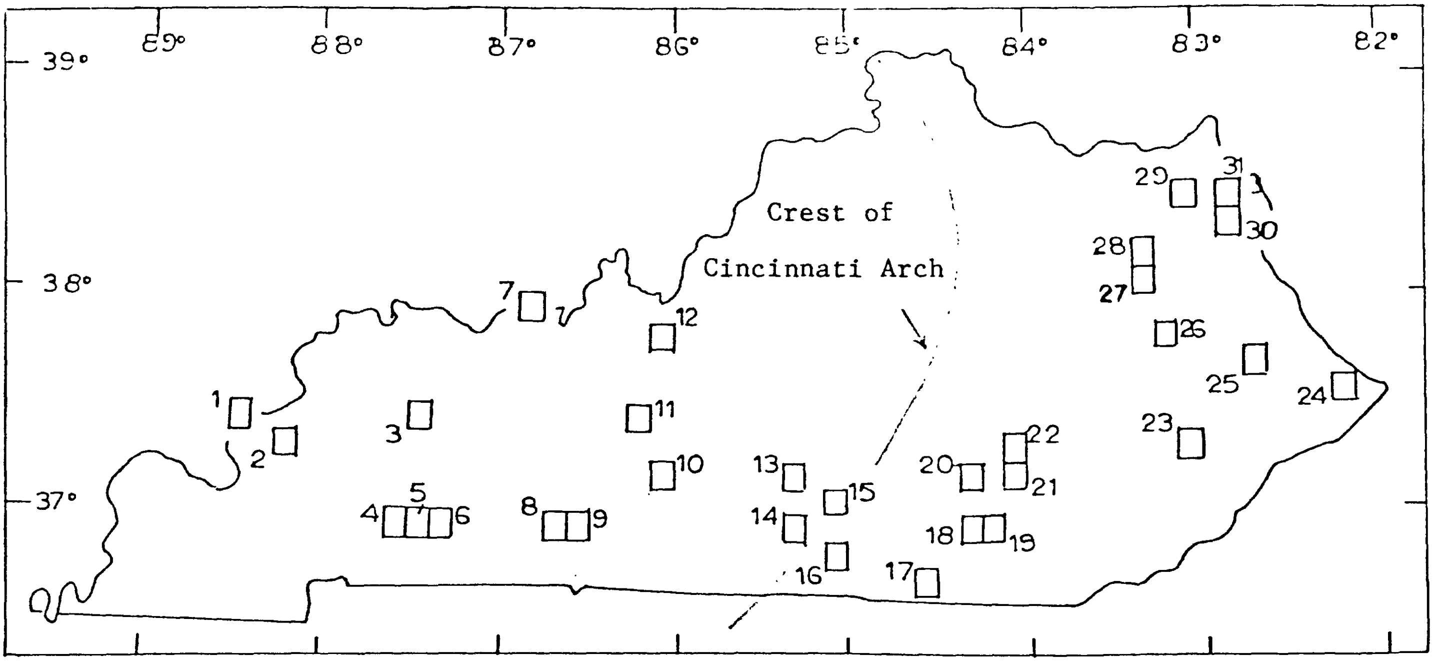


Figure 2.--Location of 7-1/2' quadrangles from which sandstone of Paleozoic age was collected [K, Knifely and associated sandstones; UM, sandstone of Upper Mississippian age (mostly Chester); P, sandstone of Pennsylvanian age]

Quadrangle No.	Name	Unit sampled	U.S.G.S. Map GQ-	Author and year
1.	Shetlerville	UM,P	400	D. H. Amos, 1965
2.	Salem	UM,P	206	R. D. Trace, 1962
3.	Hanson	P	365	G. J. Franklin, 1965
4.	Pleasant Green Hill	UM	321	W. H. Nelson, 1964
5.	Kelly	P	307	T. P. Miller, 1964
6.	Honey Grove	UM,P	376	Harry Klemic, 1965
7.	Tell City	P	356	F. D. Spencer, 1964
8.	South Union	UM	275	Harry Klemic, 1963
9.	Rockfield	UM	309	H. C. Rainey, III, 1964
10.	Mammoth Cave	P	351	D. D. Haynes, 1964
11.	Clarkson	UM	278	E. E. Glick, 1963
12.	Flaherty	UM	229	W C Swadley, 1963
13.	Cane Valley	K	369	C. H. Maxwell and W. B. Turner, 1964
14.	Amandaville	K	186	A. R. Taylor, 1962
15.	Russell Springs	K	383	R. Q. Lewis, Jr., and R. E. Thaden, 1965
16.	Cumberland City	UM	475	R. Q. Lewis, Sr., and R. E. Thaden, 1965
17.	Barthell	UM	314	J. B. Pomerene, 1964
18.	Sawyer	UM,P	179	W. P. Puffett, 1962
19.	Vox	P	224	W. P. Puffett, 1963
20.	Billows	UM	228	N. L. Hatch, Jr., 1963
21.	London	P	245	N. L. Hatch, Jr., 1963
22.	Parrot	UM,P	236	D. F. Crowder, 1963
23.	Carrie	P	422	V. M. Seiders, 1965
24.	Matewan	P	373	V. A. Trent, 1965
25.	Lancer	P	347	C. L. Rice, 1964
26.	White Oak	P	1/	W. L. Adkison, 1957
27.	Wrigley	UM,P	170	J. W. Hosterman, S. H. Patterson, and J. W. Huddle, 1961
28.	Haldeman	P	169	S. H. Patterson and J. W. Hosterman, 1961
29.	Tygarts Valley	UM	289	R. A. Sheppard, 1964
30.	Rush	P	408	J. E. Carlson, 1965
31.	Argillite	P	175	R. A. Sheppard and J. C. Ferm, 1962

1/ Published in U. S. Geological Survey Bulletin 1047-A (Coal Geology of the White Oak Quadrangle, Magoffin and Morgan Counties, Kentucky).

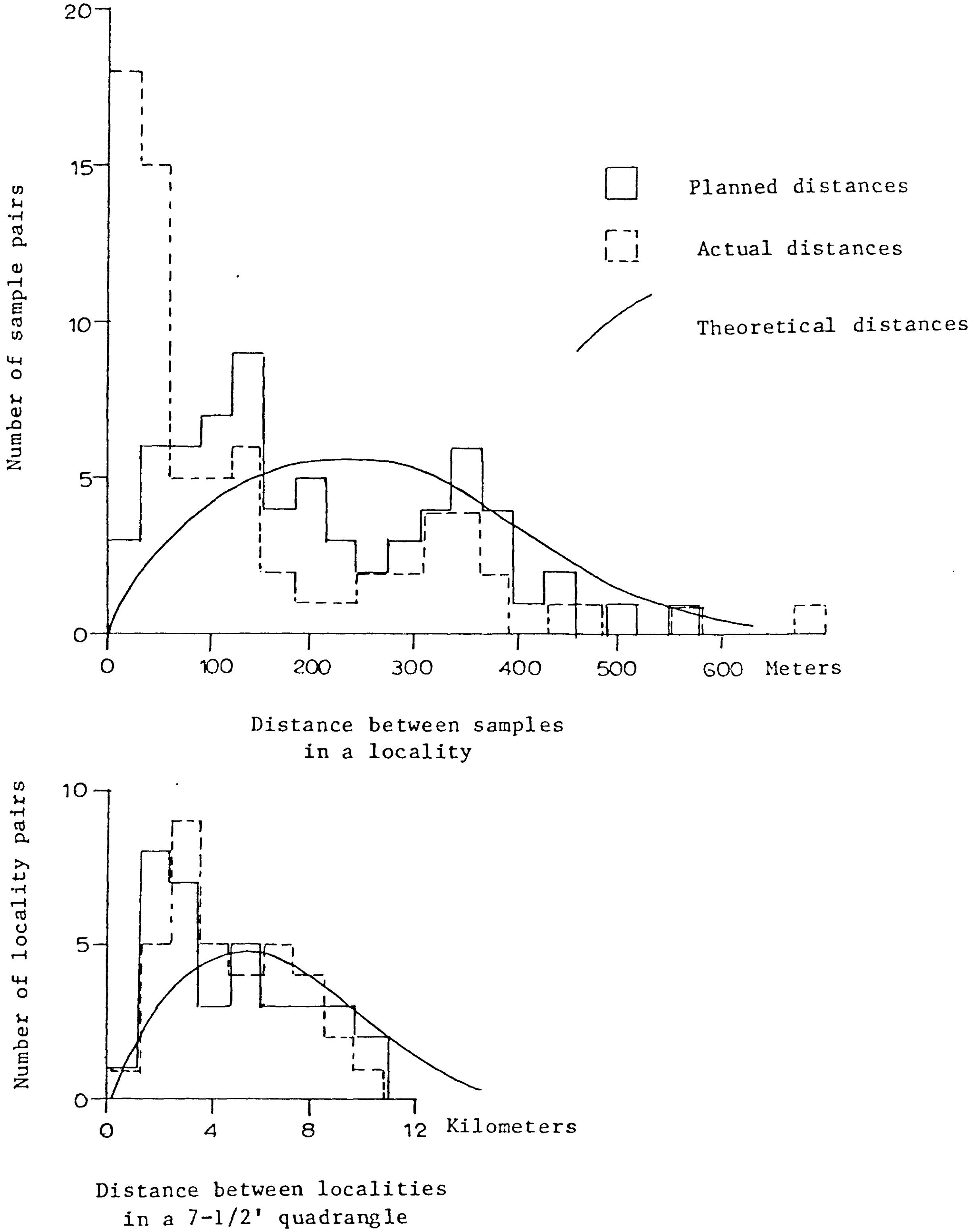


Figure 3.-- Comparison of theoretical, planned and actual distances between samples and between sampling localities in the hierachical sampling plan used in the study of Mississippian and Pennsylvanian sandstone in Kentucky.

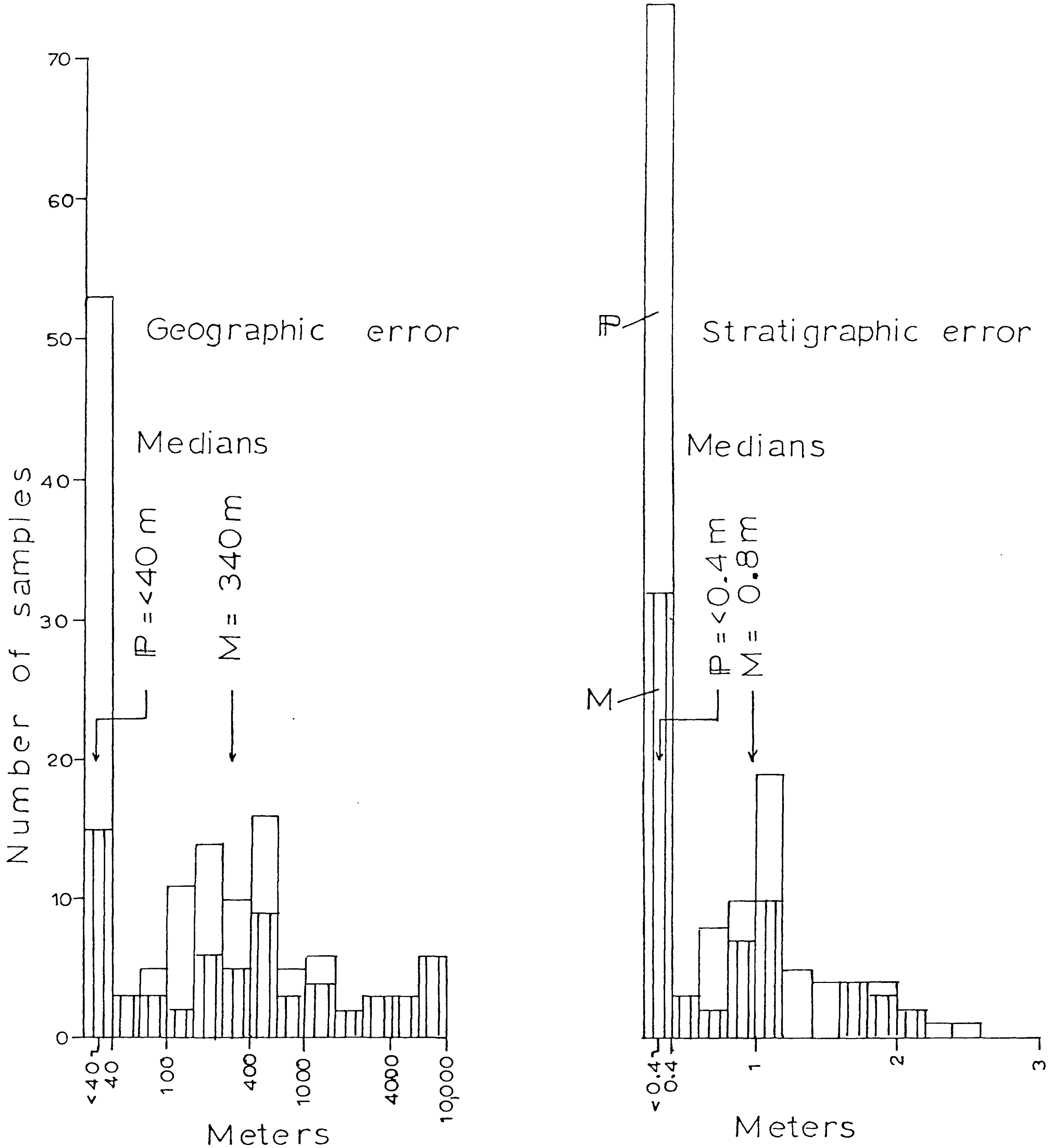


Figure 4.--Average distance (error) between planned and actual sampling sites for samples of Mississippian [M] and Pennsylvanian (P) sandstone in Kentucky.

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

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

where X(ijklm) represents an analytical value reported by the analyst; M represents the grand average (in logs) for that element in the 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 are commonly employed in trace element work 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)

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

where V(Log X) is the total logarithmic variance. Miesch (1976) discusses the concepts underlying equations (1) and (2) in detail.

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 a concentration was 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 and 5B.

Where the analysis of variance indicated significant differences between 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 6B and 6C). 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 statistically significant, one can have a prescribed confidence that at 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. Thus, v(m) as used in tables 5A and 5B is biased to the high side to an unknown (but probably small) degree. The resulting bias in v(m) is footnoted (tables 5A, 5B).

MINERALOGY

The normative mineralogy of the sandstone samples used in this study is shown in figure 5. All Al_2O_3 was assigned to illite of 26 percent Al_2O_3 composition, and excess SiO_2 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 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 (which was uncommon), the original MgO and CaO concentrations were reduced by two percent and one percent, respectively, and the two carbonate minerals recomputed.

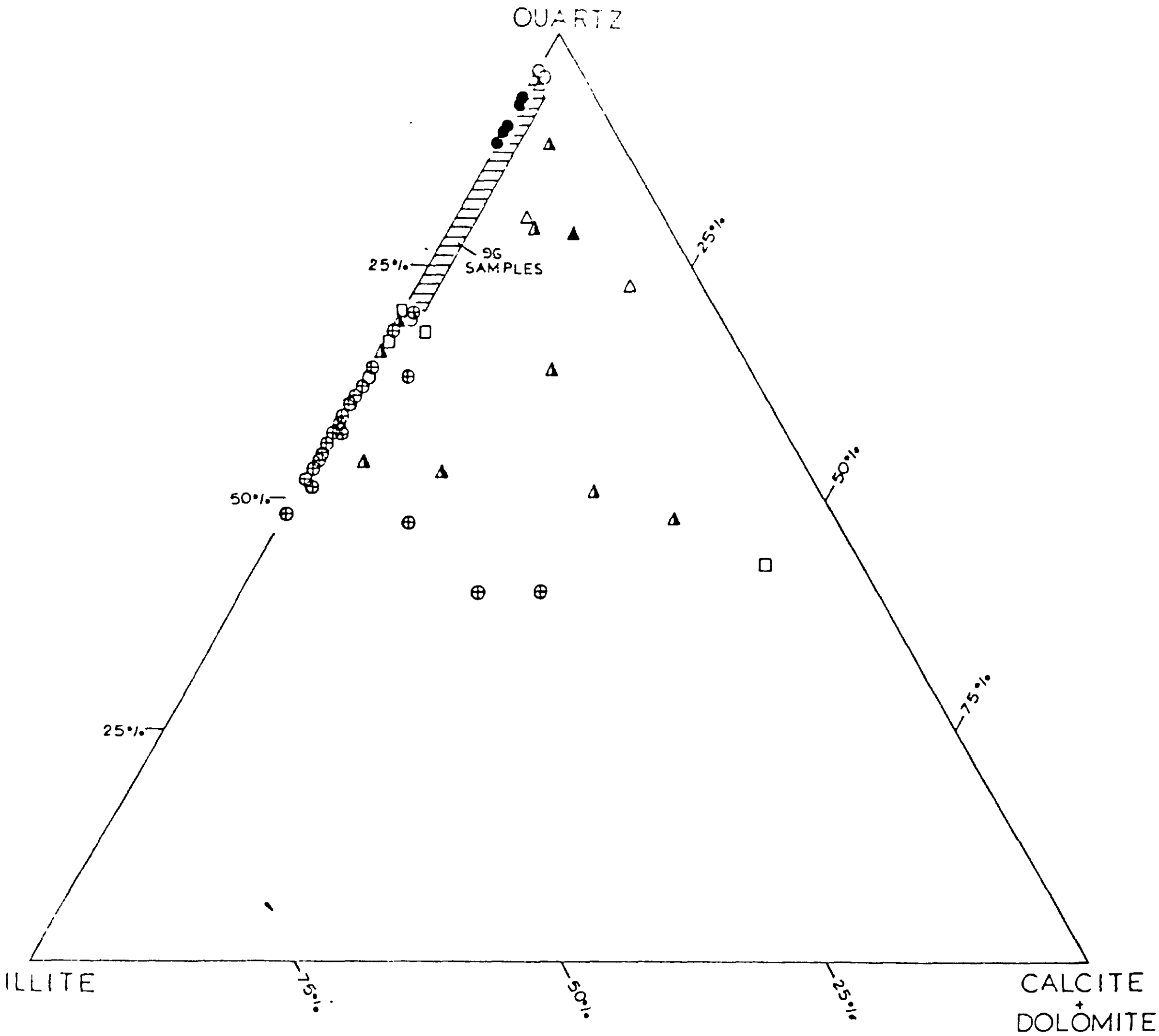


Figure 5.--Plot of normative mineralogy of Paleozoic sandstone in Kentucky.

Stratigraphic unit	Sandstone	Fe-rich	Calcareous siltstone
Pennsylvanian			
Quartzose sandstone	○	●	
Lithic sandstone	⊕		
Upper Mississippian	△		◬
Dolomitic sandstone	▲		
Knifely and associated sandstones	□		

In thin section, samples of the Knifely and associated sandstones were, in general, mineralogically immature and poorly sorted. Most were lithic sandstones; samples M-K221 and M-K222 from the Cane Valley quadrangle were so poorly sorted as to be graywackes. The framework grains included quartz, feldspar, clay pellets and schistose fragments (many chloritic) and were generally angular to subangular. Also, samples M-K221 and M-K222 were chertified. The chert occurs in bands of a few millimeters thickness and contains ghosts of dolomite rhombs, indicating that the bands may have been originally calcareous. All samples, except M-S211, were weathered to a lesser or greater degree, and some exhibited iron-stained clay wrapped around the framework grains suggesting soil development. Sample M-K121 (from the Russell Springs quadrangle) was particularly hematitic. Sample M-S211 (from the Amandaville quadrangle) was a sandy limestone (60% calcite) and was excluded from the geochemical summary (table 6A).

Samples of Upper Mississippian (Chester) sandstone for the most part consisted of very fine to medium-grained lithic arenites. These sandstones contained about twice as much rock fragmental material as they did detrital feldspar. The framework was largely composed of well-rounded (and commonly well-sorted) quartz, which was mostly clear but was in places clouded (brown) or microlitic. Authigenic overgrowths were common. The matrix was mostly a mixture of sericitic clay and silt. Sample M-Q122 (from the Honey Grove quadrangle) was virtually unsorted, but overall, these rocks tend to be texturally mature; they are less mature mineralogically. The four samples from the Sawyer quadrangle in southeast Kentucky (M-T211, M-T212, M-T221 and M-T222) were excluded from the geochemical evaluation (except as a summary on table 6A) because they are calcareous siltstones.

There is little mineralogical difference between Upper Mississippian sandstone from eastern and western Kentucky; sandstone from the Pennington Formation (eastern Kentucky) is less quartzose and more calcareous but this distinction might reflect weathering differences as much as original mineralogical differences. Also, the Pennington sandstones contained less authigenic quartz (lesser original porosity?), more feldspar and rock fragments, and more biotite and chlorite.

Rock fragments in the Upper Mississippian sandstones included chert (some like that in the underlying Meramec limestones), siltstone (some like that in the underlying Borden shales), clay pellets, stretched metaquartzite, and rare pelitic and phyllitic detritus. Feldspar included both microcline and plagioclase. Accessory minerals included leucoxene, tourmaline, zircon, sphene, pyrite, hornblende, and garnet (?). Sample M-Q111 (Honey Grove quadrangle) contained coarse, well-rounded particles of watermelon tourmaline.

Petrographically, sandstones of Pennsylvanian age belong to two groups. The first consists of quartzose, coarse, locally conglomeratic sandstone found mostly in the basal formations (Caseyville and Tradewater Formations in western Kentucky and Lee Formation in eastern Kentucky). The second group consists of finer-grained rocks, locally argillaceous, which contain abundant lithic rock fragments. Some samples in this second group were so poorly sorted as to be graywackes (P-F222, from the Rush quadrangle, P-I222 from the Hanson quadrangle, and P-N221 from the Matewan quadrangle).

Many Pennsylvanian samples exhibited effects of weathering such as surface rinds or a punky and friable texture, and varying degrees of iron-oxide staining. Five samples in the quartzose group (P-J111 and P-J112 in the Mammoth Cave quadrangle, P-Q121 and P-Q122 in the Honey Grove quadrangle, and P-Q222 in the Kelly quadrangle) were heavily cemented by hematite, presumably as a result of prolonged and intense weathering. Possibly, this hematite represents weathered pyrite cement. These five samples were treated separately in the geochemical summary (table 6C).

Strained, stretched and polycrystalline quartz grains were common. Authigenic quartz was widespread, even in the more poorly sorted lithic sandstones. Both microcline and plagioclase are present, more so in the lithic sandstones than in the quartzose ones, and much of the feldspar is flecked with micaceous decomposition products. Rock fragments included mostly sedimentary rock (shale, siltstone, clay aggregates, chert) or metamorphic rock (phyllite, schist), but volcanic (?) fragments and altered biotite suggest that minor igneous rocks were exposed in the source terrane(s).

Detrital muscovite is common; chlorite is rare. Glauconite is present, as are assorted opaque and non-opaque minerals, including hornblende, zircon, tourmaline, sphene, fluorite (?) and garnet (?). Samples P-N122 and P-N222 (Matewan quadrangle) contained hematite pseudomorphous after pyrite. Calcite cement is rare in these rocks, and was seen only in the lithic sandstones; perhaps similar cement in the coarser, more quartzose sandstones has been weathered out.

GEOCHEMICAL VARIABILITY

The analysis of geochemical variance and the geochemical summaries for these sandstones are given in tables 5A-5B and 6A-6C, respectively. In sandstone of Upper Mississippian age, six constituents exhibited statistically significant regional variation--MgO, Na2O, K2O, H2O+, Ba and Mn. The high MgO and H2O+ in the Cumberland City-Barthell and Billows-Parrot areas (table 6B, Part II) appears to reflect a more abundant matrix in those rocks. The high Na2O in the Billows-Parrot area partially reflects this matrix but also reflects a relatively greater plagioclase content. The high K2O in the Clarkson-Flaherty area probably reflects potassium feldspar. The high Mn in the Pleasant Green Hill-Honey Grove and Wrigley-Tygarts Valley area remains unexplained as does the unusually low Ba in the Shetlerville-Salem area.

The calcareous siltstones from the Sawyer quadrangle (table 6B, Part I) are high in all constituents except SiO2 when compared to the ordinary sandstones of this unit. CaO and CO2 are higher by 100 times or more. Most constituents are higher by more moderate amounts, from about 2 to 10 times, indicating that these calcareous rocks are also more argillaceous than the main body of sandstone. The Knifely and associated sandstones (table 6A) are similar to the calcareous siltstone (table 6B, Part I) in Al2O3, Fe2O3, K2O, H2O+, Ba, and V but in general, they are compositionally closer to the main body (Chester) of sandstone.

The analysis of variance of sandstone of Pennsylvanian age is given in table 5B. Much of the regional variance (V(A), first entry of each triplet) reflects the geochemical contrast between the quartzose and lithic sandstones.

Both the percentage and significance of this component drops when the two groups are analyzed separately (V(A), second and third entries). Only SiO_2 displays a significant effect at this level of the design regardless of group. In both groups, sandstone from eastern Kentucky contained slightly less SiO_2 (table 6C, Part II). The only other constituent to display a significant regional component in the quartzose sandstone group was Mn, and that element shows a higher concentration in samples from eastern Kentucky. Additional constituents in the lithic sandstone group which display regional variance are Al_2O_3, Fe_2O_3, K_2O and H_2O+, all important components of argillic material. These oxides tend to be higher in samples from eastern Kentucky (table 6C, Part II), and along with the trend in SiO_2 and Mn, reflect a lesser mineralogical maturity in samples of either group as source is approached.

The highly variable nature of these rocks is demonstrated in figure 6. The frequency distributions in this figure are visual representations based on 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. The distributions demonstrate that much of the geochemical variability in these sandstones arises as a consequence of the presence of distinct geochemical subpopulations within both geologic units. In particular, the quartzose and lithic sandstones of Pennsylvanian age tend to differ in many elements, and most of this difference reflects the argillaceous nature of the lithic group. This argillic material (mostly clay) clearly constitutes a ready reservoir for a variety of trace elements.

Similarly, variation arising as a result of geographic location (differences among area means) mostly reflects geographic differences in argillaceous content. Variation not specifically identified in the diagrams includes variation described by the intermediate-scaled components of equation (2). Such variation commonly accounts for more than half the total, and represents geochemical differences among samples within localities, V(D), among localities within quadrangles, V(C), and among quadrangles within one-degree areas, V(B). V(B) is uniformly small in both geologic units; V(C) is small for sandstone of Pennsylvanian age, but not for sandstone of Upper Mississippian age. Variation at these lower levels of the design largely reflects variation in the quartz/clay ratio among samples. Finally, part of the variation in each distribution reflects laboratory errors, V(E).

On the whole, the distributions in figure 6 are meant to provide a first approximation to the definition of geochemical variability in the Upper Paleozoic sandstones of Kentucky. The fitted distributions are reasonably good. Exceptions include FeO, MgO, CaO, P_2O_5, Mn, and Sr, all associated in part with carbonate cement, which is an erratic component of these rocks. Some distributions in the Pennsylvanian are distinctly bimodal, reflecting the geochemical contrast between the quartzose and lithic groups. Variation (scatter) is relatively large, comparable to that in the Paleozoic limestones (Connor, 1981a), and contrasts with a much greater uniformity of element variation in the Paleozoic shales (Connor, 1981b).

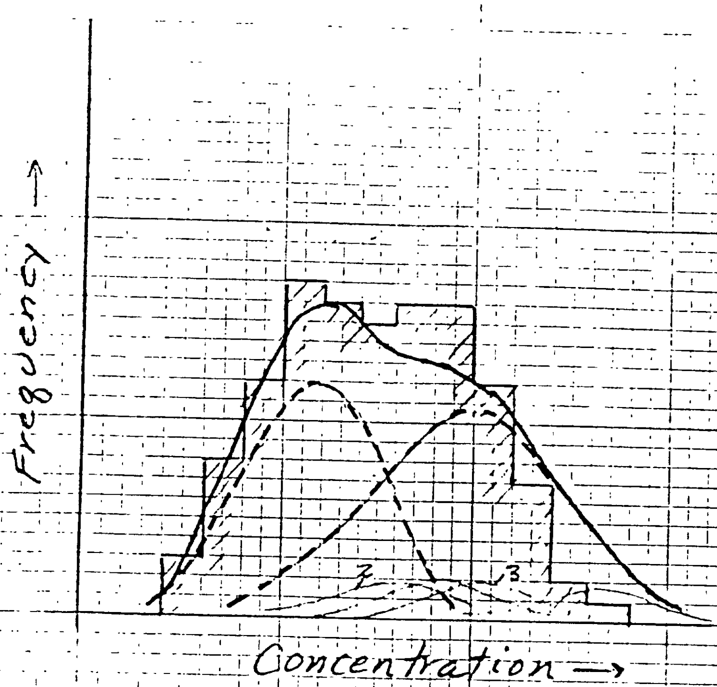


Figure 6.--Explanation of geochemical frequency distributions. The distributions shown on the following pages are meant to visualize the summary data in tables 6A-6D. Histograms for each geochemical variable in the three sandstone units are outlined by hachures. Each histogram is modeled by a heavy black solid line which, in the Upper Mississippian and Pennsylvanian units, is the "sum" of two or more lithically distinct subpopulations, shown by heavy, dashed, black lines. These subpopulations are listed in Part I of tables 6B and 6C, as follows

Table 6B	Sandstone (Ss)
	Calcareous siltstone (Cal Sts)
Table 6C	Lithic sandstone (Lith Ss)
	Quartzose sandstone (Qtz Ss)
	Fe-rich sandstone (Fe Ss)

Subpopulations shown by the light, solid lines are based on the area means of Part II, tables 6B-6C. 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, a GD of 1.5 was assumed.

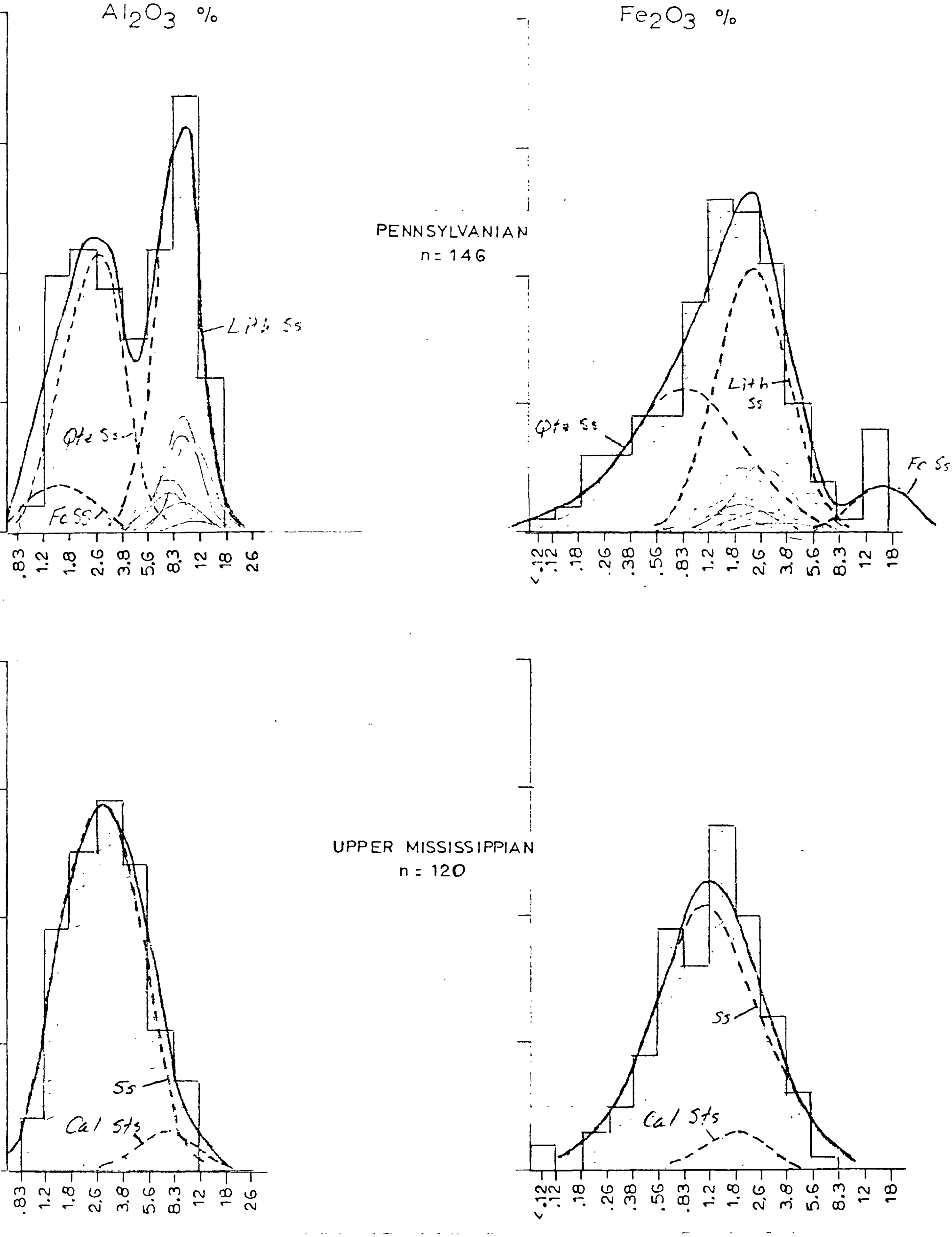


Figure 6.--Continued

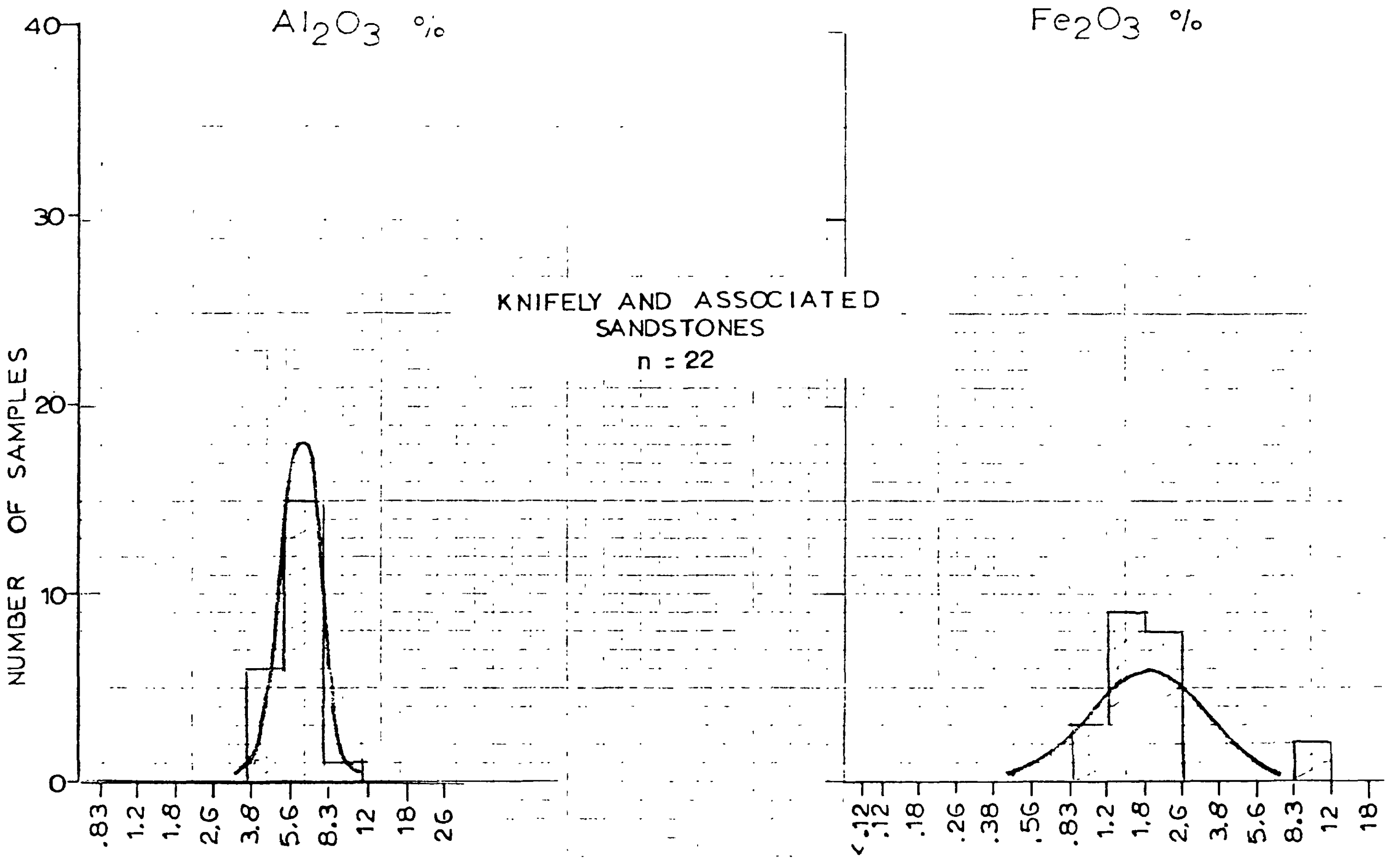


Figure 6.--Continued

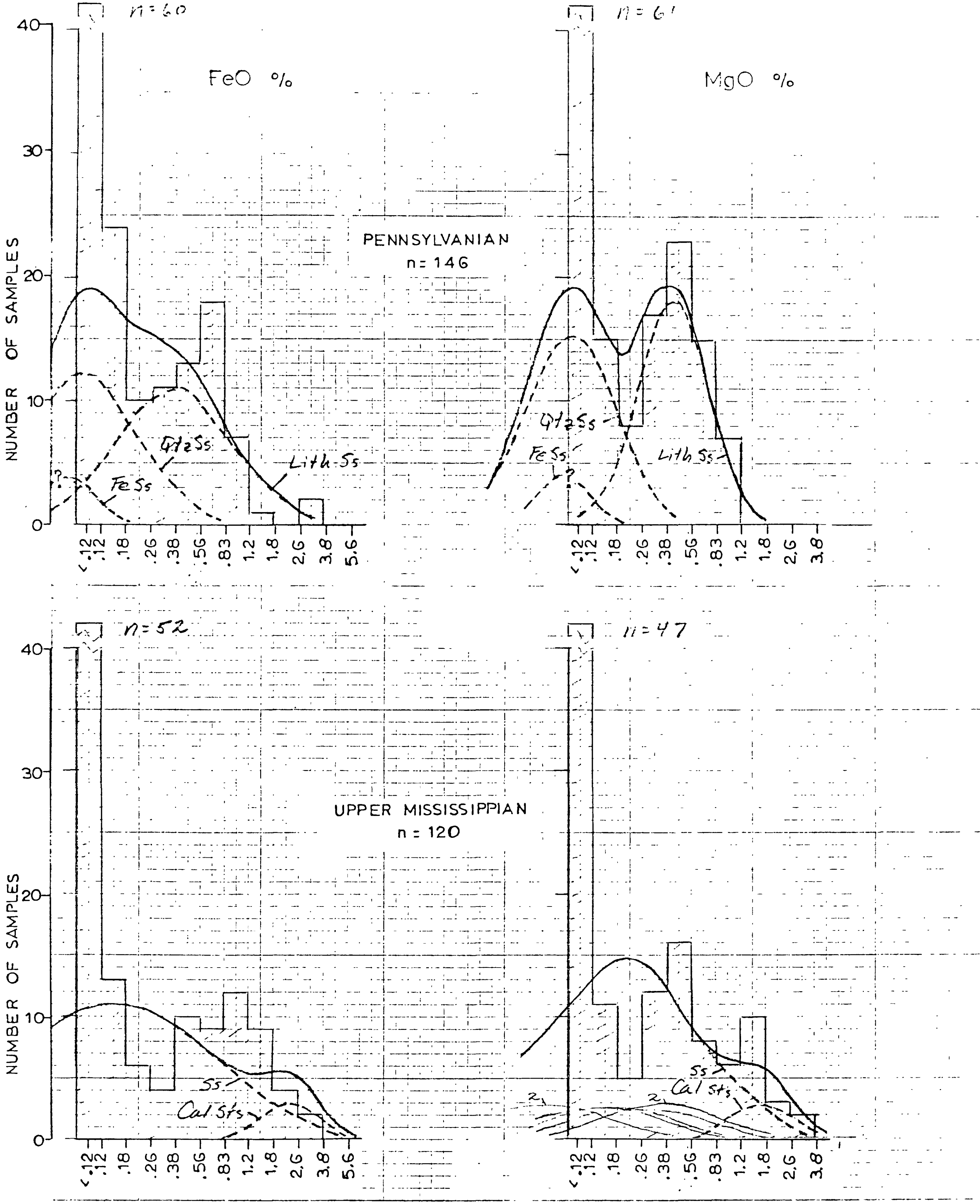

FeO %
MgO %
PENNSYLVANIAN
n = 146
UPPER MISSISSIPPIAN
n = 120
NUMBER OF SAMPLES
Qtz Ss
Fe Ss
Lith Ss
Ss
Cal Sts
n = 52
n = 47

Figure 6.--

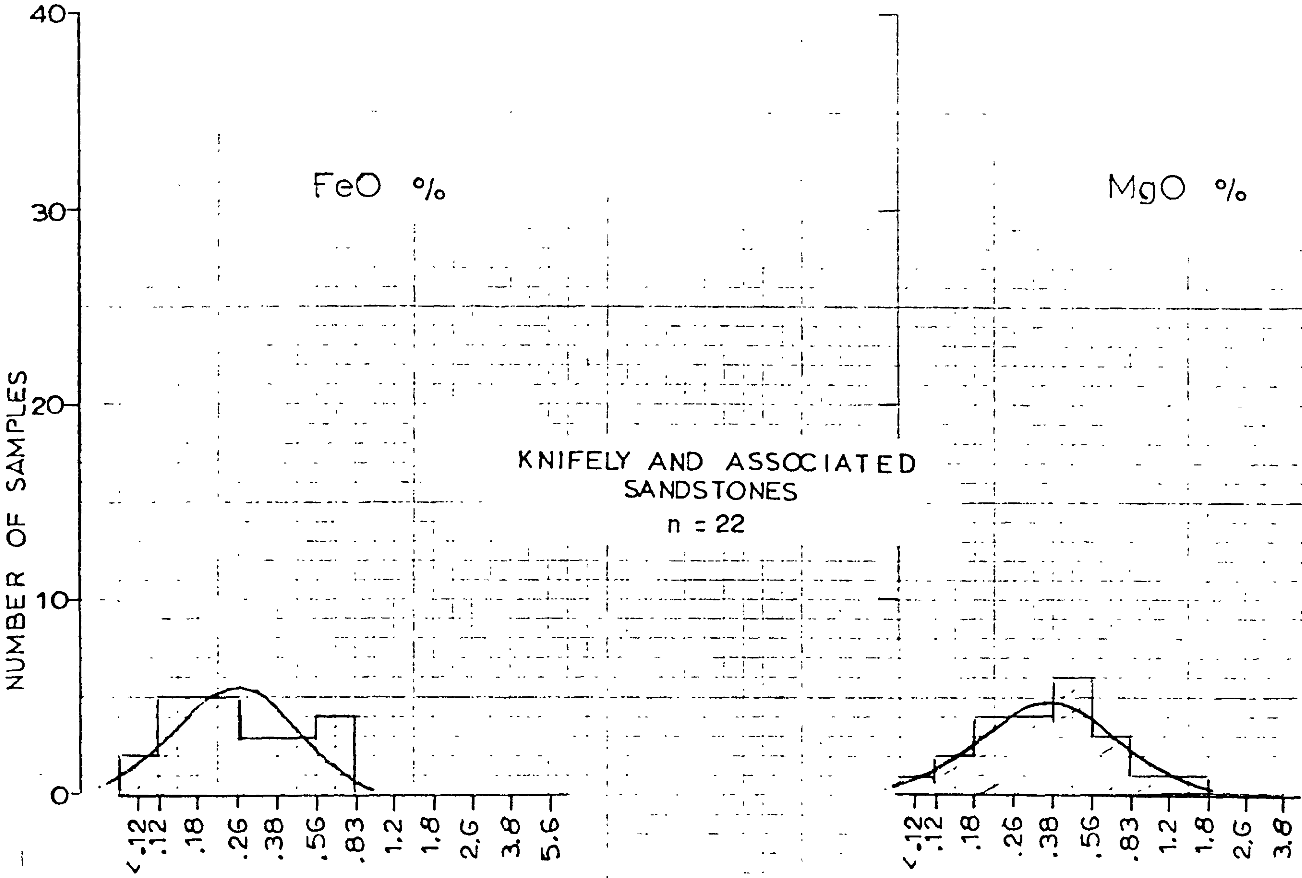


Figure 6.--Continued

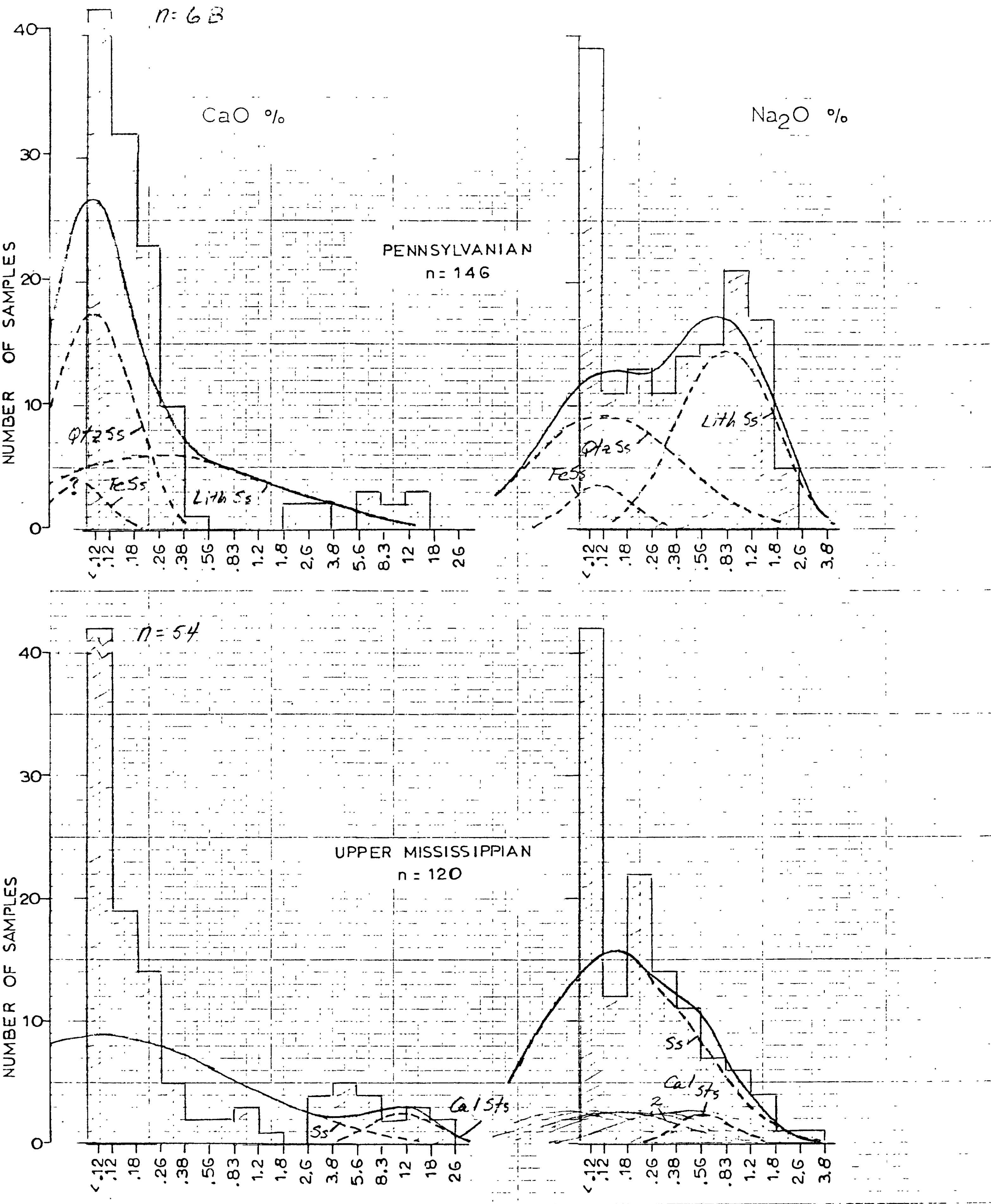


Figure 6.--Continued

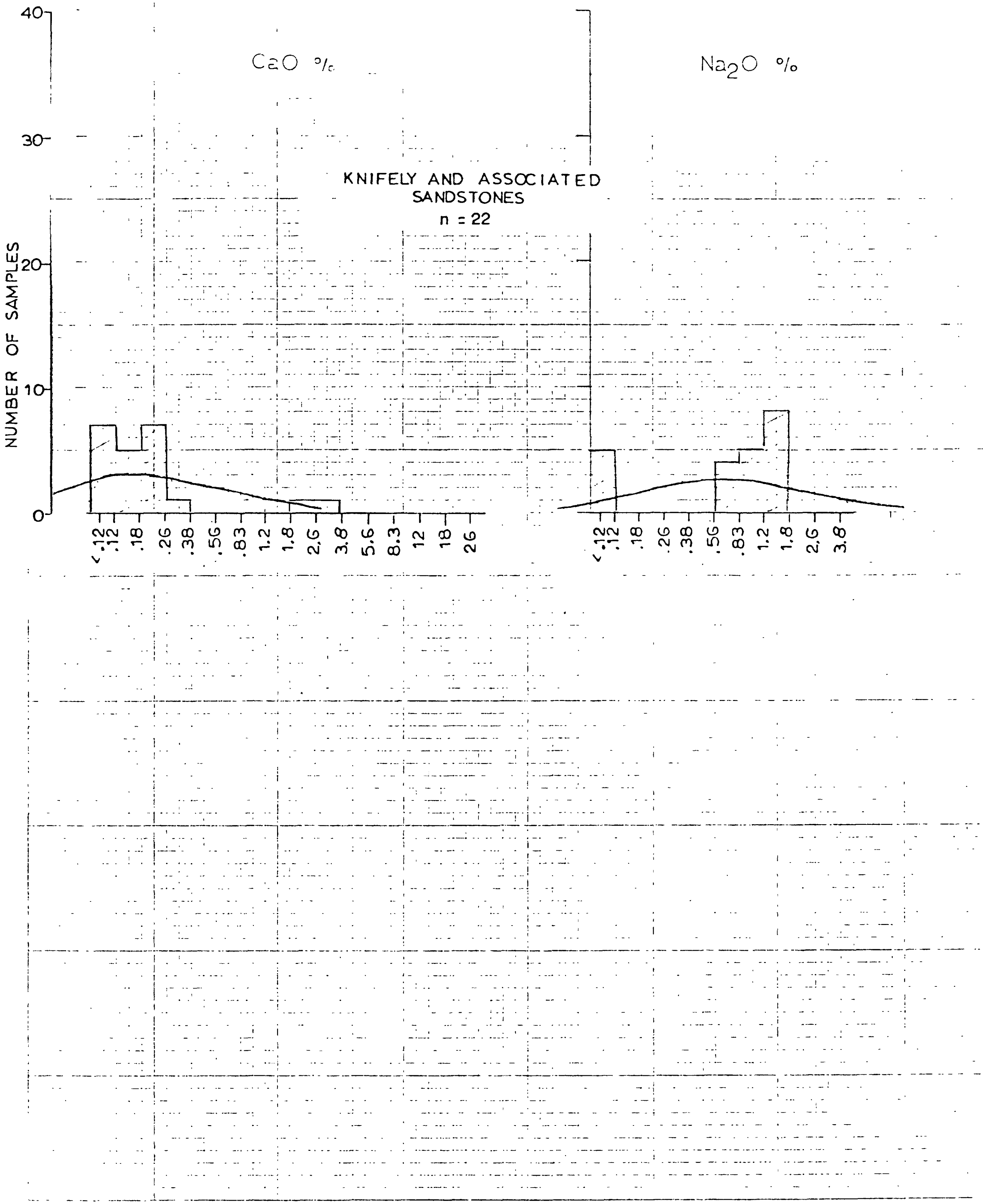


Figure 6.--Continued

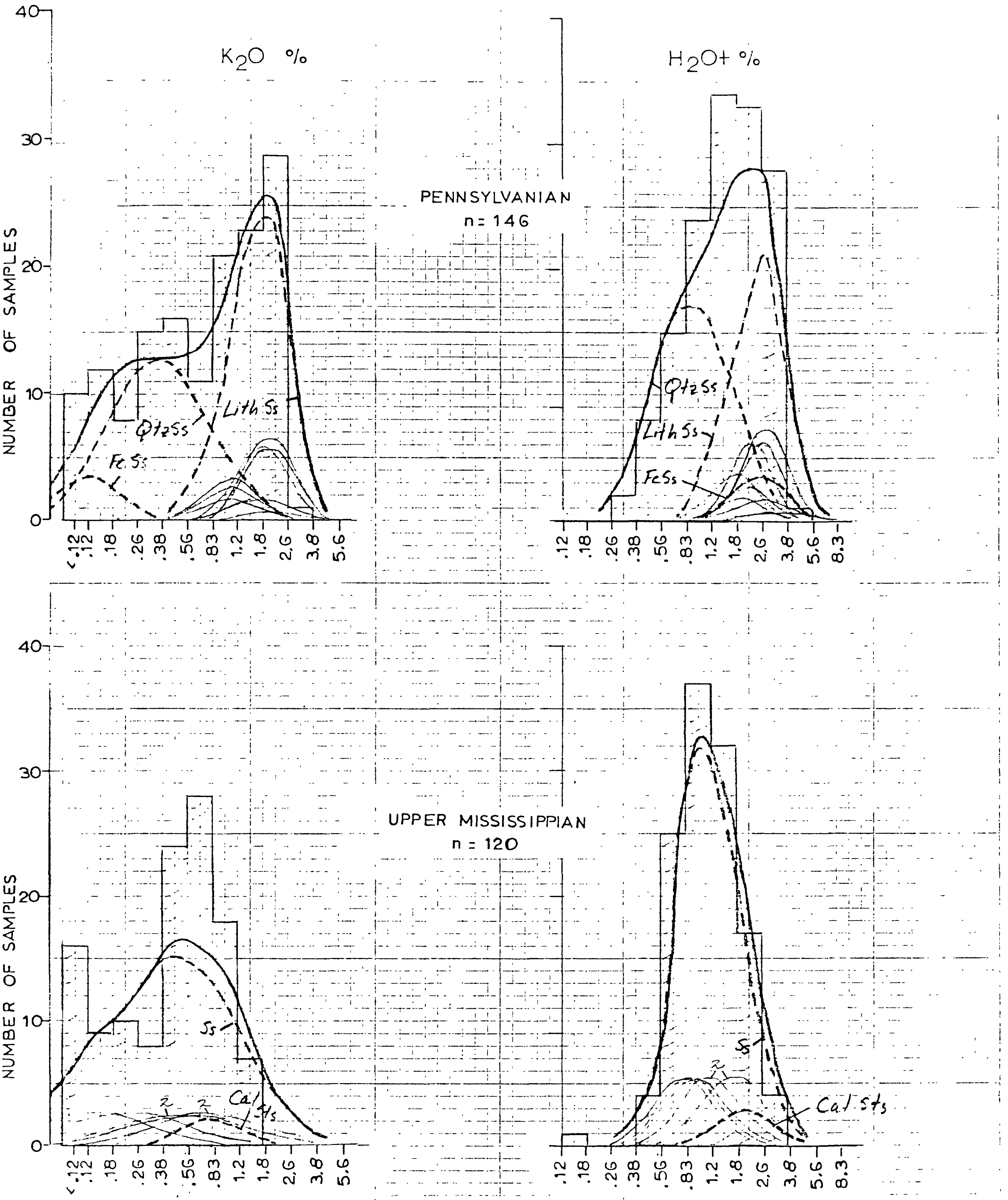


Figure 6.--Continued

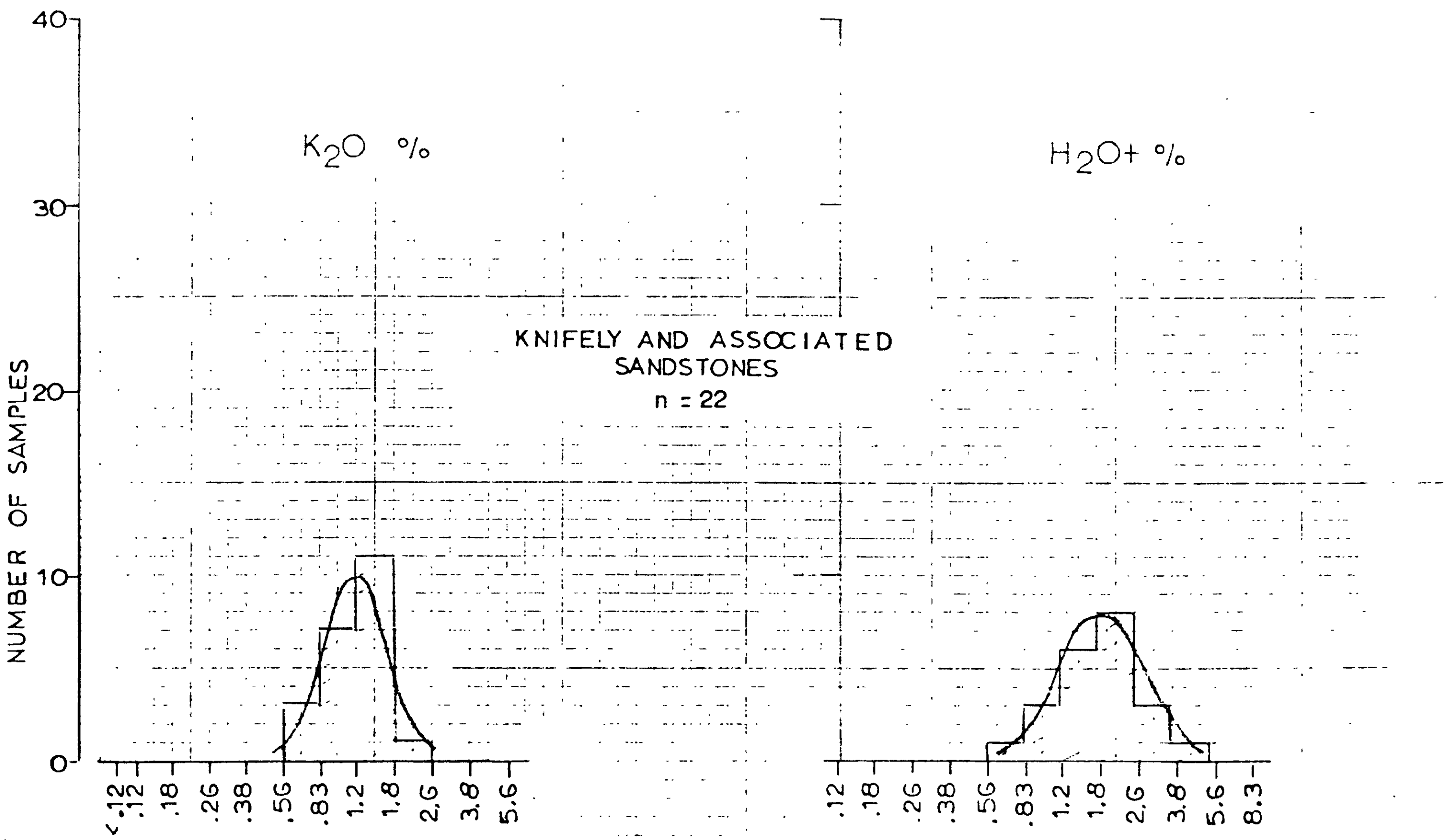


Figure 6.--Continued

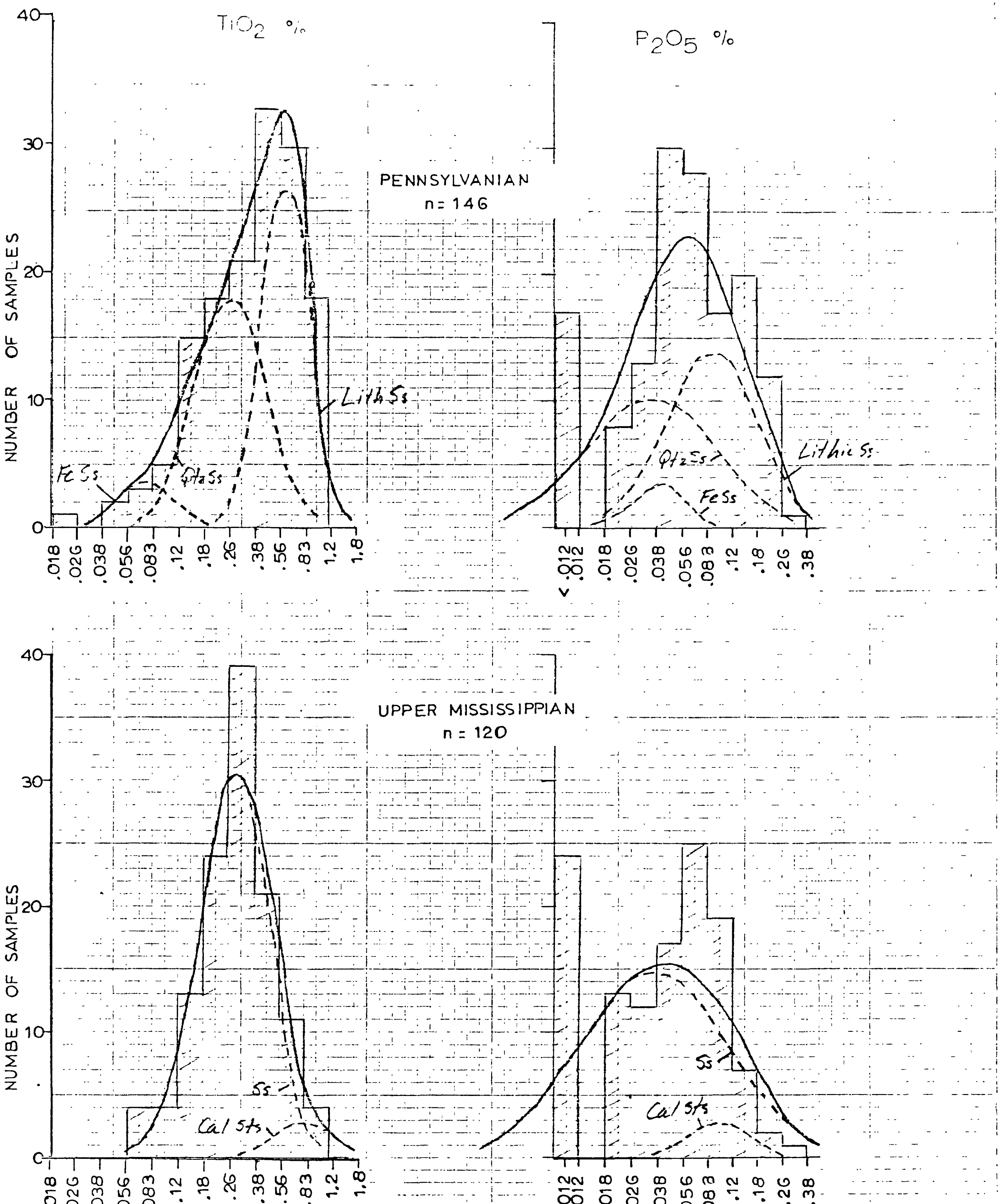


Figure 6.--Continued

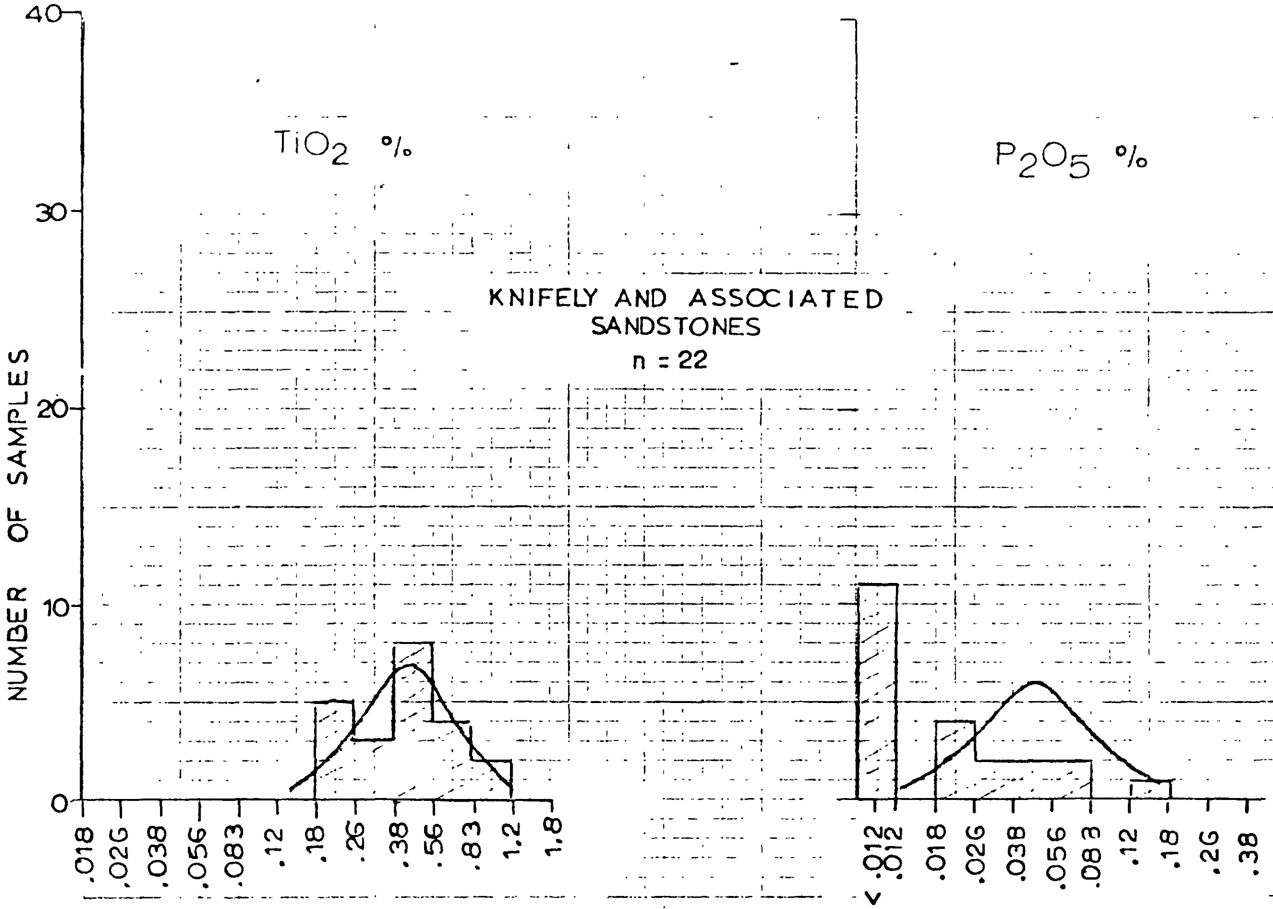


Figure 6.--Continued

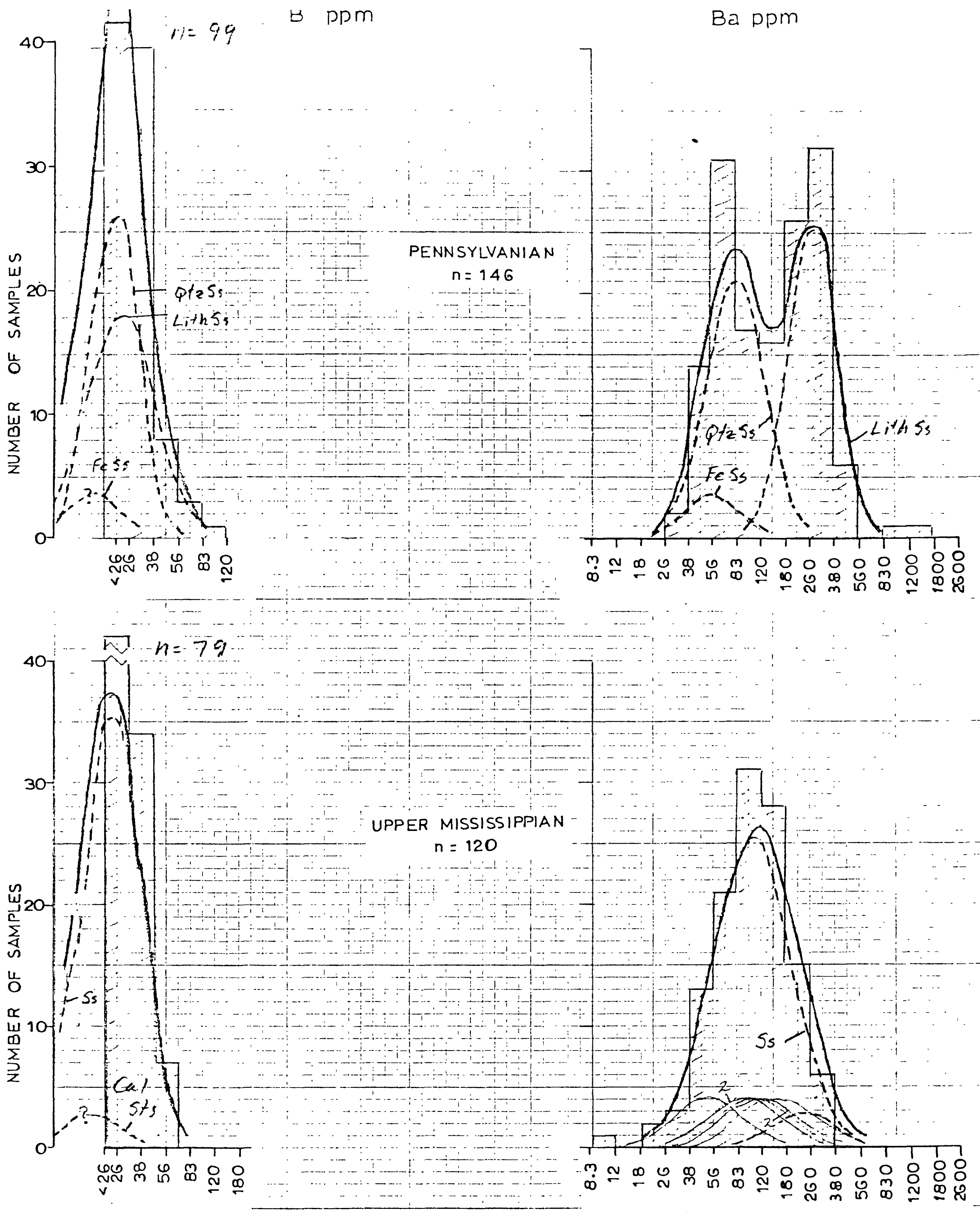


Figure 6.--Continued

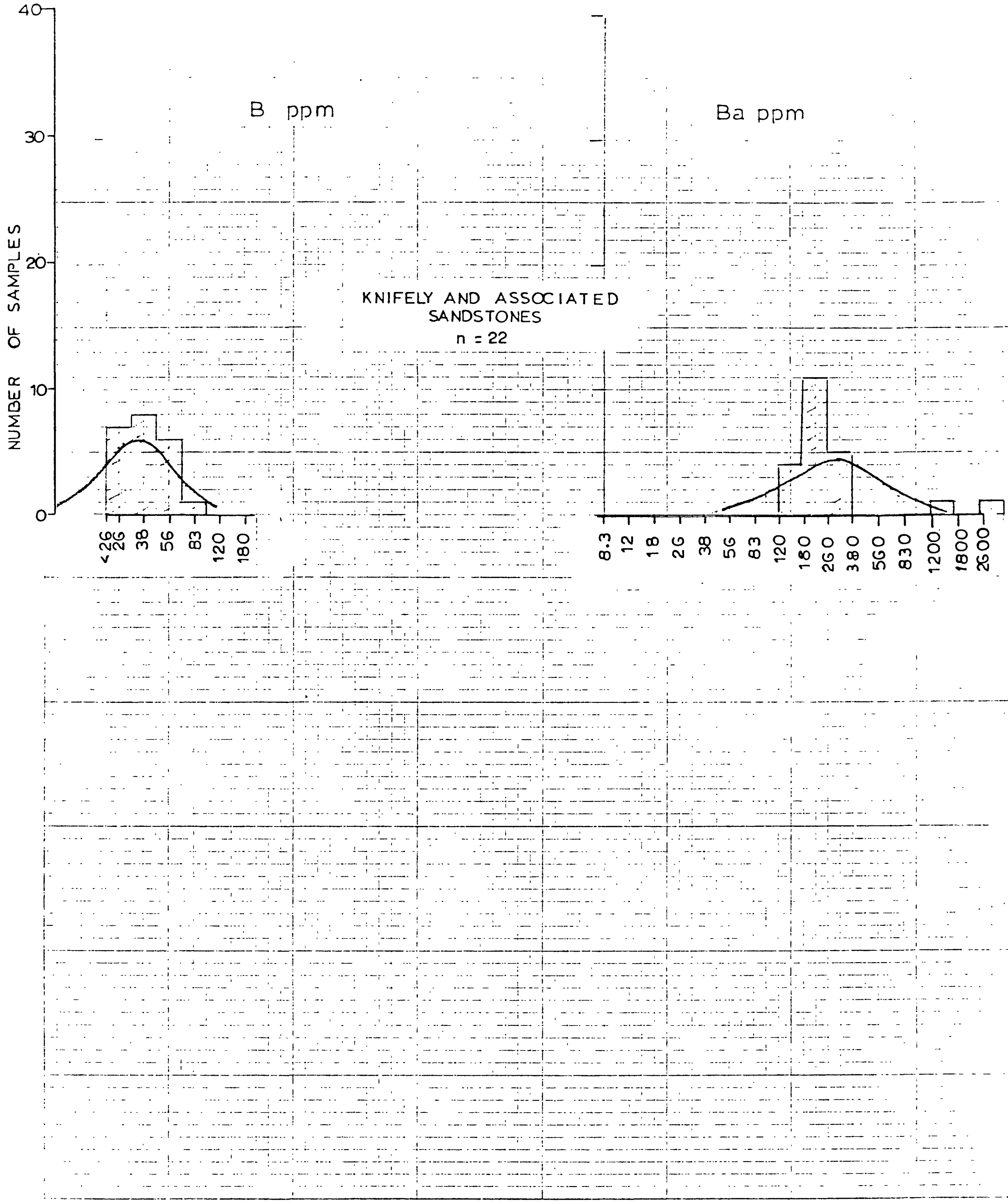


Figure 6.--Continued

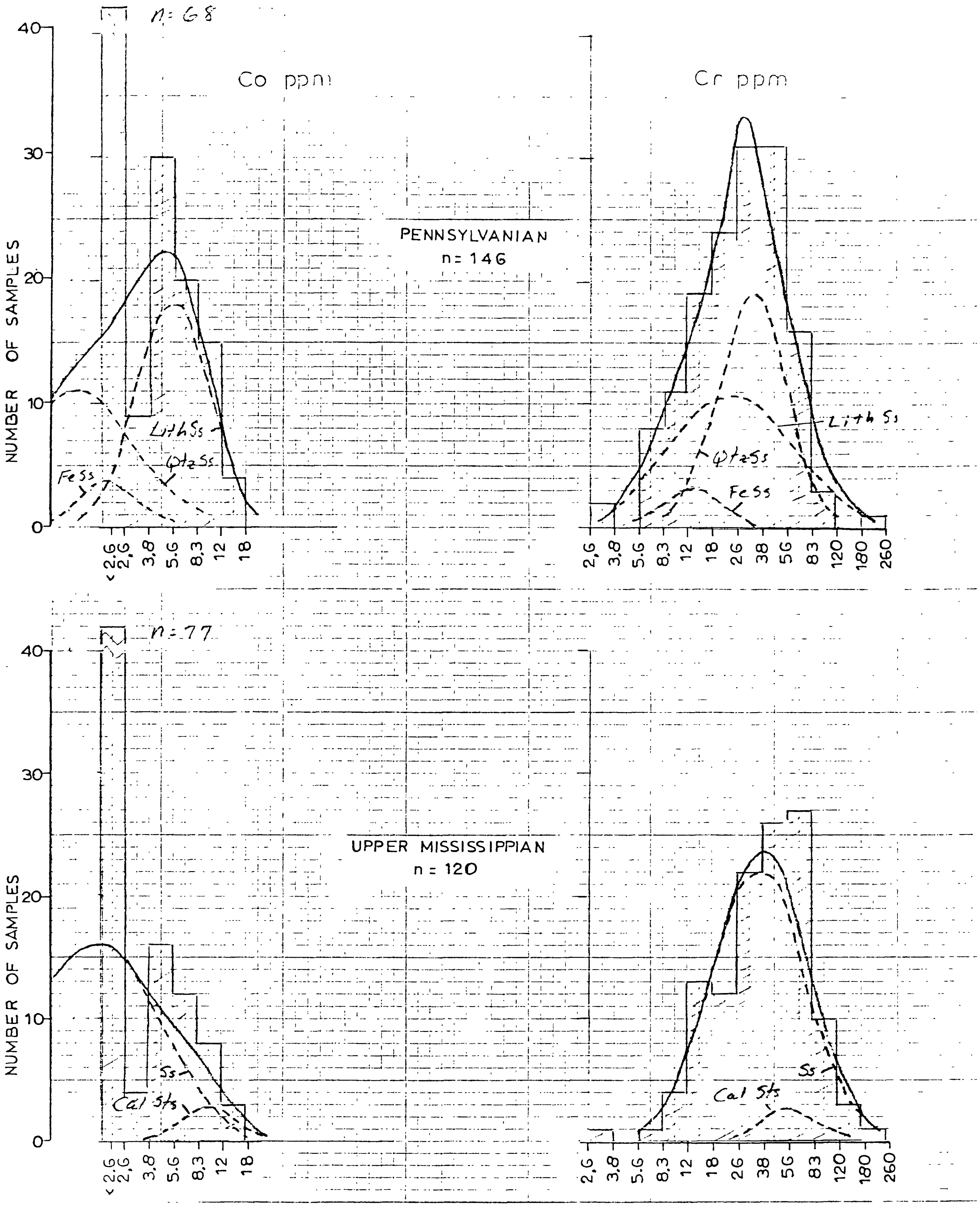


Figure 6.--Continued

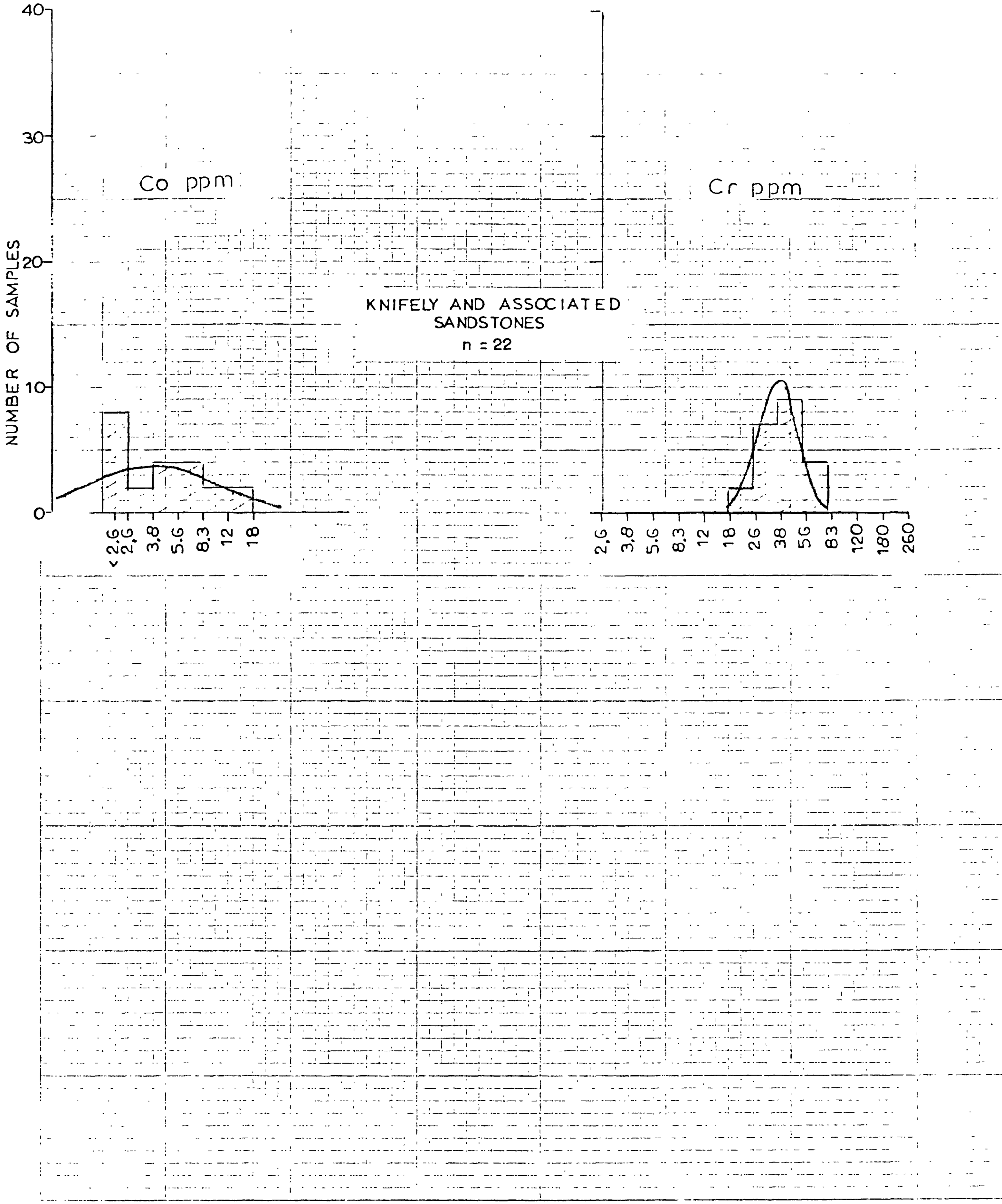


Figure 6.--Continued

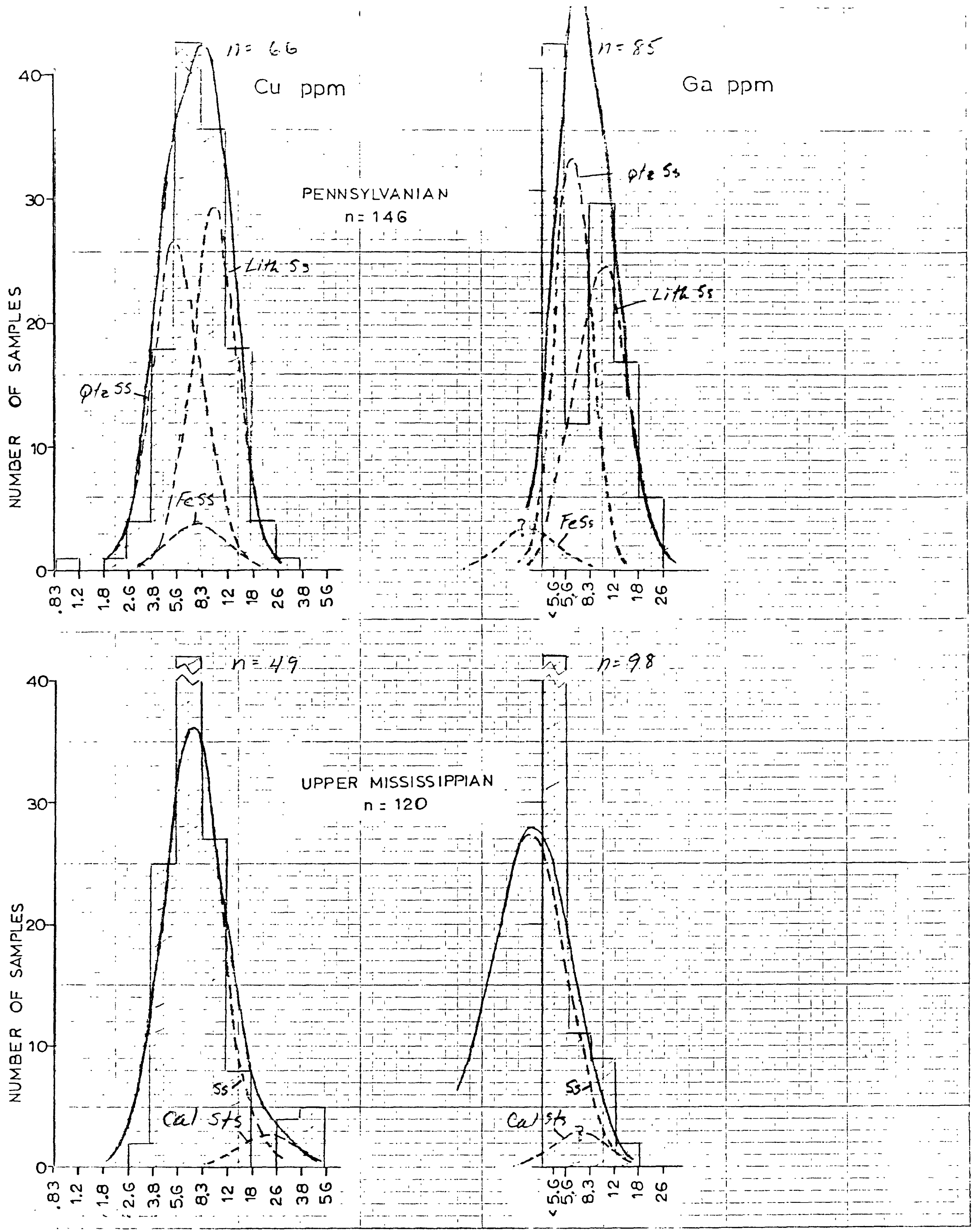


Figure 6.--Continued

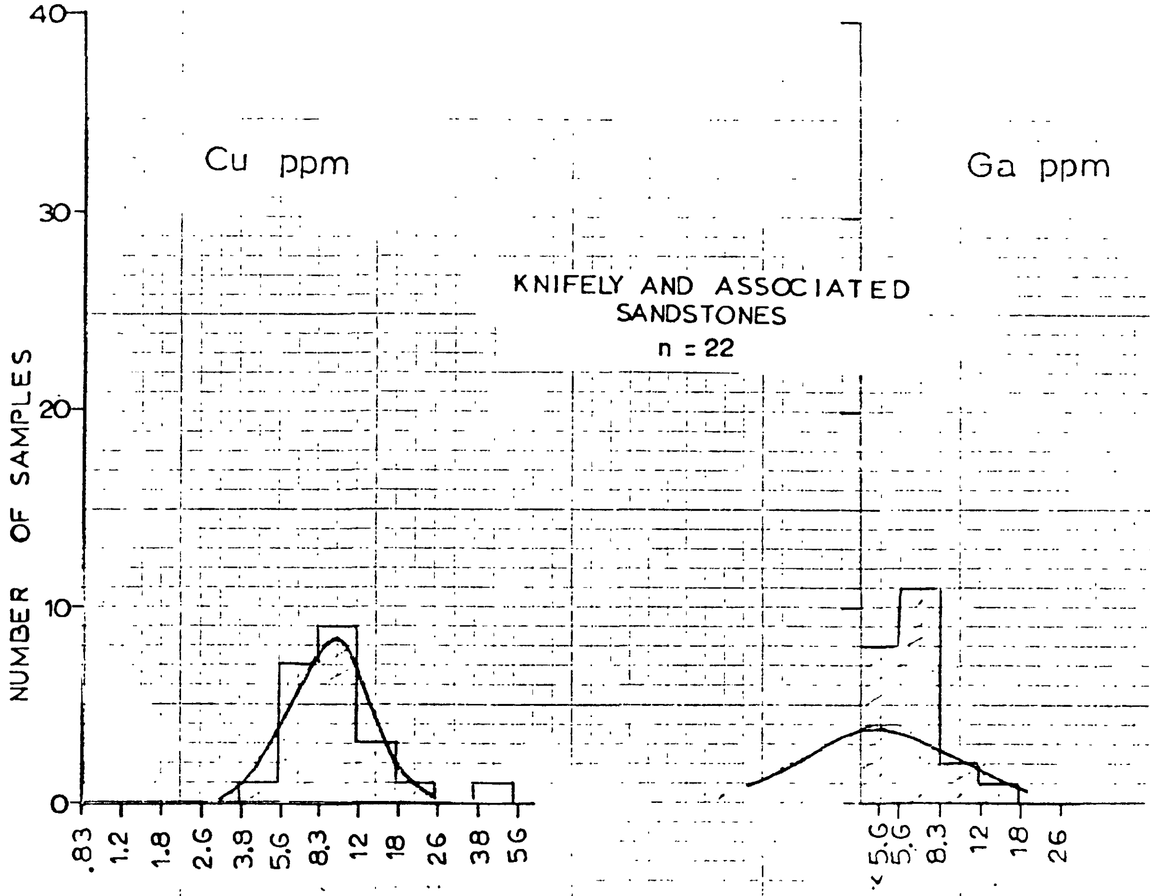


Figure 6.--Continued

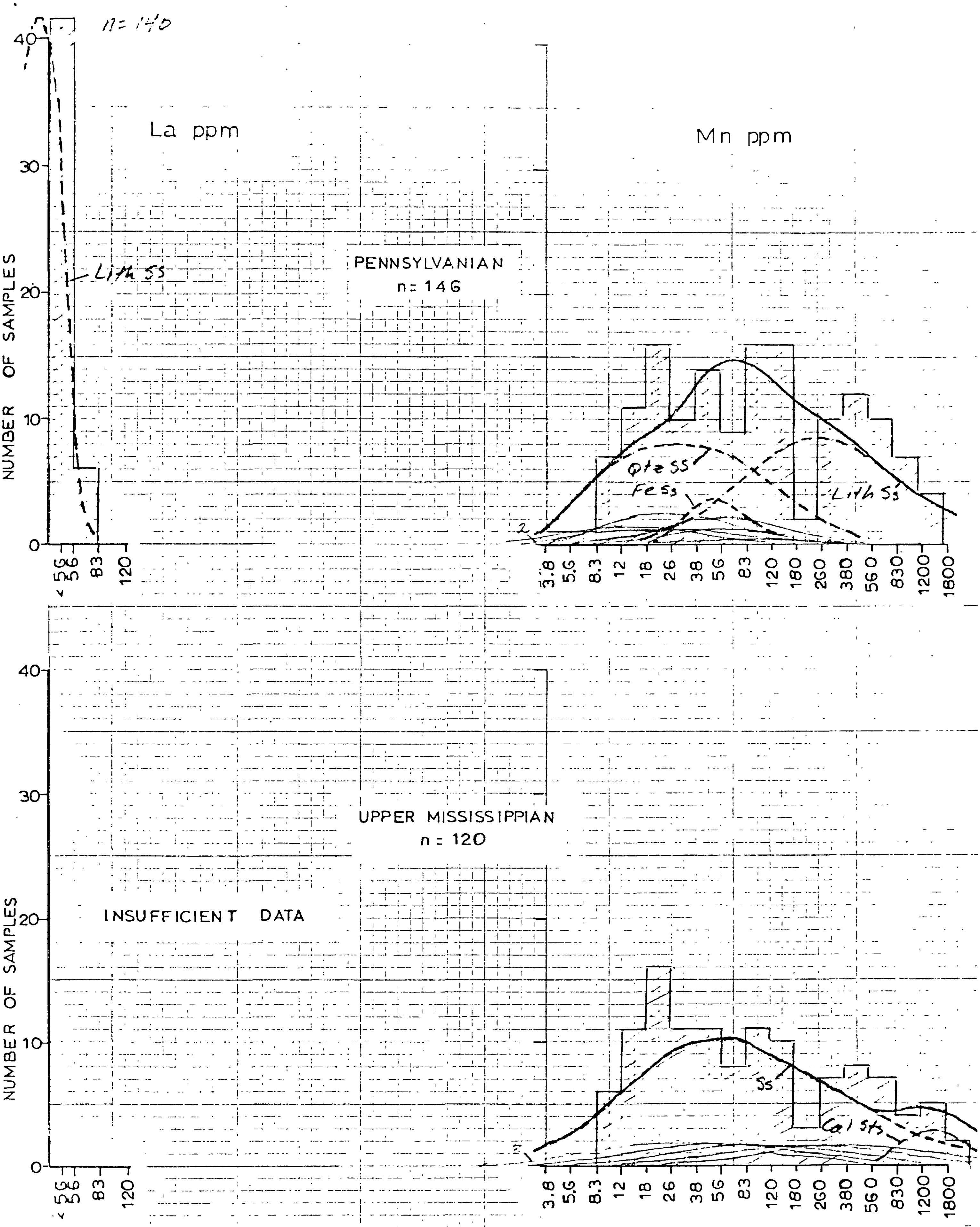


Figure 6.--Continued

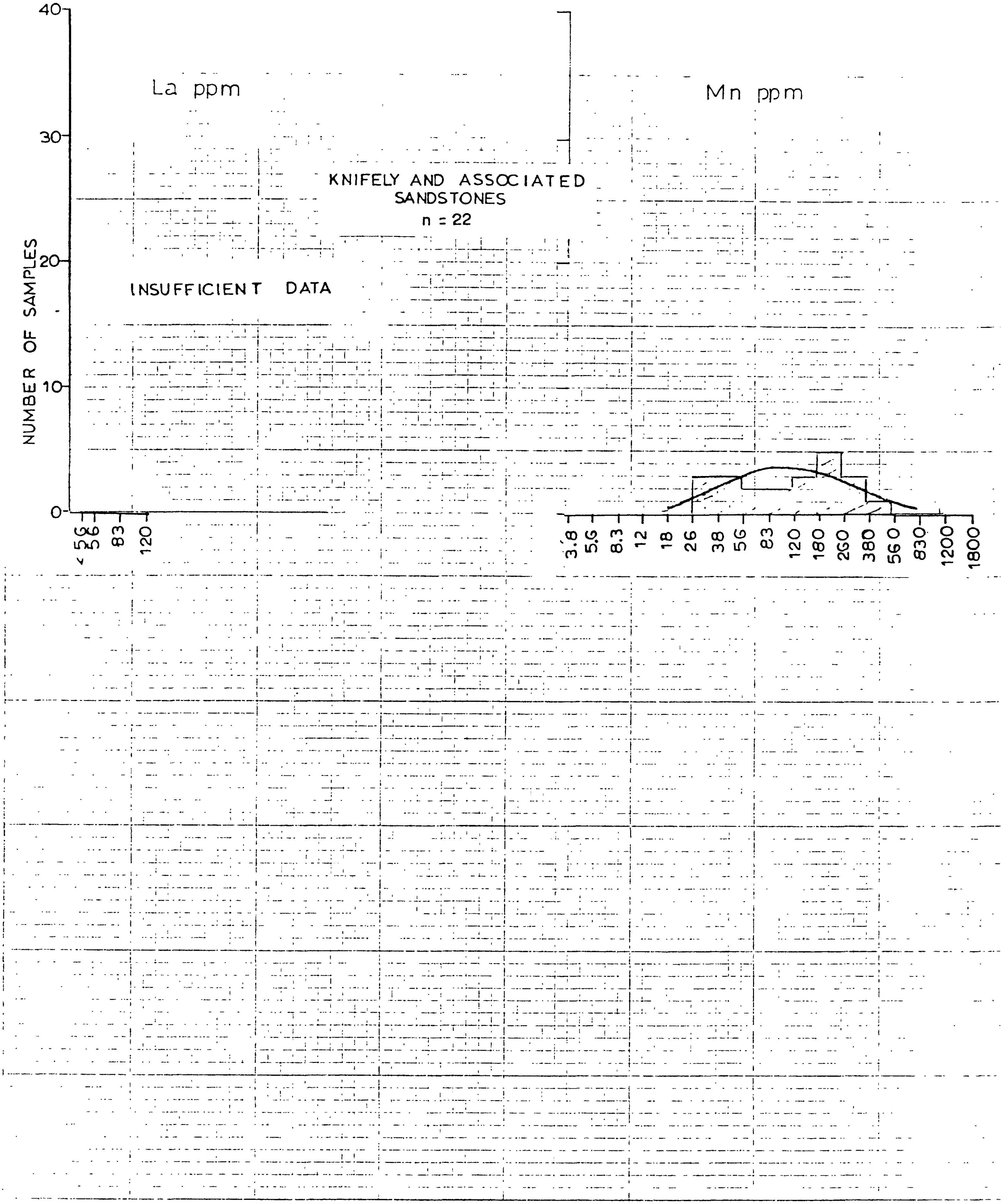
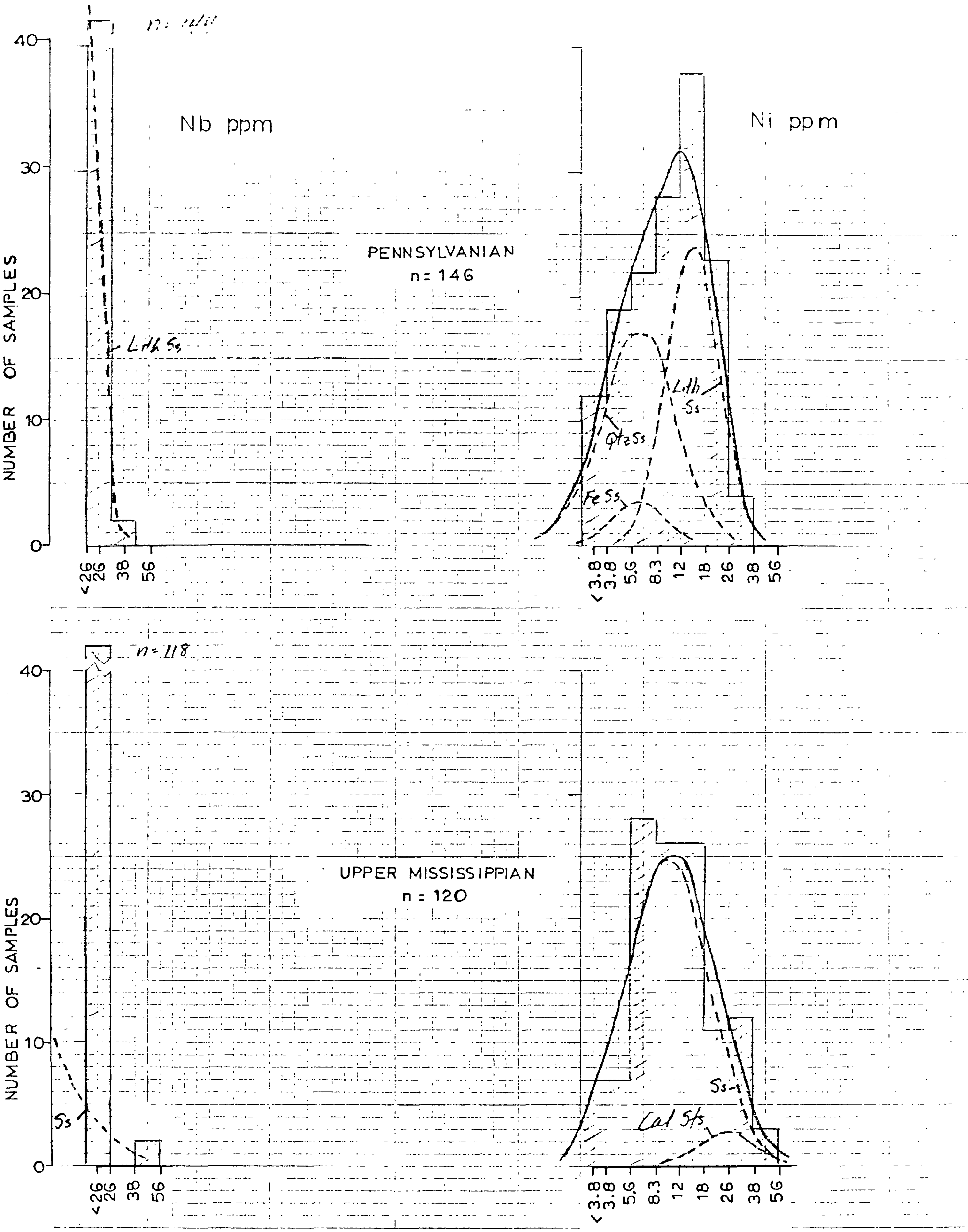


Figure 6.--Continued



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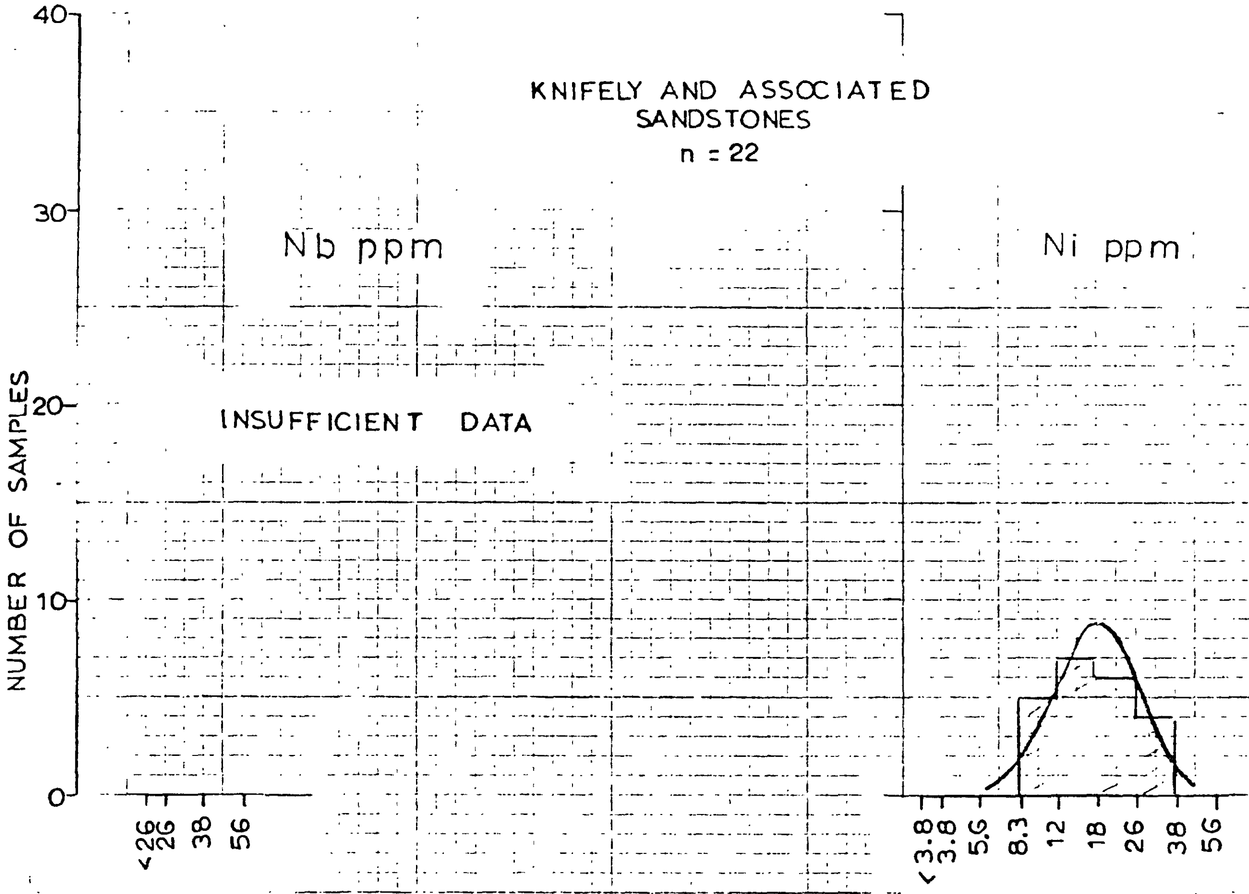

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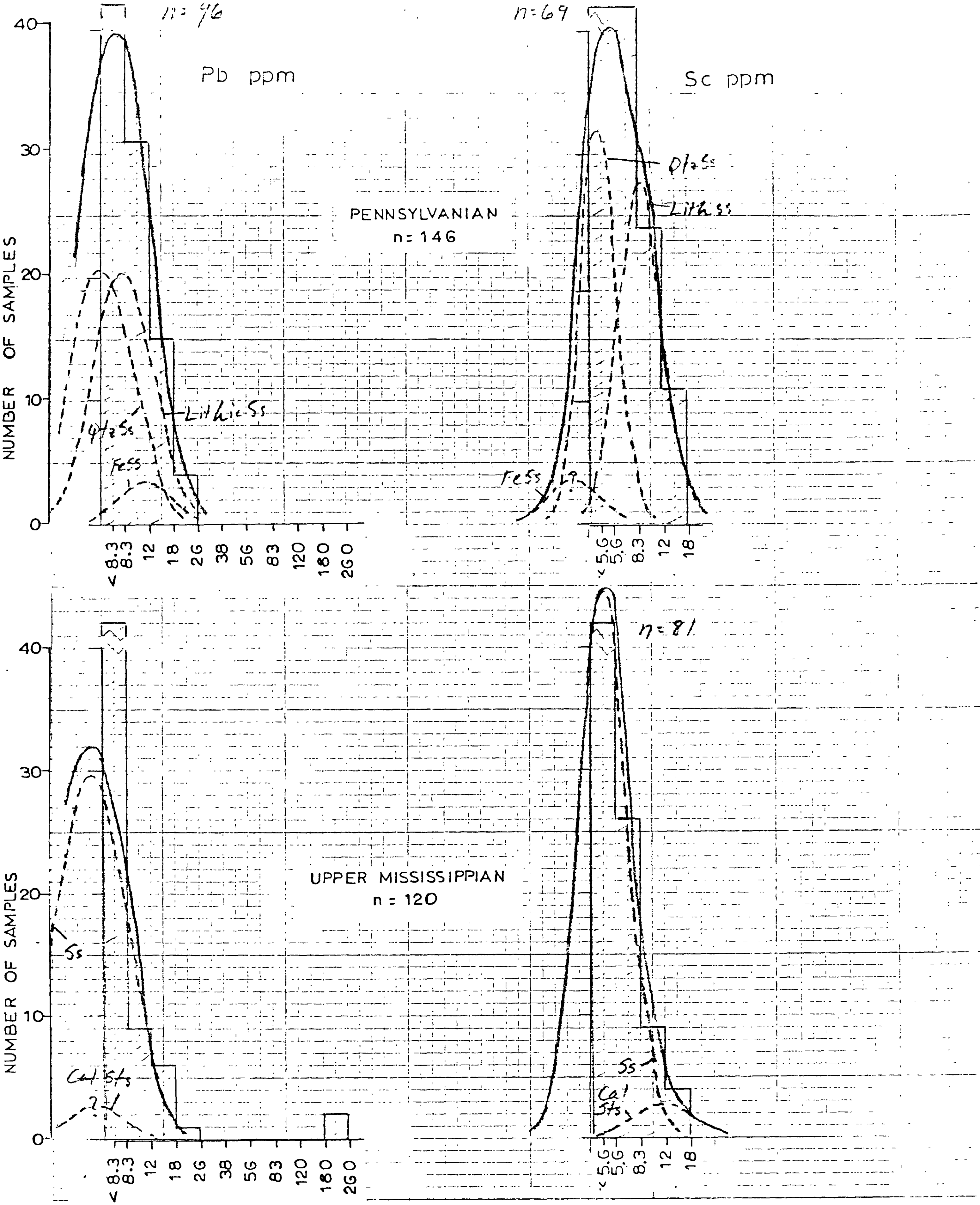


Figure 6.--Continued

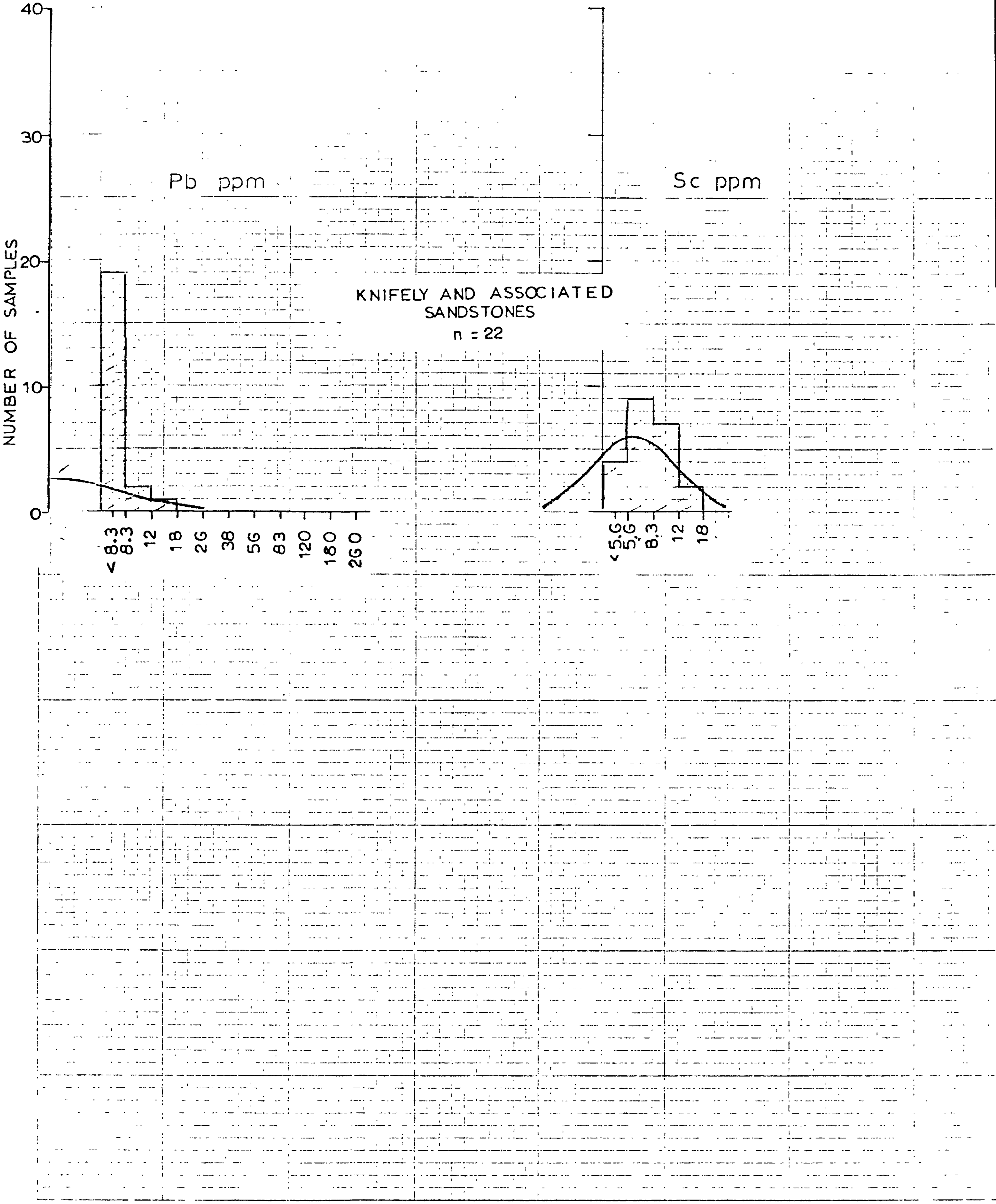


Figure 6.--Continued

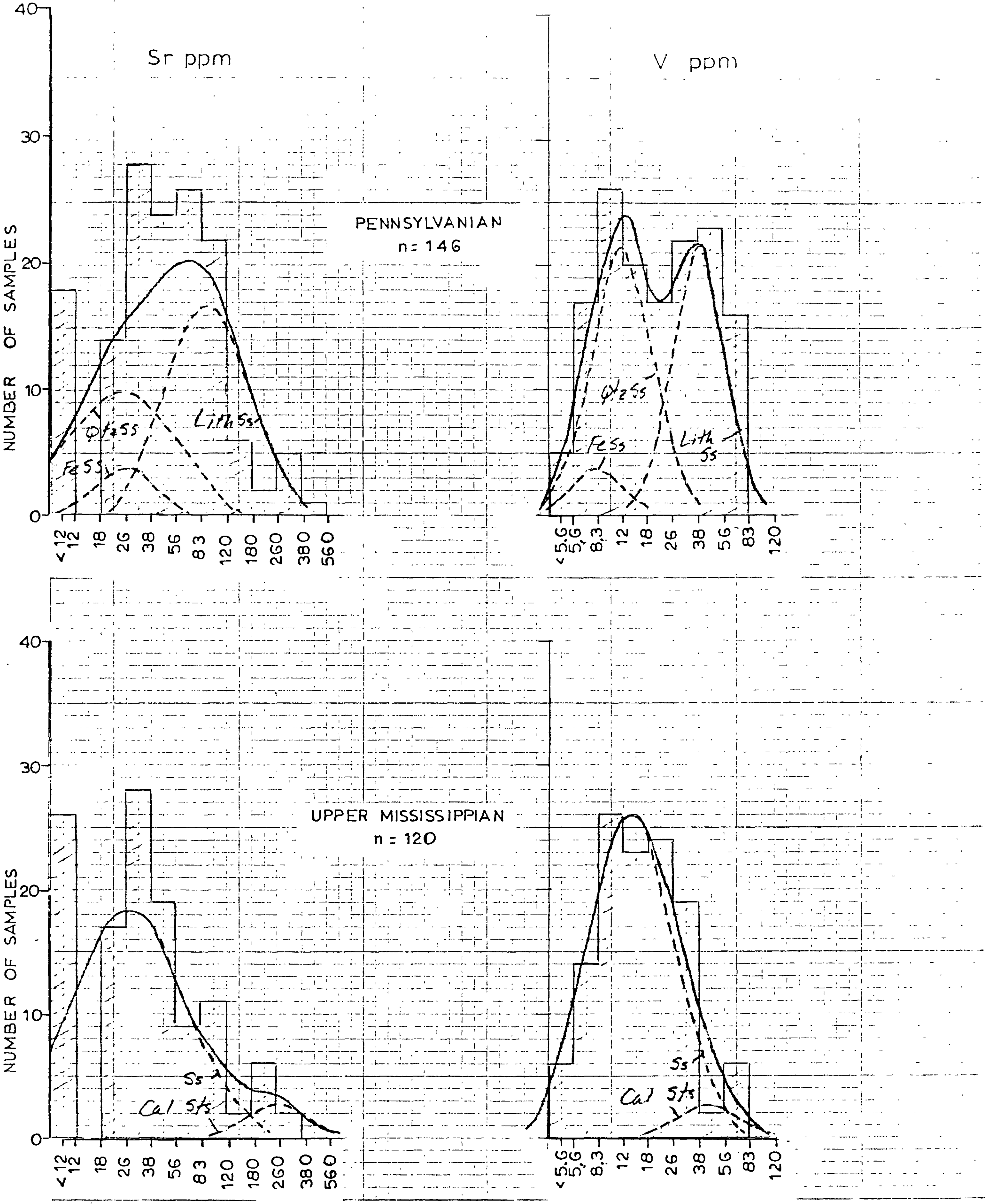
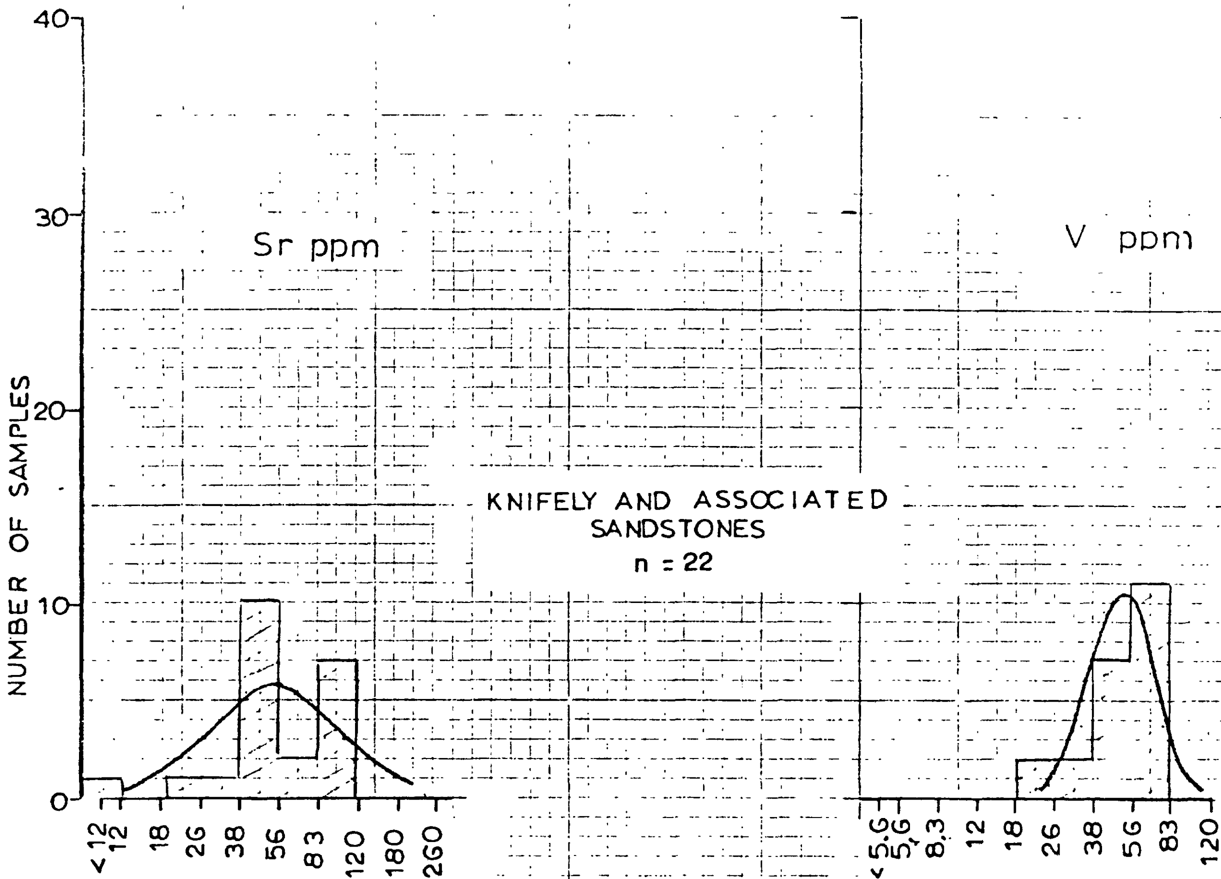


Figure 6.--Continued



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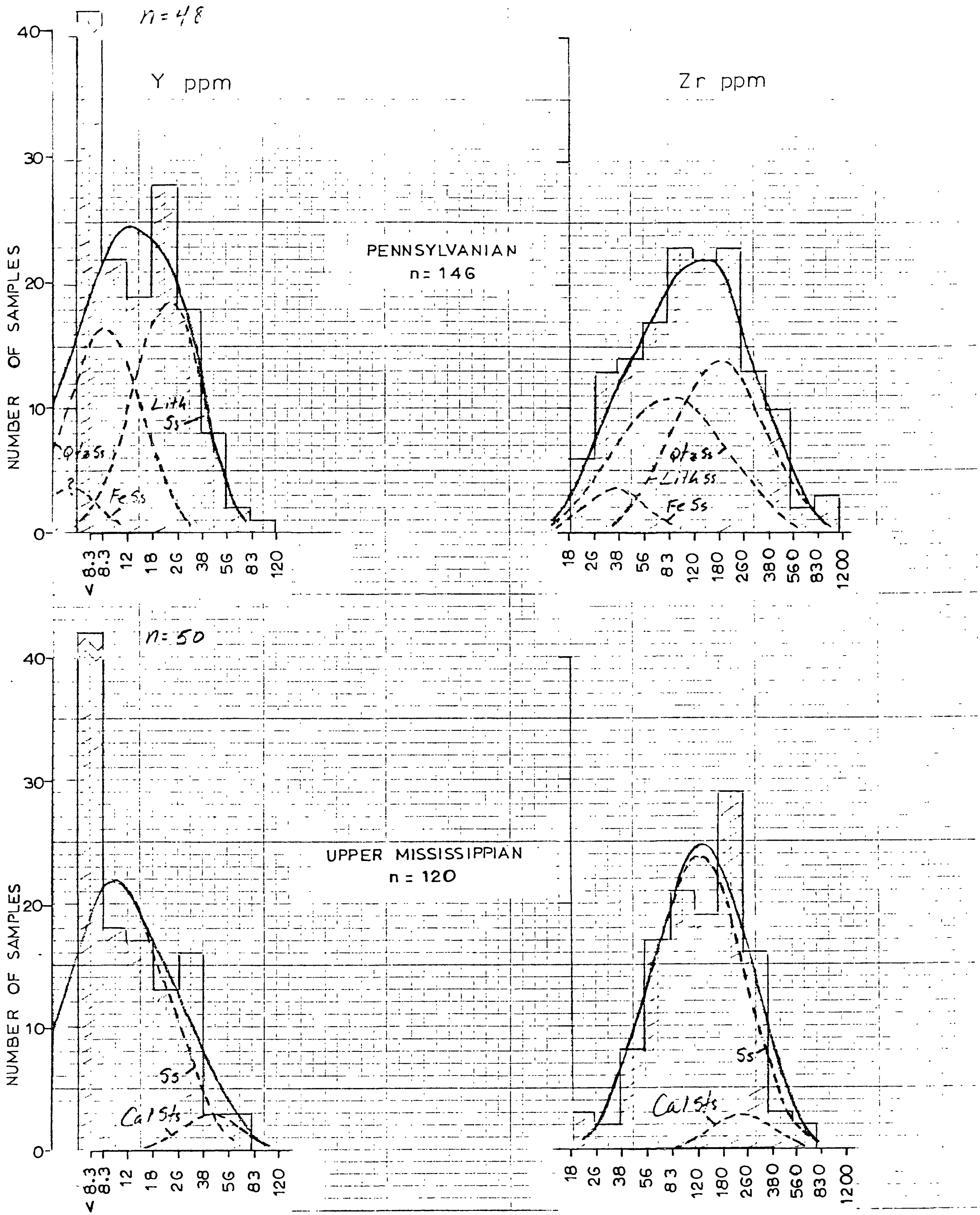

Figure 6.--Continued

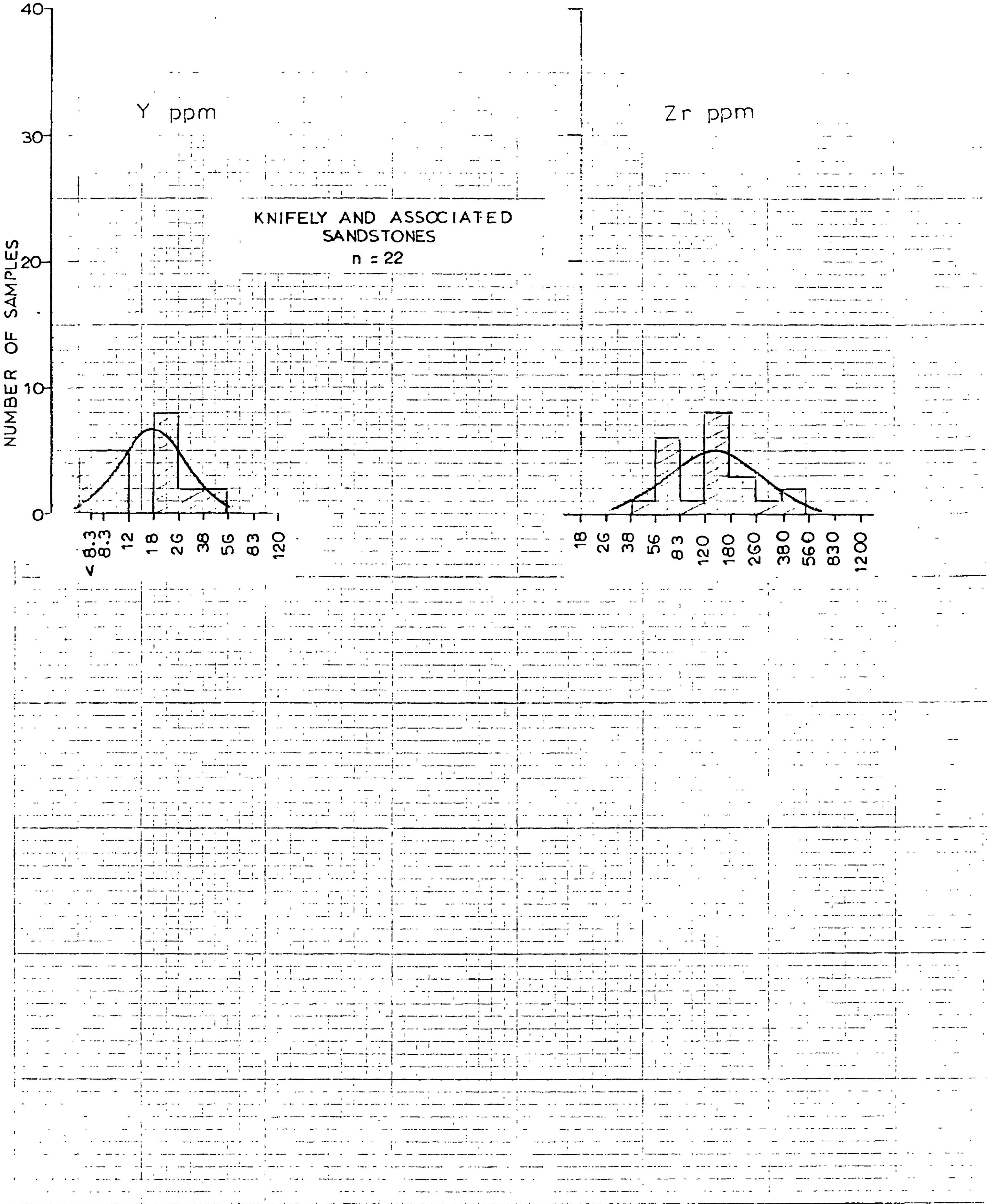

Figure 6.--Continued

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Table 1A.--Geochemical analyses of Knifely and associated sandstones in Kentucky. [%, percent; ppm, parts per million; N, not detected; labels ending in "-S" are spectrographic determinations]

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
M-S211	36 52 0	85 15 0	120,947	46.0	2.5	.65	.28	.43	26.70	.64	.50	.65	.12
M-S211	36 52 0	85 15 0	120,958	45.6	2.4	.56	.28	.51	26.60	.65	.41	.76	.12
M-S212	36 52 0	85 15 0	120,946	88.3	5.2	1.50	.12	.26	<.01	.75	.63	1.40	.31
M-S212	36 52 0	85 15 0	120,954	88.6	5.0	1.40	.12	.27	<.01	.68	.59	1.40	.33
M-S221	36 52 0	85 15 0	120,931	84.2	7.3	2.40	.12	.37	N	.11	.87	2.00	.68
M-S221	36 52 0	85 15 0	120,953	84.1	7.4	2.50	.12	.43	<.01	N	.82	2.60	.60
M-S222	36 52 0	85 15 0	120,948	82.7	8.1	1.90	.20	.50	.26	N	1.20	2.80	.53
M-S222	36 52 0	85 15 0	120,917	82.6	7.7	1.90	.16	.51	N	N	1.40	2.20	.70
M-K111	37 0 0	85 0 0	118,770	85.9	7.1	1.40	.16	.24	N	N	.86	2.70	.39
M-K111	37 0 0	85 0 0	118,827	84.5	7.3	1.80	.16	.29	.20	.72	1.00	2.30	.40
M-K112	37 0 0	85 0 0	118,964	88.5	5.2	1.10	.22	.11	.15	1.60	1.20	.82	.18
M-K112	37 0 0	85 0 0	118,971	88.5	5.4	1.10	.22	.15	.16	1.50	1.20	.92	.18
M-K121	37 0 0	85 0 0	118,974	80.9	5.2	8.80	.22	.17	.11	1.10	1.40	2.10	.32
M-K121	37 0 0	85 0 0	118,774	79.1	5.2	8.60	.20	.23	.20	1.60	1.30	2.00	.29
M-K122	37 0 0	85 0 0	118,969	87.9	6.3	1.30	.26	.24	.30	1.20	1.30	1.10	.39
M-K122	37 0 0	85 0 0	119,016	86.1	6.2	1.10	.32	.32	.20	1.10	1.20	3.90	.40
M-K211	37 8 0	85 15 0	118,819	83.5	8.5	1.90	.60	.70	.20	1.70	1.80	1.20	.21
M-K211	37 8 0	85 15 0	118,870	82.6	7.7	1.60	.60	.65	.20	1.60	1.60	1.50	.35
M-K212	37 8 0	85 15 0	118,755	79.7	7.0	1.70	.76	1.20	2.20	1.30	1.40	1.20	.25
M-K212	37 8 0	85 15 0	118,952	78.4	7.5	1.60	.70	1.20	2.90	1.60	1.50	1.40	.30
M-K221	37 8 0	85 15 0	118,814	82.9	7.4	1.90	.44	.70	.17	1.40	1.70	1.80	.42
M-K221	37 8 0	85 15 0	118,972	84.5	7.3	1.80	.42	.60	.22	.91	1.70	2.30	.14
M-K222	37 8 0	85 15 0	119,001	84.6	7.2	1.90	.32	.52	.15	.80	1.00	2.00	.53
M-K222	37 8 0	85 15 0	118,998	85.6	6.7	1.80	.28	.50	.12	1.00	1.20	1.80	.53

Table 1A.--Cont.

Sample	TiO2%	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
M-S211	.41	.02	<.01	‾17.50	.72	.066	100	N	120	4	30	5
M-S211	.50	.04	.02	21.20	.73	.060	93	N	110	3	16	3
M-S212	.64	.03	.02	<.05	1.40	.180	100	31	170	4	23	40
M-S212	.69	.02	.02	<.05	1.30	.180	95	27	160	5	21	12
M-S221	.42	.02	<.01	<.05	1.70	.130	40	27	170	N	41	16
M-S221	.62	.03	<.01	<.05	2.00	.140	38	29	170	N	30	14
M-S222	1.10	.02	<.01	<.05	1.70	.450	37	60	220	N	58	11
M-S222	.84	.06	<.01	<.05	1.70	.600	37	55	220	N	60	11
M-K111	.26	.07	.01	<.05	1.20	.140	160	N	230	12	44	10
M-K111	.35	.08	.01	<.05	1.10	.150	190	30	250	12	51	11
M-K112	.22	.03	.08	<.05	.85	.110	48	N	210	3	29	7
M-K112	.22	.03	.01	<.05	.82	.100	50	27	200	2	30	7
M-K121	.24	.06	.01	<.05	6.40	.100	270	N	210	11	30	5
M-K121	.24	.07	.02	<.05	5.80	.120	350	23	250	14	37	7
M-K122	.31	.06	.01	<.05	1.00	.120	420	N	200	5	39	8
M-K122	.29	.05	.02	<.05	1.00	.110	280	N	230	N	38	7
M-K211	.59	.09	.16	<.05	1.90	.280	250	30	360	6	65	8
M-K211	.53	.03	.02	<.05	1.90	.350	210	46	320	6	40	8
M-K212	.47	.07	.03	2.30	1.90	.250	240	26	290	7	40	11
M-K212	.47	.12	.07	3.50	1.90	.250	250	N	290	6	41	10
M-K221	.48	.09	.01	<.05	1.60	.230	170	45	1,300	4	59	12
M-K221	.44	.05	.01	<.05	1.80	.210	140	43	3,600	3	39	9
M-K222	.43	.04	.04	<.05	1.70	.190	75	42	270	2	36	9
M-K222	.53	.04	.04	<.05	1.40	.180	66	39	250	N	39	9

Table 1A.--Cont.

Sample	Mo ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S
M-S211	N	N	N	9	300	29	N	60	N
M-S211	N	3	N	9	300	26	N	60	N
M-S212	N	10	10	9	50	38	25	330	N
M-S212	N	9	N	N	30	38	25	230	N
M-S221	20	16	17	8	40	53	N	130	8
M-S221	N	17	N	9	40	47	N	160	N
M-S222	N	28	N	12	50	67	43	500	8
M-S222	N	27	8	12	40	66	37	520	10
M-K111	N	17	7	6	10	52	9	75	5
M-K111	N	18	N	7	20	60	11	74	8
M-K112	N	10	N	N	50	25	7	61	N
M-K112	N	9	N	N	50	26	7	45	N
M-K121	N	14	7	7	50	38	27	63	6
M-K121	N	18	12	7	90	58	38	78	8
M-K122	N	13	7	6	50	58	11	150	5
M-K122	N	12	N	N	60	53	N	70	N
M-K211	N	18	N	12	100	80	22	170	14
M-K211	N	21	N	10	90	77	22	180	7
M-K212	N	18	N	10	90	59	19	180	7
M-K212	N	15	N	9	90	60	20	150	7
M-K221	N	30	N	9	90	60	24	230	12
M-K221	N	29	N	8	100	56	20	120	7
M-K222	N	21	N	7	50	49	10	140	7
M-K222	N	20	N	7	60	48	10	130	8

Table 1d.--Geochemical analyses of sandstone 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	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
M-E111	38 23 0	83 0 0	118,947	88.600	4.30	3.10	.42	.36	N	.26	.62	1.60	.45
M-E111	38 23 0	83 0 0	118,891	89.000	4.10	3.40	.48	.36	.20	N	1.00	1.50	.44
M-E112	38 23 0	83 0 0	118,879	87.300	4.50	3.40	.54	.50	.16	.23	.70	1.50	.55
M-E112	38 23 0	83 0 0	118,887	86.800	4.40	3.40	.54	.43	.21	N	.70	1.90	.49
M-E121	38 23 0	83 0 0	118,906	94.100	2.30	.97	N	.10	N	N	.40	.92	.18
M-E121	38 23 0	83 0 0	118,846	92.200	2.90	1.30	N	.15	.38	N	.34	.96	.24
M-E122	38 23 0	83 0 0	118,753	92.300	3.40	.75	<.01	N	N	N	.25	1.10	.10
M-E122	38 23 0	83 0 0	118,783	94.700	3.30	.39	N	N	N	.10	.39	1.30	.06
M-E211	38 0 0	83 15 0	118,836	84.900	2.60	.50	1.60	2.20	4.50	.24	.80	.63	.09
M-E211	38 0 0	83 15 0	118,987	79.000	2.30	.80	1.40	2.30	6.10	.40	.75	.52	.14
M-E212	38 0 0	83 15 0	118,835	79.700	3.60	1.60	1.10	1.30	4.70	N	1.00	1.00	.19
M-E212	38 0 0	83 15 0	118,818	80.300	3.40	1.40	1.00	1.30	3.50	.20	1.00	1.10	.14
M-E221	38 0 0	83 15 0	119,015	94.400	2.20	.35	N	.12	.12	<.01	.63	.58	.14
M-E221	38 0 0	83 15 0	118,872	94.400	2.10	.18	N	.10	.19	.30	.85	.76	.16
M-E222	38 0 0	83 15 0	118,893	86.300	2.10	1.70	N	.14	4.10	N	.80	.77	.17
M-E222	38 0 0	83 15 0	118,757	89.200	1.40	1.20	N	N	2.80	N	.45	.71	.10
M-H111	37 23 0	88 23 0	118,996	92.600	2.70	1.30	.12	N	N	.10	.45	1.20	.29
M-H111	37 23 0	88 23 0	118,909	92.500	2.80	1.40	N	N	N	.20	.26	1.10	.29
M-H112	37 23 0	88 23 0	118,867	92.500	3.20	.85	N	.10	N	.74	.21	.78	.33
M-H112	37 23 0	88 23 0	118,976	93.200	2.90	.75	N	N	<.01	.50	.50	.75	.25
M-H121	37 23 0	88 23 0	118,692	92.100	1.50	4.40	N	N	N	N	.30	1.20	.21
M-H121	37 23 0	88 23 0	118,908	93.100	1.50	3.20	N	N	<.01	.11	.15	1.00	.17
M-H122	37 23 0	88 23 0	118,967	93.600	1.10	3.10	.10	<.01	N	<.01	.11	.68	.12
M-H122	37 23 0	88 23 0	118,662	92.300	.95	3.60	N	N	.15	.41	N	1.00	.17
M-H211	37 15 0	88 8 0	118,765	94.400	2.00	.55	.36	.12	N	N	.26	.74	.16
M-H211	37 15 0	88 8 0	119,025	94.400	2.20	.74	.18	.10	<.01	<.01	.40	.67	.15
M-H212	37 15 0	88 8 0	118,905	95.500	1.40	1.90	N	N	N	.25	.10	1.00	.15
M-H212	37 15 0	88 8 0	118,817	95.100	1.80	1.50	.12	N	N	.30	.10	.78	.09
M-H221	37 15 0	88 8 0	118,800	95.400	1.40	.40	.12	N	.11	N	.23	.45	.07
M-H221	37 15 0	88 8 0	118,785	95.500	1.40	.80	N	N	N	N	.24	.57	.07
M-H222	37 15 0	88 8 0	118,937	96.000	1.50	N	N	N	.10	N	.10	.52	.09
M-H222	37 15 0	88 8 0	119,005	96.300	1.50	N	N	N	N	.38	<.01	.61	.12
M-J111	37 45 0	86 0 0	118,960	93.200	2.20	1.60	N	N	.13	.20	.65	1.00	.19
M-J111	37 45 0	86 0 0	118,919	94.600	1.80	.32	N	.16	<.01	.15	.60	1.00	.23
M-J112	37 45 0	86 0 0	118,795	77.500	1.60	.42	.16	.35	8.20	N	.42	.58	.16
M-J112	37 45 0	86 0 0	118,842	71.400	1.80	.58	.16	.25	13.60	N	.37	.61	.37
M-J121	37 45 0	86 0 0	119,024	96.200	1.50	.46	.10	N	N	<.01	.71	.40	.13
M-J121	37 45 0	86 0 0	118,991	94.400	1.30	.34	.24	N	.35	.40	.80	.85	.06
M-J122	37 45 0	86 0 0	118,869	93.700	1.20	1.60	N	N	.14	.30	.72	.71	.13
M-J122	37 45 0	86 0 0	118,805	95.000	1.30	1.30	.16	N	.20	.14	.15	.53	.07
M-J211	37 23 0	86 8 0	118,945	91.500	3.40	2.00	N	.13	N	.20	.92	.16	.20
M-J211	37 23 0	86 8 0	119,028	92.000	3.00	1.80	.12	N	<.01	<.01	1.00	.86	.14
M-J212	37 23 0	86 8 0	118,794	91.700	3.80	.63	N	N	N	.15	.99	1.30	.06
M-J212	37 23 0	86 8 0	118,767	91.900	3.60	.52	.32	N	.18	N	.94	1.00	.11
M-J221	37 23 0	86 8 0	118,864	90.300	4.20	1.40	N	.12	.12	.32	.62	1.60	.34
M-J221	37 23 0	86 8 0	118,760	92.000	3.60	1.30	N	N	N	N	.95	1.00	.18
M-J222	37 23 0	86 8 0	118,958	91.900	2.80	1.20	N	.10	.11	.25	.90	.80	.17
M-J222	37 23 0	86 8 0	118,807	92.200	3.00	1.50	N	.11	.15	.18	1.10	.95	.15
M-L111	37 8 0	84 15 0	118,926	93.300	2.30	.70	.40	.30	N	.21	.25	.71	.29
M-L111	37 8 0	84 15 0	118,986	93.600	2.20	.23	.60	.14	.12	.33	.25	1.10	.11

Table 1b.--Cont.

Sample	TiO2%	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
M-E111	.35	.03	.02	<.05	3.00	.180	130	N	160	5	49	9
M-E111	.31	.04	<.01	<.05	2.50	.180	130	29	180	5	42	9
M-E112	.35	.07	.01	<.05	2.70	.180	99	21	220	6	60	9
M-E112	.34	.07	.10	<.05	2.80	.160	100	32	180	5	28	10
M-E121	.28	<.01	.16	<.05	.36	.110	440	N	70	6	36	6
M-E121	.44	.05	.02	<.05	.34	.093	520	N	90	5	210	6
M-E122	.33	.06	.14	<.05	.23	.120	480	N	100	5	62	7
M-E122	.34	.02	.23	<.05	.20	.120	480	N	120	N	30	6
M-E211	.24	.09	.28	<.05	1.60	.063	900	N	170	N	30	8
M-E211	.16	.05	.11	7.40	1.20	.075	670	N	120	N	41	4
M-E212	.15	.05	.06	5.20	1.50	.092	750	N	240	N	52	5
M-E212	.20	.09	.16	4.90	1.80	.090	800	N	220	2	23	8
M-E221	.20	.04	.02	<.05	.21	.100	30	31	130	N	60	4
M-E221	.20	.03	.07	<.05	.20	.090	26	29	150	N	74	5
M-E222	.10	.04	.09	3.00	.68	.039	310	N	140	N	8	7
M-E222	.08	.06	.04	2.30	.74	.030	330	N	140	N	29	6
M-H111	.39	.01	.03	<.05	.74	.120	24	28	50	N	90	6
M-H111	.33	.02	.01	<.05	.81	.130	29	21	50	N	50	5
M-H112	.42	.02	.11	<.05	.46	.170	73	45	80	2	87	5
M-H112	.42	.03	.02	<.05	.47	.180	76	30	60	N	36	4
M-H121	.08	.01	.03	<.05	2.00	.038	120	N	50	2	19	9
M-H121	.16	<.01	.02	<.05	2.30	.052	150	N	20	3	12	11
M-H122	.09	.02	.26	<.05	1.70	.027	170	N	50	N	15	6
M-H122	.08	.03	.08	<.05	1.80	.020	180	30	30	N	9	6
M-H211	.21	.07	.05	<.05	.46	.100	36	23	50	N	37	8
M-H211	.27	.02	<.01	<.05	.44	.094	35	23	60	N	26	4
M-H212	.17	<.01	.08	<.05	.95	.088	20	N	40	N	15	6
M-H212	.33	.06	.06	<.05	.89	.068	17	N	60	N	26	7
M-H221	.26	.01	.04	<.05	.20	.050	12	20	40	N	24	4
M-H221	.31	.08	.04	<.05	.20	.059	11	N	10	N	21	5
M-H222	.08	<.01	<.01	<.05	.11	.019	12	N	40	N	34	5
M-H222	.19	.02	.02	<.05	.09	.024	15	N	30	N	3	9
M-J111	.22	.09	.03	<.05	.74	.062	11	N	110	N	42	7
M-J111	.14	.06	.04	<.05	.80	.072	12	N	110	N	18	42
M-J112	.15	.03	.05	9.60	.31	.055	90	N	90	N	31	4
M-J112	.17	.04	.02	10.50	.28	.048	98	N	70	N	16	5
M-J121	.19	.02	.01	<.05	.27	.041	21	N	110	N	25	4
M-J121	.23	.01	<.01	<.05	.23	.048	18	N	100	N	29	4
M-J122	.37	<.01	<.01	<.05	.61	.092	22	54	70	N	43	7
M-J122	.28	.06	<.01	<.05	.59	.077	26	21	80	N	60	9
M-J211	.30	<.01	.02	<.05	1.40	.110	60	20	130	6	60	6
M-J211	.29	.12	<.01	<.05	1.40	.120	60	21	130	4	40	4
M-J212	.10	.03	.01	<.05	.32	.042	19	N	140	N	10	4
M-J212	.13	.03	.02	<.05	.34	.043	18	N	150	N	15	4
M-J221	.22	.05	.02	<.05	1.00	.092	20	30	110	2	40	9
M-J221	.28	.07	.01	<.05	.81	.090	16	N	90	N	23	10
M-J222	.30	.01	.01	<.05	.86	.120	40	27	130	N	45	8
M-J222	.40	.06	.01	<.05	.75	.140	37	N	160	N	78	5
M-L111	.14	.01	.08	<.05	.44	.072	20	N	60	4	27	5
M-L111	.16	.02	.01	<.05	.46	.071	20	20	20	N	13	3

Table 18.--Cont.

Sample	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S	Yb ppm-S
M-E111	N	N	36	7	7	40	24	24	180	5	--
M-E111	N	N	38	N	7	40	24	31	230	5	--
M-E112	N	N	36	11	7	30	25	33	250	5	--
M-E112	N	N	34	N	6	30	22	15	210	5	--
M-E121	N	N	14	N	5	10	13	9	270	N	--
M-E121	N	N	12	N	N	30	14	6	230	N	--
M-E122	N	N	13	9	6	N	16	12	280	N	--
M-E122	N	N	13	N	N	N	13	7	270	N	--
M-E211	N	N	9	N	6	80	15	27	180	N	--
M-E211	N	N	8	N	5	50	12	17	75	N	--
M-E212	N	N	14	N	7	70	25	22	81	N	--
M-E212	N	N	12	N	N	80	28	21	75	N	--
M-E221	N	N	4	N	N	30	9	N	95	N	--
M-E221	N	N	4	N	N	30	9	N	140	N	--
M-E222	N	N	7	N	5	40	9	8	59	N	--
M-E222	N	N	6	7	N	N	11	13	60	N	--
M-H111	N	N	10	N	5	40	18	11	260	N	--
M-H111	N	N	12	N	5	50	16	12	310	N	--
M-H112	N	40	8	N	6	90	12	15	530	N	--
M-H112	N	40	8	N	5	80	13	10	250	N	--
M-H121	N	N	14	N	N	20	10	N	88	N	--
M-H121	N	N	10	N	N	20	10	N	44	N	--
M-H122	N	N	8	9	N	20	9	8	22	N	--
M-H122	N	N	7	N	N	20	7	N	21	N	--
M-H211	N	N	9	N	N	10	13	12	250	N	--
M-H211	N	N	7	N	N	30	9	7	160	N	--
M-H212	N	N	10	10	N	30	9	N	60	N	--
M-H212	N	N	6	N	N	20	6	7	96	N	--
M-H221	N	N	N	N	N	10	5	N	52	N	--
M-H221	N	N	3	N	N	N	8	N	61	N	--
M-H222	N	N	9	N	N	30	10	N	24	N	--
M-H222	N	N	N	N	N	N	N	N	44	N	--
M-J111	N	N	7	13	N	20	8	N	90	N	--
M-J111	N	N	6	12	N	20	8	N	100	N	--
M-J112	N	N	7	N	N	80	19	17	90	N	--
M-J112	N	N	7	N	N	90	18	17	92	N	--
M-J121	N	N	3	10	N	N	N	N	76	N	--
M-J121	N	N	3	N	N	20	N	N	56	N	--
M-J122	N	N	5	N	N	20	7	9	140	N	--
M-J122	N	N	N	N	N	N	6	7	60	N	--
M-J211	N	N	15	N	N	40	14	9	150	N	--
M-J211	N	N	12	N	N	30	11	8	130	N	--
M-J212	N	N	6	12	N	10	9	N	44	N	--
M-J212	N	N	4	N	N	10	10	N	37	N	--
M-J221	N	N	9	N	5	30	20	7	110	N	--
M-J221	N	N	10	N	N	20	21	8	60	N	--
M-J222	N	N	10	N	5	30	13	9	300	N	--
M-J222	N	N	8	8	N	20	12	11	210	N	--
M-L111	N	N	12	8	N	20	15	9	52	N	--
M-L111	N	N	9	N	N	20	10	N	66	N	--

Table 18.--Cont.

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
M-L112	37 8 0	84 15 0	118,847	92.800	2.60	1.30	.10	N	N	.20	.13	.66	.26
M-L112	37 8 0	84 15 0	118,877	93.100	2.10	1.30	.10	.23	.16	.50	N	1.00	.29
M-L121	37 8 0	84 15 0	118,881	87.700	.45	2.20	1.20	1.10	.23	1.50	1.10	2.20	.47
M-L121	37 8 0	84 15 0	118,923	79.000	8.90	2.00	1.30	1.20	.12	1.30	1.20	2.20	.48
M-L122	37 8 0	84 15 0	118,966	82.000	8.80	2.10	.86	.85	.24	1.40	1.20	2.00	.42
M-L122	37 8 0	84 15 0	118,833	80.200	9.00	2.60	.90	.96	.30	1.50	1.20	2.00	.35
M-L211	37 15 0	84 0 0	119,000	84.900	7.70	1.50	1.40	.75	.17	.90	.62	2.10	.31
M-L211	37 15 0	84 0 0	118,983	84.400	8.00	1.60	1.30	.70	.20	.93	1.00	2.30	.32
M-L212	37 15 0	84 0 0	118,759	90.000	4.50	1.10	.36	.26	N	.47	.35	1.40	.13
M-L212	37 15 0	84 0 0	118,771	90.899	4.50	.74	.56	.26	.14	.42	.81	1.30	.14
M-L221	37 15 0	84 0 0	118,766	91.200	1.90	.80	1.10	.42	1.30	.15	N	.84	.04
M-L221	37 15 0	84 0 0	118,763	92.700	1.80	1.10	.80	.31	1.00	N	.53	.86	.07
M-L222	37 15 0	84 0 0	118,782	88.000	4.80	1.10	1.40	.60	N	.21	.14	1.80	.16
M-L222	37 15 0	84 0 0	118,815	89.600	4.60	1.60	1.00	.45	N	3.00	.20	1.90	.15
M-Q111	36 53 0	87 15 0	118,868	92.100	2.40	2.10	N	.15	.12	.22	.15	1.00	.22
M-Q111	36 53 0	87 15 0	118,773	92.700	2.00	1.90	N	.10	N	N	N	.87	.13
M-Q112	36 53 0	87 15 0	118,822	82.000	3.10	2.30	.40	.30	4.30	.55	.40	1.20	.21
M-Q112	36 53 0	87 15 0	118,812	82.000	3.10	2.20	.44	.36	4.40	2.10	.33	1.20	.21
M-Q121	36 53 0	87 15 0	118,832	84.000	6.50	2.50	.56	.60	.21	.40	.68	2.30	.48
M-Q121	36 53 0	87 15 0	118,871	84.300	6.40	2.80	.54	.65	.20	.62	.81	2.00	.79
M-Q122	36 53 0	87 15 0	118,826	84.300	7.20	2.70	.68	.68	.24	1.00	.70	2.60	.47
M-Q122	36 53 0	87 15 0	119,004	84.100	7.20	4.00	.64	.70	.28	.40	.20	2.50	.61
M-Q211	36 53 0	87 30 0	118,756	95.500	1.70	.25	.12	.20	.15	.13	.13	.73	.09
M-Q211	36 53 0	87 30 0	118,939	95.600	1.60	.32	N	.12	.22	.23	.10	.64	.16
M-Q212	36 53 0	87 30 0	118,876	89.000	1.70	5.70	N	N	.15	.21	N	1.40	.22
M-Q212	36 53 0	87 30 0	119,007	92.100	1.60	4.00	N	N	.15	.20	<.01	1.10	.17
M-Q221	36 53 0	87 30 0	118,853	89.500	3.30	3.40	N	N	.10	<.01	N	1.20	.27
M-Q221	36 53 0	87 30 0	118,772	91.600	2.40	2.80	N	N	N	N	N	1.10	.18
M-Q222	36 53 0	87 30 0	119,021	94.700	1.70	1.60	N	N	<.01	<.01	.12	1.00	.22
M-Q222	36 53 0	87 30 0	118,852	92.000	2.60	2.10	N	N	N	N	N	.83	.27
M-R111	36 53 0	86 30 0	118,920	91.800	2.60	1.30	N	.15	N	.15	.68	1.20	.38
M-R111	36 53 0	86 30 0	118,821	69.200	3.50	2.10	.12	.35	.16	.25	.90	1.30	.29
M-R112	36 53 0	86 30 0	118,902	89.600	4.10	2.60	.12	.36	<.01	<.01	.75	1.50	.46
M-R112	36 53 0	86 30 0	119,014	91.600	3.10	1.90	.16	.44	.27	<.01	.60	1.20	.43
M-R121	36 53 0	86 30 0	118,846	90.100	5.50	1.80	.14	.39	N	<.01	1.10	1.10	.69
M-R121	36 53 0	86 30 0	118,813	86.900	5.20	1.70	.20	.40	N	.40	1.30	1.60	.41
M-R122	36 53 0	86 30 0	118,764	87.600	5.00	1.70	.20	.44	N	N	1.20	1.60	.43
M-R122	36 53 0	86 30 0	118,935	88.300	5.00	1.60	.28	.50	.15	.20	1.40	1.60	.52
M-R211	36 53 0	86 38 0	118,835	93.500	2.60	.83	N	.19	.11	.23	.46	1.00	.12
M-R211	36 53 0	86 38 0	118,916	93.600	2.50	.69	N	.10	.10	.20	.41	1.00	.22
M-R212	36 53 0	86 38 0	118,806	95.000	1.60	.90	N	.10	.15	N	.20	.65	.08
M-R212	36 53 0	86 38 0	118,951	95.600	1.20	.28	N	N	.16	.35	.15	.77	.08
M-R221	36 53 0	86 38 0	118,861	86.300	3.20	3.90	N	.11	.11	.30	.41	1.30	.35
M-R221	36 53 0	86 38 0	118,922	90.399	2.90	3.30	N	.10	N	N	.41	1.50	.32
M-R222	36 53 0	86 38 0	119,009	90.800	2.20	3.70	.12	N	.14	.13	<.01	.94	.26
M-R222	36 53 0	86 38 0	118,913	85.600	2.20	3.80	N	N	<.01	.10	.15	1.10	.27
M-S111	36 45 0	85 0 0	120,914	91.200	3.80	1.40	.12	N	N	.12	.41	1.20	.35
M-S111	36 45 0	85 0 0	120,916	90.700	3.30	.78	.16	.46	N	.28	.76	2.30	.36
M-S112	36 45 0	85 0 0	120,929	91.600	3.30	.81	.14	.37	.22	.15	.61	1.20	.26
M-S112	36 45 0	85 0 0	120,913	91.100	3.20	1.00	.14	.43	.23	.28	.64	.69	.31

Table 1B.--Cont.

Sample	TiO2%	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
M-L112	.24	.05	.16	<.05	.74	.096	180	25	70	2	18	7
M-L112	.25	.01	.07	<.05	.71	.110	160	30	60	4	18	5
M-L121	.72	.13	.08	<.05	2.10	.370	420	31	230	12	73	11
M-L121	.76	.09	.07	<.05	3.40	.480	430	36	210	9	72	12
M-L122	.73	.12	.03	<.05	2.80	.450	500	44	210	11	64	16
M-L122	.77	.18	.01	<.05	2.50	.410	540	44	220	12	60	15
M-L211	.53	.09	.04	<.05	2.70	.310	84	32	180	4	50	9
M-L211	.51	.10	.01	<.05	2.70	.320	90	29	180	4	60	9
M-L212	.60	.11	.14	<.05	1.00	.240	94	37	90	2	50	13
M-L212	.46	.12	.01	<.05	.91	.310	95	41	100	2	52	13
M-L221	.26	.01	.02	.52	1.30	.060	97	N	70	N	21	9
M-L221	.18	.06	.07	<.05	1.20	.061	79	N	50	N	130	7
M-L222	.24	.06	.07	<.05	1.80	.083	22	N	70	N	30	7
M-L222	.28	.06	.03	<.05	1.70	.100	22	N	80	N	140	8
M-G111	.62	.02	.09	<.05	1.20	.330	280	N	110	3	120	8
M-G111	.53	.07	.10	<.05	1.00	.220	230	26	100	2	150	7
M-G112	.53	.06	.08	3.90	2.10	.140	910	N	140	2	40	7
M-G112	.46	.06	.23	4.00	2.20	.160	920	N	140	3	100	7
M-G121	.48	.05	.15	<.05	3.20	.320	410	25	230	N	95	29
M-G121	.50	.02	.08	<.05	3.00	.300	380	41	210	4	83	27
M-G122	.53	.07	.03	<.05	2.60	.210	110	30	320	N	73	15
M-G122	.59	.07	.03	<.05	2.70	.210	130	30	340	N	71	16
M-G211	.23	.05	.02	<.05	.21	.085	33	N	30	N	60	4
M-G211	.24	<.01	.01	<.05	.21	.099	40	34	50	N	13	4
M-G212	.25	.02	.01	<.05	1.90	.047	16	27	50	N	63	7
M-G212	.27	.02	<.01	<.05	1.50	.042	14	N	40	N	11	7
M-G221	.34	.09	.14	<.05	1.30	.130	130	37	70	4	57	7
M-G221	.27	.11	.02	<.05	1.60	.120	150	26	70	3	64	8
M-G222	.27	.04	.10	<.05	.97	.140	590	N	120	7	98	11
M-G222	.35	.07	.11	<.05	1.00	.130	580	30	140	6	26	8
M-R111	.12	<.01	.04	<.05	.76	.055	33	N	100	N	30	7
M-R111	.35	.14	.02	<.05	.78	.061	38	20	130	N	60	8
M-R112	.15	.01	<.01	<.05	1.20	.038	33	N	90	2	13	7
M-R112	.15	.04	.02	<.05	1.30	.032	40	N	110	2	35	7
M-R121	.29	.05	.07	<.05	1.30	.140	24	29	230	4	90	8
M-R121	.35	.06	<.01	<.05	1.30	.150	21	28	200	4	61	9
M-R122	.23	.06	.08	<.05	1.20	.110	29	N	220	2	30	7
M-R122	.37	.21	.01	<.05	1.30	.120	27	N	230	6	32	8
M-R211	.37	.05	<.01	<.05	.30	.076	25	N	80	N	16	6
M-R211	.29	<.01	<.01	<.05	.30	.094	24	N	60	N	53	6
M-R212	.20	.03	<.01	<.05	.21	.059	11	N	80	N	24	4
M-R212	.17	<.01	.02	<.05	.20	.083	9	N	70	N	54	6
M-R221	.31	.07	.12	<.05	2.20	.034	340	N	120	4	11	8
M-R221	.29	.02	.02	<.05	2.40	.077	320	N	100	4	16	8
M-R222	.27	.01	<.01	<.05	3.10	.100	17	N	40	N	51	7
M-R222	.24	<.01	.02	<.05	2.90	.110	14	N	60	N	29	7
M-S111	.34	.05	.08	<.05	.60	.140	65	N	120	N	31	7
M-S111	.34	.03	<.01	<.05	.71	.150	80	26	160	N	38	6
M-S112	.37	<.01	<.01	<.05	.64	.120	42	30	120	N	27	8
M-S112	.34	.03	.02	<.05	.71	.170	49	27	150	N	48	3

Table 1B.--Cont.

Sample	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S	Yb ppm-S
M-L112	N	N	10	N	N	30	12	10	87	N	--
M-L112	N	N	10	N	N	30	11	N	170	N	--
M-L121	54	20	37	7	12	100	70	39	270	10	--
M-L121	N	N	29	N	11	80	50	36	300	11	--
M-L122	N	N	28	N	11	90	55	37	250	11	--
M-L122	N	20	28	N	11	100	59	30	280	11	--
M-L211	N	N	32	N	7	60	37	22	200	8	--
M-L211	N	N	31	N	7	80	36	26	210	9	--
M-L212	N	N	14	N	8	30	22	30	390	N	--
M-L212	N	N	14	9	5	50	22	23	360	6	--
M-L221	N	N	11	N	N	40	12	12	240	N	--
M-L221	N	N	11	N	N	10	12	10	87	N	--
M-L222	N	N	18	N	N	20	23	7	120	N	--
M-L222	N	N	18	N	5	40	27	8	100	7	--
M-Q111	N	N	13	N	8	40	16	21	700	N	--
M-Q111	N	N	13	N	6	30	15	19	720	N	--
M-Q112	N	N	13	N	5	100	18	17	180	N	--
M-Q112	N	N	15	N	7	100	21	20	230	N	--
M-Q121	N	N	25	N	7	60	33	26	270	9	--
M-Q121	N	N	26	N	8	50	35	21	240	7	--
M-Q122	N	N	21	N	6	60	30	18	230	8	--
M-Q122	N	N	20	N	6	70	29	19	230	9	--
M-Q211	N	N	5	N	N	10	9	8	190	N	--
M-Q211	N	N	9	N	N	20	9	9	160	N	--
M-Q212	N	N	5	9	N	30	9	N	81	N	--
M-Q212	N	N	N	9	N	30	7	N	41	N	--
M-Q221	N	N	10	9	6	30	18	15	300	N	--
M-Q221	N	N	11	N	5	N	20	12	180	N	--
M-Q222	N	N	9	N	6	20	20	12	150	N	--
M-Q222	N	N	9	N	5	30	16	15	160	N	--
M-R111	N	N	11	N	N	30	15	N	60	N	--
M-R111	N	N	10	8	N	N	18	7	51	N	--
M-R112	N	N	13	8	N	30	21	N	33	N	--
M-R112	N	N	13	N	N	30	20	N	100	N	--
M-R121	N	N	19	N	5	40	21	11	260	N	--
M-R121	N	N	18	N	N	50	24	12	120	N	--
M-P122	N	N	17	N	N	50	22	14	100	7	--
M-R122	N	N	21	7	7	50	29	17	130	6	--
M-R211	N	N	7	N	N	10	9	8	60	N	--
M-R211	N	N	8	N	N	10	8	7	82	N	--
M-R212	N	N	5	8	N	N	6	9	110	N	--
M-R212	N	N	6	N	N	10	7	N	59	N	--
M-R221	N	N	7	N	5	30	13	13	60	N	--
M-R221	N	N	8	N	5	30	15	10	84	N	--
M-R222	N	N	6	N	N	N	12	8	99	N	--
M-R222	N	N	6	8	5	N	12	8	90	N	--
M-S111	N	N	8	N	N	20	8	N	190	N	--
M-S111	N	N	9	N	N	30	9	N	230	N	--
M-S112	N	N	8	N	N	N	8	N	160	N	--
M-S112	N	N	6	N	N	30	9	N	250	N	--

Table 1B.--Cont.

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
M-S121	36 45 0	85 0 0	120,935	90.500	3.80	.82	.44	.87	N	.11	.46	1.50	.24
M-S121	36 45 0	85 0 0	120,915	89.800	3.90	.84	.42	.92	N	<.01	.55	2.80	.35
M-S122	36 45 0	85 0 0	120,918	92.700	2.00	.64	.20	.39	N	.20	.40	2.00	.16
M-S122	36 45 0	85 0 0	120,925	93.200	3.20	.45	.20	.32	N	.14	.46	.68	.15
M-T111	36 38 0	84 30 0	118,962	71.000	4.60	.50	1.00	1.50	10.10	.65	.65	1.60	.23
M-T111	36 38 0	84 30 0	118,896	70.600	4.70	.76	.94	1.40	10.30	.60	.60	1.30	.27
M-T112	36 38 0	84 30 0	118,792	88.400	4.40	1.00	1.10	.82	.82	.63	.48	1.30	.19
M-T112	36 38 0	84 30 0	118,824	37.000	4.60	2.20	1.00	.86	.93	1.00	.40	1.40	.20
M-T121	36 38 0	84 30 0	118,941	88.800	5.80	.90	.80	.40	.46	.10	.47	1.90	.16
M-T121	36 38 0	84 30 0	118,953	88.300	5.60	.82	.80	.46	.50	.18	.40	1.70	.29
M-T122	36 38 0	84 30 0	118,948	87.200	6.30	1.20	.86	.45	.39	.16	.30	2.10	.22
M-T122	36 38 0	84 30 0	119,018	88.200	5.80	1.40	.76	.40	.35	<.01	.52	2.00	.23
M-T211	36 52 0	84 15 0	120,938	72.100	10.50	1.70	2.40	1.30	3.30	.89	1.20	2.70	.40
M-T211	36 52 0	84 15 0	120,951	71.600	10.60	2.10	2.00	1.30	3.40	.80	1.40	2.50	.48
M-T212	36 52 0	84 15 0	120,944	65.700	8.90	1.70	3.30	1.40	7.80	.83	1.30	2.50	.35
M-T212	36 52 0	84 15 0	120,949	66.700	8.90	1.70	3.40	1.60	6.40	.80	1.20	2.60	.33
M-T221	36 52 0	84 15 0	120,956	51.900	4.00	.77	1.30	1.70	20.30	.26	.34	1.20	.14
M-T221	36 52 0	84 15 0	120,921	51.900	3.70	.66	1.40	1.80	19.80	.33	.47	1.10	.17
M-T222	36 52 0	84 15 0	120,957	56.000	5.80	1.10	2.30	2.90	13.80	.27	.59	1.40	.19
M-T222	36 52 0	84 15 0	120,936	56.200	5.00	1.00	2.30	2.80	13.60	.37	.58	1.50	.20

Table 13.--Cont.

Sample	TiO2%	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
M-S121	.42	<.01	<.01	<.05	.66	.084	11	N	90	N	20	10
M-S121	.28	.03	<.01	<.05	.68	.079	15	28	90	N	17	7
M-S122	.34	.04	<.01	<.05	.60	.120	39	30	160	N	30	9
M-S122	.38	<.01	<.01	<.05	.60	.120	40	22	150	N	71	9
M-T111	.26	.16	.03	6.50	1.20	.160	680	N	140	6	60	17
M-T111	.24	.14	.05	8.70	1.00	.120	570	N	110	7	37	12
M-T112	.34	.08	.16	.31	1.50	.170	120	21	140	N	42	10
M-T112	.38	.09	.04	.36	1.70	.180	140	31	140	N	44	10
M-T121	.48	.32	<.01	<.05	1.20	.220	47	22	100	8	55	27
M-T121	.45	.32	.01	<.05	1.10	.200	43	30	100	9	38	28
M-T122	.45	.25	<.01	<.05	1.30	.220	60	N	90	7	62	11
M-T122	.63	.27	.02	<.05	1.20	.220	49	N	100	2	42	10
M-T211	.88	.10	.11	2.40	3.60	.430	880	30	310	11	66	37
M-T211	.98	.10	.11	2.50	4.30	.440	1,300	39	310	11	60	41
M-T212	.96	.10	.26	4.90	5.50	.460	2,300	37	290	14	75	46
M-T212	.99	.11	.26	5.00	4.70	.420	2,300	30	270	12	73	47
M-T221	.73	.10	.14	16.50	1.70	.180	1,500	N	100	6	53	4
M-T221	.42	.10	.15	17.80	1.90	.180	1,600	N	100	6	60	9
M-T222	.76	.10	.14	14.60	3.00	.180	1,400	N	140	9	51	11
M-T222	.56	.09	.14	14.80	2.80	.180	1,500	N	120	9	43	11

Table 18.--Cont.

Sample	La ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S	Yb ppm-S
M-S121	N	N	7	N	N	N	N	N	100	N	--
M-S121	N	N	8	N	N	30	8	N	140	N	--
M-S122	N	N	7	N	N	N	N	N	230	N	--
M-S122	N	N	6	N	N	N	9	N	160	N	--
M-T111	N	N	17	190	8	270	30	32	110	5	--
M-T111	N	N	18	190	7	230	30	30	110	N	--
M-T112	N	N	16	7	5	100	26	21	140	7	--
M-T112	N	N	16	N	5	100	26	17	150	N	--
M-T121	N	N	27	13	8	50	36	45	180	6	--
M-T121	N	N	22	15	6	50	30	36	210	6	--
M-T122	N	N	21	19	9	50	36	30	190	6	--
M-T122	N	N	21	16	7	30	34	31	210	5	--
M-T211	N	N	36	N	14	170	61	59	280	10	--
M-T211	N	N	39	8	13	170	60	56	220	11	--
M-T212	N	N	38	N	14	230	67	60	400	13	--
M-T212	N	N	34	N	13	210	60	57	360	13	--
M-T221	N	N	10	N	9	260	24	25	190	N	2
M-T221	N	N	13	N	11	300	28	31	320	N	--
M-T222	N	N	14	8	10	250	29	29	180	N	--
M-T222	N	N	14	N	10	240	30	30	200	N	--

Table 10.--Geochemical analyses of sandstone of Pennsylvanian age in Kentucky. [%, percent; ppm, parts per million; N, not detected; labels ending in "-S" are spectrographic determinations]

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
P-E111	38 8 0	83 15 0	118,857	94.300	2.1	.50	N	N	N	<.01	.24	.76	.10
P-E111	38 8 0	83 15 0	118,811	94.200	2.3	.23	.12	N	N	.30	.40	.70	.65
P-E112	38 8 0	83 15 0	118,878	95.800	1.4	.35	N	N	.14	.15	.20	.35	.14
P-E112	38 8 0	83 15 0	118,850	95.200	1.6	.85	N	N	N	<.01	.15	.50	.10
P-E121	38 8 0	83 15 0	118,790	97.800	1.0	.21	N	N	N	N	.18	.54	.01
P-E121	38 8 0	83 15 0	118,849	95.600	1.3	.58	N	N	N	N	.14	.36	.09
P-E122	38 8 0	83 15 0	119,010	90.800	4.4	.82	.18	.16	.14	.15	.15	1.10	.18
P-E122	38 8 0	83 15 0	118,927	88.600	4.6	1.30	N	N	N	.30	.97	1.20	.31
P-E211	38 0 0	83 15 0	118,751	92.900	2.8	.80	.12	N	N	N	.65	1.10	.09
P-E211	38 0 0	83 15 0	118,801	90.200	4.9	1.20	N	.13	N	N	1.10	1.30	.15
P-E212	38 0 0	83 15 0	119,006	92.400	2.2	3.30	N	N	N	.60	.55	1.40	.21
P-E212	38 0 0	83 15 0	118,943	91.900	2.5	3.40	N	.11	N	.35	.40	.88	.22
P-E221	38 0 0	83 15 0	118,837	90.399	4.5	.46	.22	.16	.13	.81	.96	.66	.16
P-E221	38 0 0	83 15 0	118,791	92.300	4.0	.23	.24	.14	N	.67	.93	.64	.66
P-E222	38 0 0	83 15 0	118,829	73.700	12.7	3.70	.56	.77	.25	.60	2.20	3.30	.42
P-E222	38 0 0	83 15 0	118,809	73.900	12.5	3.20	.60	.70	.30	.40	2.30	3.50	.34
P-F111	38 23 0	82 45 0	119,013	54.600	8.3	2.50	1.20	.75	16.40	1.40	.37	1.60	.30
P-F111	38 23 0	82 45 0	118,968	54.600	8.0	2.50	1.10	.70	15.90	1.10	1.60	1.70	.30
P-F112	38 23 0	82 45 0	118,793	75.000	12.9	2.90	.28	.41	N	.33	2.40	3.50	.24
P-F112	38 23 0	82 45 0	119,020	79.000	12.0	2.70	.28	.39	.30	.20	2.30	3.10	.34
P-F121	38 23 0	82 45 0	118,914	68.400	8.7	6.10	.10	.25	N	.75	2.10	2.60	.40
P-F121	38 23 0	82 45 0	118,875	77.700	8.6	6.20	N	.30	.15	.80	1.80	2.90	.43
P-F122	38 23 0	82 45 0	119,017	76.000	8.5	3.70	.58	.58	3.40	.90	1.30	2.40	.31
P-F122	38 23 0	82 45 0	119,022	76.100	8.6	3.80	.58	.55	3.20	.90	1.30	2.10	.32
P-F211	38 15 0	82 45 0	119,027	76.700	11.3	3.30	1.00	.85	.20	1.20	1.90	2.70	.39
P-F211	38 15 0	82 45 0	118,797	76.000	11.4	3.30	.92	.85	.25	1.20	1.80	2.70	.34
P-F212	38 15 0	82 45 0	118,910	76.900	12.6	2.90	.16	.25	N	.25	2.90	3.40	.27
P-F212	38 15 0	82 45 0	119,023	80.800	10.8	2.40	.18	.20	.10	.13	2.50	2.90	.26
P-F221	38 15 0	82 45 0	118,823	83.400	6.4	3.80	.12	N	.16	.40	2.20	1.70	.10
P-F221	38 15 0	82 45 0	118,860	85.000	6.6	2.60	N	N	N	.18	2.20	1.50	.16
P-F222	38 15 0	82 45 0	118,883	71.000	12.3	3.70	.72	.90	2.00	.75	1.90	2.80	.50
P-F222	38 15 0	82 45 0	118,787	72.600	11.9	3.10	.80	.89	1.50	.69	1.80	3.20	.34
P-H111	37 23 0	88 23 0	118,978	94.900	2.0	1.20	N	<.01	.10	N	.40	.88	.12
P-H111	37 23 0	88 23 0	118,859	93.200	2.2	1.80	N	N	.12	.17	.25	.81	.11
P-H112	37 23 0	88 23 0	119,012	93.800	2.0	1.50	.12	N	.17	.30	<.01	.92	.18
P-H112	37 23 0	88 23 0	118,840	92.300	2.4	2.00	.10	.12	N	.19	.28	.73	.20
P-H121	37 23 0	88 23 0	118,934	95.600	1.6	.43	N	.10	.10	N	.35	.48	.15
P-H121	37 23 0	88 23 0	118,992	94.600	1.8	.36	.12	N	.15	.40	.35	.59	.14
P-H122	37 23 0	88 23 0	118,961	93.900	1.7	1.60	.12	N	N	N	.43	2.70	.10
P-H122	37 23 0	88 23 0	118,926	90.200	4.5	2.40	N	.15	.10	N	.60	.65	.28
P-H211	37 15 0	88 8 0	118,989	95.500	1.5	N	.16	N	.15	.20	.28	.55	.13
P-H211	37 15 0	88 8 0	118,769	95.500	1.4	.17	N	N	N	N	.42	.52	.12
P-H212	37 15 0	88 8 0	119,011	93.400	2.6	.76	.18	.14	N	.30	<.01	.79	.21
P-H212	37 15 0	88 8 0	119,003	93.400	2.7	.94	.16	.15	N	.20	.65	1.00	.20
P-H221	37 15 0	88 8 0	118,758	95.100	1.7	.25	N	N	N	N	.45	.60	.11
P-H221	37 15 0	88 8 0	118,810	95.600	1.6	.23	.12	.10	.14	.16	.30	.61	.09
P-H222	37 15 0	88 8 0	118,820	93.000	2.8	.57	.16	.20	N	.45	.70	.79	.11
P-H222	37 15 0	88 8 0	118,956	93.900	2.5	.28	N	.15	.15	N	.50	.55	.17
P-I111	37 23 0	87 23 0	118,775	83.300	7.9	1.30	.32	.30	.15	1.30	1.10	2.00	.23
P-I111	37 23 0	87 23 0	118,995	84.600	8.0	1.40	.20	.35	.30	.90	1.00	1.90	.32

Table 10.--Cont.

Sample	TiO2%	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
P-E111	.29	.04	<.01	<.05	.15	.120	29	27	100	2	32	5
P-E111	.26	.05	.15	<.05	.14	.088	20	21	90	N	26	7
P-E112	.32	.02	.07	<.05	.18	.160	110	28	70	3	75	6
P-E112	.47	.05	.05	<.05	.19	.110	99	20	90	N	75	9
P-E121	.36	.02	.10	<.05	.09	.130	25	23	60	N	58	2
P-E121	.41	.05	.02	<.05	.08	.120	20	N	50	N	31	4
P-E122	.49	.01	<.01	<.05	.80	.220	91	32	160	5	62	5
P-E122	.42	.01	.02	<.05	.72	.200	85	25	150	5	110	7
P-E211	.17	.06	.02	<.05	.38	.034	60	N	110	6	34	7
P-E211	.50	.08	<.01	<.05	.42	.097	60	20	130	6	66	7
P-E212	.23	.05	.22	<.05	1.90	.024	360	N	90	N	11	8
P-E212	.10	.04	.11	<.05	2.10	.030	500	N	90	N	13	8
P-E221	.15	.05	.03	<.05	.20	.033	24	N	110	N	3	4
P-E221	.09	.02	.01	<.05	.17	.030	20	N	120	N	3	4
P-E222	.92	.21	.01	<.05	3.60	.530	290	30	410	8	49	18
P-E222	.83	.19	.02	<.05	3.30	.590	250	27	390	9	47	20
P-F111	.63	.10	.20	13.00	2.70	.180	1,200	N	270	5	29	7
P-F111	.59	.12	.16	13.10	3.60	.230	1,100	N	290	6	35	8
P-F112	.61	.05	.03	<.05	2.60	.250	93	N	320	5	32	8
P-F112	.63	.18	.02	<.05	2.60	.280	80	N	310	4	31	9
P-F121	.57	.06	.07	<.05	3.80	.210	410	21	240	13	20	8
P-F121	.61	.08	.05	<.05	4.20	.210	460	23	250	13	21	6
P-F122	.90	.20	.03	2.10	4.30	.400	820	33	1,100	4	34	11
P-F122	.92	.19	.06	2.20	3.70	.420	830	37	1,700	4	35	10
P-F211	1.10	.20	.03	<.05	5.00	.810	470	39	410	11	56	26
P-F211	1.10	.17	.21	<.05	3.90	.810	540	44	480	15	60	27
P-F212	.47	.01	.02	<.05	1.50	.130	41	N	260	N	20	23
P-F212	.40	.03	<.01	<.05	1.80	.140	52	N	260	N	24	26
P-F221	.40	.07	<.01	<.05	1.10	.087	30	20	210	N	8	8
P-F221	.24	.05	.02	<.05	1.20	.100	32	20	230	N	8	8
P-F222	.85	.14	.21	.89	4.30	.520	1,300	26	390	9	46	15
P-F222	.86	.14	.17	.88	3.90	.480	1,100	N	380	11	49	15
P-H111	.16	.03	.01	<.05	.60	.060	31	N	60	N	56	9
P-H111	.21	.05	.05	<.05	.68	.073	35	29	70	N	12	7
P-H112	.26	.02	.02	<.05	.75	.033	23	20	40	N	210	9
P-H112	.18	.06	.01	<.05	.77	.049	22	27	80	N	42	7
P-H121	.33	.01	<.01	<.05	.23	.052	13	22	50	N	41	6
P-H121	.26	.02	.01	<.05	.22	.050	15	N	60	N	21	4
P-H122	.19	.04	<.01	<.05	1.00	.052	130	30	70	2	83	6
P-H122	.16	<.01	.08	<.05	.68	.067	120	N	50	3	31	5
P-H211	.16	.03	<.01	<.05	.15	.040	37	43	70	4	25	4
P-H211	.14	.06	.02	<.05	.15	.041	45	N	70	N	44	3
P-H212	.47	.01	<.01	<.05	.60	.160	22	29	100	N	53	10
P-H212	.44	.01	.04	<.05	.60	.160	25	46	100	N	36	7
P-H221	.13	.03	.02	<.05	.15	.044	43	N	60	N	18	5
P-H221	.13	.06	.01	<.05	.16	.037	39	21	80	N	14	4
P-H222	.48	.07	.05	<.05	.20	.060	15	28	60	N	18	5
P-H222	.19	<.01	<.01	<.05	.21	.060	15	22	70	N	15	5
P-I111	.91	.10	.01	<.05	1.10	.570	130	49	260	4	29	12
P-I111	.89	.04	.06	<.05	1.30	.720	170	30	280	N	43	10

Table 10.--Cont.

Sample	La ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S
P-E111	N	N	N	7	7	5	30	11	21	170	N
P-E111	N	N	N	6	N	N	20	12	N	120	N
P-E112	N	N	N	9	N	6	20	10	15	480	N
P-E112	N	N	N	8	N	N	30	9	11	200	N
P-E121	N	N	N	N	7	6	10	10	12	350	N
P-E121	N	N	N	5	N	N	30	7	12	260	N
P-E122	N	N	N	16	15	N	50	18	50	300	N
P-E122	N	N	N	15	20	8	50	21	18	280	6
P-E211	N	N	N	11	11	N	10	14	8	79	N
P-E211	N	N	N	13	10	N	N	17	9	110	N
P-E212	N	N	N	7	N	N	30	9	N	39	N
P-E212	N	N	N	11	N	N	40	13	N	100	N
P-E221	N	N	N	6	6	N	20	9	N	31	N
P-E221	N	N	N	4	N	N	30	10	N	23	N
P-E222	50	N	22	21	10	15	100	75	50	500	20
P-E222	60	N	23	21	8	15	110	71	60	420	19
P-F111	N	N	N	13	N	7	310	40	20	84	8
P-F111	N	N	N	15	N	10	360	47	21	73	10
P-F112	N	N	N	14	7	8	70	46	15	110	16
P-F112	N	N	N	12	10	6	60	45	10	140	15
P-F121	N	N	N	19	9	8	70	25	19	160	9
P-F121	N	N	N	20	10	7	50	23	26	190	8
P-F122	N	N	N	14	N	10	130	44	28	180	8
P-F122	N	N	N	15	N	10	140	44	27	210	10
P-F211	53	N	25	31	13	14	90	63	46	680	15
P-F211	60	N	26	30	14	16	130	78	87	960	19
P-F212	N	N	N	10	N	6	50	30	18	100	9
P-F212	N	N	N	10	11	6	50	33	22	95	9
P-F221	N	N	N	4	18	N	50	12	9	100	N
P-F221	N	N	N	5	20	N	30	10	15	130	N
P-F222	N	N	21	20	N	12	90	78	36	280	13
P-F222	N	N	20	21	7	13	110	68	39	240	17
P-H111	N	N	N	9	N	N	30	8	8	61	N
P-H111	N	N	N	9	N	N	30	7	8	98	N
P-H112	N	N	N	4	N	N	20	5	N	28	N
P-H112	N	N	N	3	N	N	30	8	11	36	N
P-H121	N	N	N	7	N	N	60	13	N	26	N
P-H121	N	N	N	N	N	N	60	7	N	31	N
P-H122	N	N	N	10	N	N	60	16	7	46	N
P-H122	N	N	N	14	N	N	60	18	8	36	N
P-H211	N	N	N	3	N	5	30	19	N	60	N
P-H211	N	N	N	N	N	N	10	21	N	66	N
P-H212	N	N	N	8	N	N	20	11	13	290	N
P-H212	N	N	N	9	N	5	20	14	11	190	N
P-H221	N	N	N	3	N	N	N	7	N	43	N
P-H221	N	N	N	4	7	N	10	8	7	38	N
P-H222	N	N	N	3	N	N	N	10	N	92	N
P-H222	N	N	N	4	N	N	30	9	7	59	N
P-I111	N	N	N	15	N	11	120	40	22	220	7
P-I111	N	N	N	12	N	8	140	44	29	140	9

Table 10.--Cont.

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
P-I112	37 23 0	87 23 0	118,884	82.500	8.8	1.80	.16	.36	.25	.95	1.30	2.10	.32
P-I112	37 23 0	87 23 0	118,929	81.600	8.2	1.70	.14	.27	.20	1.10	1.20	1.60	.40
P-I121	37 23 0	87 23 0	118,831	84.900	6.7	2.30	N	.30	.20	.93	.95	1.70	.27
P-I121	37 23 0	87 23 0	118,880	85.100	6.8	2.20	N	.50	.16	.80	.90	1.70	.42
P-I122	37 23 0	87 23 0	118,780	84.100	7.1	1.80	.16	.33	.26	.90	.99	1.60	.26
P-I122	37 23 0	87 23 0	118,804	85.700	7.3	1.80	.16	.30	.15	.94	1.20	1.70	.24
P-J111	37 8 0	86 0 0	118,799	76.300	1.6	16.00	.12	N	N	N	N	2.70	.31
P-J111	37 8 0	86 0 0	118,925	75.400	2.4	16.40	N	N	N	.13	.15	3.30	.51
P-J112	37 8 0	86 0 0	118,985	78.000	1.5	15.50	.10	<.01	.11	.11	<.01	2.50	.35
P-J112	37 8 0	86 0 0	118,933	79.400	1.6	15.00	N	<.01	N	.14	.15	1.80	.37
P-J121	37 8 0	86 0 0	118,940	95.300	1.6	1.00	N	N	N	N	.15	.80	.11
P-J121	37 8 0	86 0 0	118,789	94.800	1.4	1.00	N	N	N	N	N	.60	.03
P-J122	37 8 0	86 0 0	118,917	92.500	2.9	1.30	N	.10	<.01	.10	.15	1.30	.28
P-J122	37 8 0	86 0 0	118,924	93.000	2.4	1.00	<.01	.14	<.01	N	.27	1.30	.27
P-J211	37 53 0	86 45 0	118,983	93.800	1.8	.72	.24	N	.22	.40	.45	.94	.16
P-J211	37 53 0	86 45 0	118,930	94.300	1.6	1.00	N	N	N	N	.35	.63	.31
P-J212	37 53 0	86 45 0	118,874	83.600	7.6	1.60	.32	.40	.22	.90	1.00	1.80	.30
P-J212	37 53 0	86 45 0	118,738	84.200	7.5	1.30	.40	.38	.18	.56	.98	2.00	.17
P-J221	37 53 0	86 45 0	118,907	89.500	3.9	2.80	N	N	<.01	<.01	1.00	1.40	.18
P-J221	37 53 0	86 45 0	118,990	89.800	4.0	2.50	.20	N	.14	.30	1.10	1.20	.18
P-J222	37 53 0	86 45 0	118,899	81.200	10.1	1.60	N	.22	.38	N	2.20	2.50	.43
P-J222	37 53 0	86 45 0	118,778	88.400	5.3	.80	N	N	.17	.77	1.10	1.30	.16
P-L111	37 8 0	84 0 0	118,808	92.800	3.0	.17	.52	.11	.20	.30	.60	.86	.06
P-L111	37 8 0	84 0 0	118,830	92.700	2.9	.56	.16	.13	.20	.65	.53	.32	.08
P-L112	37 8 0	84 0 0	118,895	89.600	4.4	1.10	.30	.21	N	.45	.90	1.20	.17
P-L112	37 8 0	84 0 0	113,761	91.100	4.1	.84	.16	.17	N	.34	.74	1.10	.15
P-L121	37 8 0	84 0 0	118,954	85.600	7.5	1.00	.48	.46	.17	1.10	1.10	1.40	.15
P-L121	37 8 0	84 0 0	118,816	84.400	7.4	.82	.48	.45	N	1.30	1.30	1.60	.14
P-L122	37 8 0	84 0 0	119,008	84.000	7.6	1.80	.68	.50	N	.60	.54	2.00	.36
P-L122	37 8 0	84 0 0	118,970	85.000	8.1	1.90	.60	.45	N	.45	1.50	2.20	.33
P-L211	37 15 0	84 0 0	118,865	82.900	8.3	2.20	.42	.40	.16	1.00	1.00	2.20	.41
P-L211	37 15 0	84 0 0	118,973	83.700	8.2	3.50	.46	.32	.10	.73	1.10	2.20	.32
P-L212	37 15 0	84 0 0	118,975	91.200	4.8	.97	.14	N	<.01	.14	.65	1.50	.21
P-L212	37 15 0	84 0 0	118,889	88.800	5.3	1.30	.14	.15	.15	.20	.70	1.70	.20
P-L222	37 15 0	84 0 0	118,750	89.600	3.1	1.30	.44	.12	N	.13	.32	1.10	.12
P-L222	37 15 0	84 0 0	118,911	91.900	3.0	1.60	N	.14	N	.30	.30	1.20	.17
P-M111	37 45 0	83 8 0	118,921	77.000	11.6	1.50	.70	.50	.25	1.80	2.10	2.10	.27
P-M111	37 45 0	83 8 0	118,982	78.900	10.4	1.20	.66	.44	.32	1.70	2.10	2.40	.16
P-M112	37 45 0	83 8 0	118,825	76.100	11.8	1.50	.42	.52	.20	2.10	2.10	2.80	.19
P-M112	37 45 0	83 8 0	118,979	83.400	9.1	1.00	.42	.31	.12	1.30	2.00	1.70	.15
P-M122	37 45 0	83 8 0	113,942	80.800	8.6	3.80	.16	.36	.10	1.00	1.60	2.20	.37
P-M122	37 45 0	83 8 0	118,950	81.200	8.6	3.80	.14	.31	.20	.92	1.50	2.20	.41
P-M211	37 15 0	83 0 0	118,866	75.700	12.6	2.50	.58	.70	.20	2.00	2.40	2.20	.37
P-M211	37 15 0	83 0 0	118,977	79.500	11.1	1.90	.62	.60	.23	1.60	2.30	2.20	.27
P-M212	37 15 0	83 0 0	118,946	86.600	7.7	1.20	.12	.20	N	.55	1.70	1.80	.21
P-M212	37 15 0	83 0 0	118,873	84.600	7.9	1.30	.12	.25	.15	.72	1.80	1.80	.25
P-M221	37 15 0	83 0 0	118,959	78.400	11.1	2.10	.62	.65	.30	1.50	1.40	.45	.41
P-M221	37 15 0	83 0 0	118,965	79.100	11.0	1.90	.58	.42	.28	1.70	1.60	2.50	.42
P-M222	37 15 0	83 0 0	118,776	83.300	7.9	2.50	.32	.36	.16	.77	1.00	1.40	.15
P-M222	37 15 0	83 0 0	113,999	84.600	7.4	2.20	.28	.32	N	.20	.60	2.40	.21

Table 10.--Cont.

Sample	TiO2%	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
P-I112	.62	.04	.09	<.05	1.40	.330	150	28	300	8	30	10
P-I112	.62	.03	.07	<.05	1.50	.370	140	21	250	8	30	9
P-I121	.99	.10	.16	<.05	.87	.350	410	60	170	5	20	8
P-I121	1.10	.07	.13	<.05	1.80	.840	950	63	270	11	55	10
P-I122	.89	.06	.11	<.05	1.80	.750	100	90	250	7	73	15
P-I122	.89	.09	.02	<.05	1.60	.740	91	59	240	5	41	12
P-J111	.02	.06	.04	<.05	7.50	.030	23	N	60	N	13	11
P-J111	.04	.04	.04	<.05	6.70	.023	19	N	60	N	12	11
P-J112	.10	.04	<.01	<.05	9.60	.021	33	N	30	2	11	8
P-J112	.14	.03	<.01	<.05	9.70	.020	40	N	60	2	12	10
P-J121	.13	<.01	.03	<.05	.39	.036	5	N	50	N	10	4
P-J121	.21	.05	.04	<.05	.34	.028	8	21	30	N	11	3
P-J122	.29	<.01	.05	<.05	.38	.059	12	N	60	N	11	7
P-J122	.29	.02	.02	<.05	.35	.075	11	25	60	N	16	6
P-J211	.29	.13	<.01	<.05	.59	.140	29	N	120	N	52	7
P-J211	.29	.12	.06	<.05	.58	.100	28	N	120	N	54	6
P-J212	.67	.13	.06	<.05	1.50	.430	150	49	210	8	52	12
P-J212	.70	.16	.04	<.05	1.40	.420	130	44	210	8	62	12
P-J221	.28	.07	.14	<.05	.94	.065	97	N	120	N	29	6
P-J221	.35	.07	.07	<.05	1.50	.120	110	32	150	N	15	6
P-J222	.56	.03	<.01	<.05	.30	.080	18	N	150	N	11	6
P-J222	.26	.05	.01	<.05	.34	.082	19	37	140	N	12	8
P-L111	.30	.06	<.01	<.05	.30	.099	48	29	110	N	9	6
P-L111	.46	.07	<.01	<.05	.70	.240	300	27	150	3	19	9
P-L112	.46	.03	<.01	<.05	.65	.180	69	27	160	6	30	8
P-L112	.43	.09	.01	<.05	.72	.180	68	36	150	2	23	8
P-L121	.48	.04	.02	<.05	1.10	.250	140	30	220	5	30	10
P-L121	.54	.10	.01	<.05	.90	.240	150	25	240	5	55	9
P-L122	.48	.06	<.01	<.05	2.20	.260	97	25	210	3	47	12
P-L122	.62	.06	.02	<.05	2.40	.270	95	35	190	5	56	12
P-L211	.58	.06	.01	<.05	2.50	.340	450	35	230	10	69	10
P-L211	.59	.16	.01	<.05	2.20	.330	370	36	170	9	64	10
P-L212	.46	.03	.01	<.05	.63	.230	25	29	110	N	81	3
P-L212	.46	.01	.03	<.05	.70	.240	31	25	110	N	71	8
P-L222	.34	.06	.05	<.05	1.10	.170	470	35	110	4	48	9
P-L222	.29	.04	.05	<.05	.95	.160	360	21	100	4	35	6
P-M111	.62	.13	.15	<.05	1.30	.290	260	N	260	6	24	7
P-M111	.59	.13	.01	<.05	1.40	.260	320	N	270	6	26	8
P-M112	.71	.10	.06	<.05	.90	.270	100	20	330	5	26	7
P-M112	.51	.04	.01	<.05	.89	.210	90	N	300	5	21	7
P-M122	1.10	.12	.02	<.05	3.60	.680	440	N	260	9	40	11
P-M122	.99	.12	.06	<.05	4.40	.680	390	34	240	9	38	12
P-M211	.64	.13	.06	<.05	2.50	.330	440	24	410	5	36	10
P-M211	.69	.11	.01	<.05	2.00	.220	350	N	310	4	30	8
P-M212	.30	.02	.03	<.05	.72	.110	100	N	190	5	16	7
P-M212	.35	.04	.10	<.05	.77	.140	120	25	260	4	19	7
P-M221	.93	.29	.02	<.05	2.60	.760	130	32	300	5	47	13
P-M221	.95	.25	.08	<.05	2.90	.850	150	34	300	3	60	12
P-M222	.89	.22	.04	<.05	1.90	.370	460	23	200	4	27	10
P-M222	.89	.16	.08	<.05	1.80	.530	360	29	190	3	27	8

Table 10.--Cont.

Sample	La ppm-S	Mo ppm-S	Nb ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S
P-I112	N	N	N	17	8	9	110	49	24	220	6
P-I112	N	N	N	20	8	9	100	45	21	220	9
P-I121	N	N	N	12	N	7	60	23	19	240	5
P-I121	N	N	28	19	9	11	70	46	40	420	7
P-I122	N	N	23	17	9	12	90	46	37	490	9
P-I122	N	N	22	16	10	11	90	44	35	470	9
P-J111	N	8	N	4	11	7	40	10	8	35	N
P-J111	N	N	N	10	12	8	30	9	8	44	N
P-J112	N	N	N	6	11	6	40	10	N	25	N
P-J112	N	N	N	5	N	8	30	11	N	22	N
P-J121	N	N	N	3	N	N	20	N	N	26	N
P-J121	N	N	N	N	11	N	N	N	N	24	N
P-J122	N	N	N	5	N	N	20	11	10	42	N
P-J122	N	N	N	9	7	N	20	12	N	43	N
P-J211	N	N	N	5	N	5	50	15	7	240	N
P-J211	N	N	N	8	N	7	50	17	9	270	N
P-J212	N	N	21	21	16	10	60	50	37	420	11
P-J212	N	N	N	20	N	10	70	49	29	340	8
P-J221	N	N	N	6	11	N	40	12	N	66	N
P-J221	N	N	N	8	7	N	70	16	9	190	N
P-J222	N	N	N	9	11	N	50	20	10	56	N
P-J222	N	N	N	4	N	N	60	16	7	58	N
P-L111	N	N	N	6	N	N	20	9	8	60	N
P-L111	N	N	N	11	10	6	50	21	15	200	5
P-L112	N	N	N	15	8	5	50	25	19	140	N
P-L112	N	N	N	10	9	5	40	21	18	130	N
P-L121	N	N	N	17	7	8	70	30	29	160	9
P-L121	N	N	N	16	7	8	90	36	33	160	9
P-L122	N	N	N	18	7	7	50	35	20	170	10
P-L122	N	N	N	19	8	7	60	35	18	220	7
P-L211	N	N	N	30	N	11	70	44	27	430	11
P-L211	N	N	N	27	10	8	50	36	20	250	7
P-L212	N	N	N	11	9	8	30	20	27	270	5
P-L212	N	N	N	16	N	9	30	25	20	560	N
P-L222	N	N	N	15	N	6	10	17	24	290	N
P-L222	N	N	N	14	N	6	30	15	23	220	N
P-M111	N	N	N	12	8	7	80	33	13	170	9
P-M111	N	N	N	12	11	6	90	35	19	190	10
P-M112	N	N	N	13	14	9	100	36	16	210	14
P-M112	N	N	N	11	11	5	50	33	13	100	11
P-M122	60	N	20	21	15	13	70	50	52	910	10
P-M122	N	N	20	20	18	12	60	46	52	1,000	8
P-M211	N	N	N	11	7	8	140	52	18	220	15
P-M211	N	N	N	12	N	7	100	39	12	130	10
P-M212	N	N	N	13	20	5	50	22	10	82	6
P-M212	N	N	N	9	25	N	50	20	7	92	N
P-M221	60	N	22	15	N	12	100	65	46	510	12
P-M221	60	N	24	13	8	13	100	60	36	440	14
P-M222	N	N	N	20	N	9	60	30	28	160	11
P-M222	N	N	21	18	N	7	30	30	20	140	9

Table 10.--Cont.

Sample	Latitude	Longitude	LAB. NO.	SiO2%	Al2O3%	Fe2O3%	FeO%	MgO%	CaO%	Na2O%	K2O%	H2O+%	H2O-%
P-N111	37 38 0	82 38 0	118,963	81.600	10.3	1.20	.36	.40	.25	.90	2.10	2.30	.20
P-N111	37 38 0	82 38 0	118,993	87.900	1.0	1.30	.28	.55	.35	1.10	2.00	2.20	.22
P-N112	37 38 0	82 38 0	118,882	74.900	12.5	3.00	.78	.70	.20	1.90	1.90	2.60	.49
P-N112	37 38 0	82 38 0	118,841	76.500	11.8	2.90	.74	.73	.15	1.70	1.80	2.20	.49
P-N121	37 38 0	82 38 0	118,754	79.600	10.5	3.10	.20	.38	N	.89	2.10	2.60	.24
P-N121	37 38 0	82 38 0	118,854	76.100	10.4	3.50	.14	.38	.10	1.00	2.00	2.40	.40
P-N122	37 38 0	82 38 0	118,696	65.900	10.9	2.60	.88	.67	7.60	.50	1.60	2.60	.38
P-N122	37 38 0	82 38 0	118,938	66.500	10.6	2.30	.80	.70	8.30	.56	1.70	2.40	.50
P-N211	37 30 0	82 8 0	118,777	78.300	12.1	2.50	.20	.48	.23	1.30	2.10	2.70	.30
P-N211	37 30 0	82 8 0	118,866	74.700	13.4	2.90	.22	.45	.20	1.40	2.40	2.60	.42
P-N212	37 30 0	82 8 0	118,903	70.700	11.0	2.40	.54	.52	7.40	1.50	1.70	2.00	.36
P-N212	37 30 0	82 8 0	118,994	73.300	9.1	1.70	.52	.40	5.80	1.70	1.60	1.80	.23
P-N221	37 30 0	82 8 0	118,897	72.200	13.6	4.10	.98	1.00	.35	1.80	2.30	2.90	.56
P-N221	37 30 0	82 8 0	118,803	72.900	13.3	4.00	.84	.90	.20	1.80	2.10	2.50	.53
P-N222	37 30 0	82 8 0	118,762	55.000	9.1	1.80	2.40	.77	11.80	.94	1.70	1.80	.17
P-N222	37 30 0	82 8 0	118,890	53.100	9.2	1.30	3.00	.85	14.50	1.10	2.00	2.00	.20
P-G111	36 53 0	87 15 0	118,868	94.700	2.4	.35	N	N	N	.10	.15	.88	.12
P-G111	36 53 0	87 15 0	118,845	94.200	2.4	.54	N	N	N	N	.14	.84	.12
P-G112	36 53 0	87 15 0	118,997	94.200	2.4	.69	N	N	N	N	.15	.96	.14
P-G112	36 53 0	87 15 0	118,796	92.700	2.7	.69	N	.10	.22	.15	.40	.93	.07
P-G121	36 53 0	87 15 0	118,918	78.400	1.6	15.00	N	N	N	N	.10	3.00	.21
P-G121	36 53 0	87 15 0	118,838	75.100	2.9	17.10	N	N	.13	.10	.21	2.60	.25
P-G122	36 53 0	87 15 0	118,930	77.500	1.8	16.50	.10	<.01	.24	.11	.25	3.00	.21
P-G122	36 53 0	87 15 0	118,834	76.200	1.6	17.70	N	.10	.20	.25	.12	3.40	.14
P-G211	36 53 0	87 23 0	118,851	90.250	2.9	4.00	.10	N	N	<.01	.22	1.00	.17
P-G211	36 53 0	87 23 0	118,828	88.100	3.2	5.10	N	.10	.15	.20	.41	1.40	.11
P-G212	36 53 0	87 23 0	118,752	87.400	2.7	6.30	.12	N	N	N	.16	1.80	.13
P-G212	36 53 0	87 23 0	119,019	90.300	2.2	5.20	.12	N	N	<.01	.30	1.50	.20
P-G221	36 53 0	87 23 0	118,900	92.100	3.7	2.30	N	N	.13	<.01	.20	1.30	.16
P-G221	36 53 0	87 23 0	118,798	92.300	2.8	1.70	N	N	.15	N	.21	1.20	.08
P-G222	36 53 0	87 23 0	118,855	83.600	3.0	9.50	N	N	N	N	N	1.80	.18
P-G222	36 53 0	87 23 0	118,779	87.600	1.4	7.60	N	N	.35	.43	N	1.60	.07
P-T111	36 53 0	84 8 0	118,981	90.699	4.5	.70	.30	.16	.11	.22	.70	1.50	.15
P-T111	36 53 0	84 8 0	118,863	88.600	5.6	1.00	.30	.30	.15	.55	.60	1.60	.24
P-T112	36 53 0	84 8 0	118,556	75.100	12.6	4.10	.70	.61	.15	1.40	1.80	2.60	.57
P-T112	36 53 0	84 8 0	118,944	84.600	2.2	3.90	.70	.69	N	1.30	1.80	3.00	.15
P-T122	36 53 0	84 8 0	118,915	94.100	2.5	.24	N	N	<.01	.20	.50	1.00	.14
P-T122	36 53 0	84 8 0	118,856	93.800	3.2	.44	N	N	N	<.01	.41	1.00	.14
P-T211	36 53 0	84 15 0	118,932	94.900	1.8	.55	N	<.01	.10	.12	.30	.52	.23
P-T211	36 53 0	84 15 0	118,901	95.500	2.3	.92	N	N	N	N	.45	.87	.11
P-T212	36 53 0	84 15 0	119,026	82.900	10.0	1.40	.70	.50	N	.22	1.90	2.60	.26
P-T212	36 53 0	84 15 0	118,912	81.800	9.8	1.60	.54	.42	<.01	.37	1.80	2.00	.36
P-T221	36 53 0	84 15 0	118,844	90.300	4.3	.94	N	N	.14	<.01	.38	1.70	.15
P-T221	36 53 0	84 15 0	119,002	93.500	3.0	.42	.24	N	.12	.40	<.01	1.10	.11
P-T222	36 53 0	84 15 0	118,694	93.400	2.6	.84	N	N	N	N	.30	1.20	.11
P-T222	36 53 0	84 15 0	118,768	93.500	2.8	.43	N	N	N	N	.30	1.00	.11

Table 1C.--Cont.

Sample	TiO2%	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
P-N111	.69	.09	.01	<.05	.83	.250	130	30	260	4	30	7
P-N111	.54	.06	.02	<.05	.73	.220	110	N	260	4	28	7
P-N112	.76	.14	.08	<.05	3.00	.390	340	44	300	7	47	11
P-N112	.76	.16	.14	<.05	2.90	.400	360	N	320	7	40	14
P-N121	.46	.09	.07	<.05	2.40	.190	730	26	280	9	23	9
P-N121	.44	.11	.16	<.05	2.30	.180	730	37	290	7	23	12
P-N122	.79	.03	.18	6.00	2.60	.490	760	N	370	9	53	11
P-N122	.73	.04	.08	6.40	2.10	.360	780	N	360	7	45	11
P-N211	.54	.10	.08	<.05	2.10	.260	620	N	300	10	25	8
P-N211	.51	.08	.06	<.05	1.80	.230	610	N	350	9	26	9
P-N212	.34	.06	.30	5.60	1.60	.190	1,600	N	280	5	25	6
P-N212	.27	.06	.24	4.30	1.60	.120	1,700	25	250	4	19	6
P-N221	.73	.13	.17	<.05	3.80	.390	950	N	320	12	47	12
P-N221	.77	.18	.12	<.05	3.80	.440	1,000	N	340	14	51	13
P-N222	.50	.13	.13	12.50	2.90	.160	1,100	N	270	6	41	10
P-N222	.46	.07	.18	12.80	2.80	.230	1,200	N	260	8	35	10
P-Q111	.11	.04	<.01	<.05	.13	.031	15	25	40	N	7	1
P-Q111	.22	.07	.01	<.05	.13	.028	15	24	70	N	7	6
P-Q112	.53	.01	.03	<.05	.48	.210	12	32	60	N	92	7
P-Q112	.47	.04	.08	<.05	.41	.190	13	36	80	N	68	6
P-Q121	.04	.01	.09	<.05	9.90	.043	46	N	50	2	16	8
P-Q121	.14	.04	.07	<.05	7.20	.033	60	22	40	N	32	7
P-Q122	.06	.03	.02	<.05	6.70	.016	73	N	40	2	7	7
P-Q122	.11	.06	<.01	<.05	6.80	.025	84	21	50	3	13	8
P-Q211	.24	.10	<.01	<.05	1.30	.068	25	N	100	N	8	10
P-Q211	.40	.14	.02	<.05	1.30	.057	19	N	80	N	8	13
P-Q212	.16	.21	.02	<.05	3.80	.090	42	20	80	N	11	12
P-Q212	.37	.23	.02	<.05	3.10	.051	43	N	60	N	8	12
P-Q221	.13	.05	<.01	<.05	.89	.045	42	N	40	N	15	7
P-Q221	.24	.04	.17	<.05	.81	.059	40	N	80	N	18	6
P-Q222	.14	.24	.07	<.05	4.40	.028	60	24	60	3	14	9
P-Q222	.06	.16	.01	<.05	3.60	.024	60	N	70	N	18	6
P-T111	.40	.02	<.01	<.05	.59	.140	39	N	140	3	18	7
P-T111	.06	.05	<.01	<.05	.63	.300	50	37	180	4	20	8
P-T112	.58	.14	.05	<.05	5.10	.430	800	22	310	9	43	12
P-T112	.65	.10	.11	<.05	4.00	.340	800	N	290	11	42	11
P-T122	.14	<.01	.02	<.05	.14	.049	12	N	90	N	16	6
P-T122	.18	.04	.02	<.05	.10	.043	14	31	70	N	10	6
P-T211	.22	.03	<.01	<.05	.28	.060	17	N	60	N	20	5
P-T211	.19	<.01	.09	<.05	.30	.090	21	N	40	N	28	5
P-T212	.66	.05	.03	<.05	1.20	.260	150	20	200	6	27	7
P-T212	.54	.06	.03	<.05	1.30	.300	150	23	220	7	40	8
P-T221	.44	.05	.02	<.05	.20	.060	9	N	80	N	15	4
P-T221	.29	.01	.02	<.05	.19	.051	9	N	40	N	11	3
P-T222	.22	.01	.02	<.05	.26	.052	9	N	50	N	12	5
P-T222	.18	.09	.13	<.05	.26	.044	9	N	50	N	20	4

Table 1C.--Cont.

Sample	La ppm-S	Mo ppm-S	No ppm-S	Ni ppm-S	Pb ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Zr ppm-S	Ga ppm-S
P-N111	N	N	N	15	13	7	60	33	16	130	10
P-N111	N	N	N	12	N	5	60	30	14	110	8
P-N112	N	N	20	16	N	11	100	72	25	140	11
P-N112	N	N	N	14	N	10	110	60	22	150	19
P-N121	N	N	N	14	10	7	70	30	10	100	9
P-N121	N	N	N	12	14	6	50	33	13	100	11
P-N122	56	N	N	22	N	13	340	60	59	360	13
P-N122	52	N	N	21	N	12	330	60	37	240	13
P-N211	N	N	N	18	9	6	90	37	16	100	11
P-N211	N	N	N	17	N	7	90	42	14	95	11
P-N212	N	N	N	13	N	6	240	32	27	67	9
P-N212	N	N	N	10	6	6	230	26	22	79	13
P-N221	N	N	N	22	6	10	90	60	15	170	16
P-N221	N	N	N	21	14	12	120	73	26	180	21
P-N222	N	N	N	16	N	11	380	44	24	70	14
P-N222	N	N	N	20	N	11	340	49	20	120	12
P-Q111	N	N	N	3	N	N	20	6	N	33	N
P-Q111	N	N	N	4	N	N	30	7	7	35	N
P-Q112	N	N	N	6	N	N	30	13	9	280	N
P-Q112	N	N	N	6	N	6	30	17	12	280	N
P-Q121	N	N	N	6	7	5	20	8	7	30	N
P-Q121	N	N	N	6	10	N	10	5	N	40	N
P-Q122	N	N	N	7	N	N	N	N	N	26	N
P-Q122	N	N	N	8	11	N	10	6	7	43	N
P-Q211	N	N	N	4	7	N	30	9	9	46	5
P-Q211	N	N	N	5	N	N	10	7	N	46	N
P-Q212	N	N	N	3	15	5	20	12	8	60	N
P-Q212	N	N	N	4	7	N	30	7	N	36	N
P-Q221	N	N	N	9	10	5	20	17	N	57	N
P-Q221	N	N	N	7	N	N	10	18	9	40	N
P-Q222	N	N	N	10	12	N	30	9	7	110	N
P-Q222	N	N	N	12	13	N	N	8	N	46	N
P-T111	N	N	N	13	7	5	50	21	9	110	5
P-T111	N	N	N	15	N	7	30	29	20	120	N
P-T112	N	N	N	20	10	10	110	62	26	150	19
P-T112	N	N	N	20	9	11	80	56	21	220	17
P-T122	N	N	N	6	9	N	30	10	9	35	N
P-T122	N	N	N	6	9	N	30	8	10	60	N
P-T211	N	N	N	10	N	N	10	12	8	160	N
P-T211	N	N	N	7	N	N	10	10	N	110	N
P-T212	N	N	N	15	11	7	60	36	14	180	13
P-T212	N	N	N	16	8	8	60	36	20	180	10
P-T221	N	N	N	N	N	N	30	11	7	39	N
P-T221	N	N	N	4	N	N	40	10	N	36	N
P-T222	N	N	N	5	N	5	30	11	10	96	N
P-T222	N	N	N	3	N	N	N	7	N	76	N

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 sandstone of Mississippian and Pennsylvanian age in Kentucky. [LMk; Knifely and associated sandstones; UMw; sandstone of Upper Mississippian age from western and south-central (Hartsel Sandstone) Kentucky; UMp, sandstone of the Pennington Formation, eastern Kentucky; ℙq, quartzose sandstone of Pennsylvanian age (mostly of the Caseyville and Lee Formations); ℙl, lithic sandstone of Pennsylvanian age (mostly of the Breathitt Formation); ℙfe, iron oxide-rich sandstone of Pennsylvanian age; Number of thin sections on which each mode is based is shown in parentheses]

	Quartz				Feldspar	Rock	Mica	Carbonate	Matrix	Hematite	Other
	Single	Composite	Stretched	Authigenic		Fragments					
LMk (11)	27%	6%	8%	3%	7%	16%	<1%	<1%	28%	1/<1%	2%
UMw (36)	57	3	3	14	3	8	<1	<1	10	<1	2
UMp (20)	52	4	2	8	5	12	1	5	10	<1	1
ℙq (34)	64	4	6	9	2	7	<1	<1	5	<1	2
ℙl (34)	39	5	7	2	6	11	2	3	21	<1	2
ℙfe (5)	52	11	11	3	<1	<1	<1	<1	<1	24	<1

1/ Sample M-K121 (Russell Springs Quadrangle) contained 28% hematite cement.

Table 4A.--Sampling sites for the Knifely and associated sandstones in Kentucky.
[See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Cane Valley	M-K211	On north side of Fisher Bend	40 m above base of Knifely	Sandstone, lithic, poorly sorted
	M-K212	do	47 m above base of Knifely	do
	M-K221	0.9 km N of Mt. Carmel School	6 m above base of Knifely	Shale, sandy, cherty
	M-K222	do	24 m above base of Knifely	do
Russell Springs	M-K111	1.5 km E of French Valley School	18 m above base of Knifely	Sandstone, lithic,
	M-K112	do	15 m above base of Knifely	do
	M-K121	0.5 km N of Owenstown School	At base of Knifely	Sandstone, hematitic
	M-K122	do	do	Sandstone, lithic
Amandaville	M-S211	0.7 km NW of McGinnis Cemetery	24 m above top of Ft. Payne	Limestone, arenaceous
	M-S212	do	27 m above top of Ft. Payne	Sandstone, argillaceous, weathered
	M-S221	0.7 km SE of Greenbrier School	30 m above top of Ft. Payne	do
	M-S222	do	33 m above top of Ft. Payne	Sandstone, lithic

Table 4B.--Sampling sites for sandstone of Upper Mississippian age in Kentucky. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Shetlerville	M-H111	1.8 km NW of Loves Chapel	15 m above base of Cypress	Sandstone, lithic, weathered
	M-H112	do	8.5 m above base of Cypress	do
	M-H121	Above Buck Creek	9.1 m(?) above base of Hardinsburg	Sandstone, weathered, from float
	M-H122	do	At base(?) of Hardinsburg	do
Salem	M-H211	In Corn Branch	4.6 m above base of Tar Springs	Sandstone, lithic, weathered, from float
	M-H212	do	26 m above base of Tar Springs	Sandstone, weathered
	M-H221	On S end of Kirk Bluff	7.6 m above base of Hardinsburg	Sandstone, lithic
	M-H222	do	9.1 m above base of Hardinsburg	do
Pleasant Green Hill	M-Q211	0.3 km N of Allen Grove Church	6.2 m above base of Bethel	Sandstone, lithic, weathered, from float
	M-Q212	0.6 km N of Allen Grove Church	3 m above base of Bethel	Sandstone, weathered, from float
	M-Q221	1.4 km N of Sinking Fork Church	11 m above base of Big Clifty Sandstone Member (Golconda)	Sandstone, from float
	M-Q222	do	6.1 m above base of Big Clifty Sandstone Member (Golconda)	do

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Honey Grove	M-Q111	1.3 km NE of Laytonsville School	3 m above base of Cypress	Sandstone
	M-Q112	do	do	do
	M-Q121	1.7 km SE of Shiloh School	At base of Waltersburg	Sandstone, lithic, weathered
	M-Q122	do	do	Graywacke, weathered
South Union	M-R211	1.2 km S of Cave Spring Church	7.6 m above base of Big Clifty Sandstone Member (Golconda)	Sandstone, lithic
	M-R212	do	do	Sandstone
	M-R221	1.1 km N of Gasper River Cemetery	3 m above base of Hardinsburg	Sandstone, lithic, weathered, from float
	M-R222	do	4.6 m above base of Hardinsburg	Sandstone, lithic
Rockfield	M-R111	2.9 km NW of Providence Church	4.6 m above base of Big Clifty Sandstone Member (Golconda)	Sandstone
	M-R112	do	do	do
	M-R121	1.3 km W of Blue Level	do	do
	M-R122	do	do	Sandstone, lithic

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Clarkson	M-J211	1.2 km N of Pine Grove School	7.1 m above base of Hardinsburg	Sandstone, weathered
	M-J212	1.1 km N of Pine Grove School	1 m above base of Hardinsburg	Sandstone
	M-J221	1.3 km N of Rock Creek	4.6 m above base of Hardinsburg	Sandstone, lithic
	M-J222	1.5 km N of Rock Creek	3 m above base of Hardinsburg	do
Flaherty	M-J111	0.8 km SW of New New Salem Church	9.1 m above base of Sample	Sandstone, from float
	M-J112	0.9 km SW of New Salem Church	6.1 m above base of Sample	Sandstone, calcareous
	M-J121	0.6 km SW of McCoy Cemetery	9.1 m above base of Sample	Sandstone
	M-J122	0.6 km S of McCoy Cemetery	At base of Sample	Sandstone (pyrite in outcrop)
Cumberland City	M-S111	1 km E of Narvel	1 m below top of Hartsel	Sandstone, lithic
	M-S112	do	do	do
	M-S121	At head of Gross Creek	do	Sandstone
	M-S122	do	3.7 m above base of Hartsel	Sandstone, silty
Barthell	M-T111	1.3 km SW of Wolf Ridge School	34 m below top of Pennington	Sandstone, calcareous, silty, arkosic
	M-T112	do	35 m below top of Pennington	Sandstone, lithic, silty
	M-T121	0.6 km E of Oz	At top of Pennington	do
	M-T122	do	do	do

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Sawyer	M-T211	At mouth of Ned Creek	6 m(?) below top of Pennington	Siltstone, argillaceous
	M-T212	do	do	Siltstone, calcareous, argillaceous
	M-T221	At mouth of Goodin Branch	At top of Pennington	Sandstone, calcareous
	M-T222	do	do	Siltstone, calcareous, pyritic
Billows	M-L111	1 km up Dyer Branch	12 m below top of Pennington	Sandstone
	M-L112	do	14 m below top of Pennington	do
	M-L121	0.2 km N of Billows	15 m below top of Pennington	Sandstone, lithic
	M-L122	do	14 m below top of Pennington	do
Parrot	M-L211	0.4 km W of mouth, Alum Cave Br. mouth, Alum Cave Branch	6 m below top of Pennington	do
	M-L212	do	7 m below top of Pennington	do
	M-L221	0.9 km Ne of mouth, Indian Creek	do	do
	M-L222	do	do	Sandstone

Table 4B.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Wrigley	M-E211	0.4 km E of Leisure	At top of Pennington(?)	Sandstone, calcareous, lithic
	M-E212	do	do	Sandstone, calcareous
	M-E221	0.3 km SE of Leisure	3.7 m below top of Pennington(?)	Sandstone
	M-E222	do	do	Sandstone,
Tygarts Valley	M-E111	1.7 km SW of Deevert	2.1 m above base of Pennington	Sandstone, lithic, from float
	M-E112	do	3 m above base of Pennington	do
	M-E121	1 km SE of Sutton School	At top of Pennington (Carter Caves Sandstone?)	Sandstone
	M-E122	do	do	do

Table 4C.--Sampling sites for sandstone of Pennsylvanian age in Kentucky. [See figure 2 for location of 7-1/2' quadrangles]

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Shetlerville	P-H111	3.1 km SW of Carrsville	23 m above base of unnamed shale and sandstone member (Caseyville)	Sandstone, Fe-stained
	P-H112	3.2 km SW of Carrsville	15 m above base of unnamed shale and sandstone member (Caseyville)	do
	P-H121	0.3 km NW of Carrsville	6.1 m above base of unnamed shale and sandstone member (Caseyville)	Sandstone
	P-H122	do	do	do
Salem	P-H211	0.7 km SW of Glendale Church	60 m(?) above base of Caseyville	Sandstone
	P-H212	do	do	do
	P-H221	1.7 km SW of Glendale Church	11 m above base of Caseyville	do
	P-H222	2 km SW of Glendale Church	16 m above base of Caseyville	Sandstone, lithic
Kelly	P-Q211	4 km NE of Dogwood	20 m above base of Caseyville	Sandstone
	P-Q212	do	21 m above base of Caseyville	do
	P-Q221	1.1 km E of Antioch Church	18 m above base of Caseyville	do
	P-Q222	do	4.6 m above base of Caseyville	Sandstone, Fe-oxide cement, from float

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Honey Grove	P-Q111	9 m above road on Pilot Rock	12 m above base of Caseyville	Sandstone, punky
	P-Q112	0.5 km W of Pilot Rock	21 m above base of Caseyville	Sandstone
	P-Q121	1.1 km N of Pleasant Hill	35 m(?) above base of Caseyville	Sandstone, Fe-oxide cement, from float
	P-Q122	1.2 km N of Pleasant Hill	29 m(?) above base of Caseyville	do
Hanson	P-I111	1.2 km E of Providence Church	250 m(?) above No. 9 Coal (Carbondale)	Sandstone, lithic
	P-I112	do	do	do
	P-I121	On NE edge of Hanson	280 m(?) above No. 9 Coal (Carbondale)	do
	P-I122	do	do	Graywacke
Tell City	P-J211	On W edge of Hawesville	46 m below Lead Creek Limestone of Crider (1913)	Sandstone
	P-J212	0.4 km W of Hawesville	43 m below Lead Creek Limestone of Crider (1913)	Sandstone, lithic
	P-J221	1.2 km S of Poplar Grove Church	6.1 m above Lewisport Coal	Sandstone
	P-J222	1 km S of Poplar Grove Church	4.6 m above Lewisport Coal	do

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Mammoth Cave	P-J111	0.9 km NW of Little Jordan Cemetery	3.7 m above base of of Caseyville	Conglomerate, Fe-oxide cement, from float
	P-J112	do	do	do
	P-J121	1.3 km NW of Wilkens Cemetery	6.1 m above base of Caseyville	Sandstone, punky
	P-J122	do	12 m above base of Caseyville	do
Sawyer	P-T211	3.0 km N of Young Chapel, above Whitman Branch	4.6 m above base of sandstone member g (Lee)	Sandstone
	P-T212	do	From top(?) of sandstone member g (Lee)	Sandstone, lithic, from float
	P-T221	2.1 km N of Young Chapel at head of Whitman Branch	14 m above base of Corbin Sandstone Member (Lee)	Sandstone
	P-T222	do	17 m above base of Corbin Sandstone Member (Lee)	do
Vox	P-T111	1.4 km SE of Corinth School	9.1 m(?) below Blue Gem Coal (Breathitt)	Sandstone, from float
	P-T112	1.3 km SE of Corinth School	1.5 m above Blue Gem Coal (Breathitt)	Sandstone, lithic
	P-T122	0.7 km NW of Barton Chapel	12 m below top of Corbin Sandstone Member (Lee)	Sandstone, lithic, from float

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
London	P-L111	1 km NE of Macedonia School	32 m above Lily Coal (Breathitt)	Sandstone, lithic, from float
	P-L112	do	do	do
	P-L121	0.8 km NW of McWhorter	14 m below horizon (?) of Lily Coal (Breathitt)	do
	P-L122	1.3 km NW of McWhorter	At horizon(?) of Lily Coal (Breathitt)	Sandstone, silty, lithic
Parrot	P-L211	2.3 km SE of Cornett Church	From Corbin(?) Sandstone Member (Lee)	Sandstone, silty, lithic, from float
	P-L212	do	do	Sandstone, lithic
	P-L222	1.6 km NE of Peoples	26 m below base of Corbin(?) Sandstone Member (Lee)	do
Carrie	P-M211	1.5 km NE of Ritchie	18 m below Magoffin Member (Breathitt)	Sandstone, Fe-stained, lithic, weathered
	P-M212	1 km NE of Ritchie	3 m(?) above Hazard No. 7 Coal (Breathitt)	Sandstone, lithic
	P-M221	0.5 km SE of Kelly Fork School	3 m(?) below Haddix Coal (Breathitt)	Siltstone, sandy
	P-M222	0.3 km S of Kelly Fork School	On top(?) of Hazard No. 7 Coal (Breathitt)	Sandstone, lithic, from float

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
White Oak	P-M111	0.2 km N of Rockhouse School	12 m below Fire Clay Coal (Breathitt)	Sandstone, lithic
	P-M112	0.6 km NW of Rockhouse School	9 m(?) above Fire Clay Coal	Sandstone, from float, lithic, punky
	P-M122	1.7 km E of Hall Cemetery	37 m above Magoffin Member (Breathitt)	Sandstone, Fe-stained, lithic
Lancer	P-N111	0.8 km N of Endicott	18 m(?) below Broas Coal (Breathitt)	Sandstone, from float, lithic, weathered
	P-N112	do	12 m above Magoffin Member (Breathitt)	Sandstone, silty, lithic
	P-N121	0.7 km SW of Dewey Dam	18 m below Magoffin Member (Breathitt)	Sandstone, Fe-stained, lithic, weathered
	P-N122	0.8 km SW of Dewey Dam	1 m(?) above Fire Clay Rider Coal (Breathitt)	Sandstone, lithic, calcareous
Matewan	P-N211	At head of Long Fork	12 m below Taylor Coal (Breathitt)	Sandstone, lithic, weathered
	P-N212	do	37 m below Fire Clay Coal (Breathitt)	Sandstone, lithic, calcareous
	P-N221	2.1 km N of Dicks Knob	6.1 m below Upper Thacker Coal (Breathitt)	Graywacke, from float
	P-N222	do	3 m below Alma Coal (Breathitt)	Sandstone, calcareous, lithic

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Wrigley	P-E211	0.6 km E of mouth of Shop Hollow	1 m below top of Lee	Sandstone
	P-E212	do	37 m below top of Lee	Conglomerate, weathered
	P-E221	1.2 km NW of Wrigley	7.6 m below top of Lee	Sandstone, lithic
	P-E222	0.9 km NW of Wrigley	24 m above base of Breathitt	Sandstone, from float, argillaceous
Haldeman	P-E111	1.8 km S of Hays Crossing	From top(?) of Lee	Sandstone, from float
	P-E112	do	do	do
	P-E121	0.4 km SW of Newsill Cemetery	30 m(?) below top Lee	do
	P-E122	do	3.1 m(?) above base of Breathitt	do
Rush	P-F211	1.4 km N of Means Tunnel	4.6 m above Princess No. 7 Coal (Breathitt)	Sandstone, argillaceous
	P-F212	1.7 km N of Means Tunnel	18 m below Princess No. 7 Coal (Breathitt)	Sandstone, Fe-stained
	P-F221	1 km W of Webb Cemetery	6.1 m above Princess No. 5 Coal (Breathitt)	Sandstone, lithic, weathered
	P-F222	0.8 km W of Webb Cemetery	6.1 m above Princess No. 7 Coal (Breathitt)	Graywacke

Table 4C.--Cont.

Quadrangle	Sample No.	Sample Site	Stratigraphic Position	Remarks
Argillite	P-F111	0.4 km SW of Palmyra School	21 m below Princess No. 3 Coal (Breathitt)	Sandstone, lithic, calcareous
	P-F112	do	27 m below Princess No. 3 Coal (Breathitt)	Sandstone, lithic
	P-F121	1.5 km E of Danleyton	3 m above Princess No. 7 Coal (Breathitt)	do
	P-F122	do	10 m below Princess No. 7 Coal (Breathitt)	Sandstone, lithic, from float

Table 5A.--Components of geochemical variance for sandstone of Upper Mississippian age in Kentucky. [Components given as percentages of total logarithmic variance, 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(E)	v(m) 1/
Oxides:							
SiO2 2/	28.73	<1%	4%	34%*	53%*	9%	<1.0
Al2O3	.0576	2	3/ 27	27*	14*	30	<1.0
MgO	.2080	30*	3	51*	8*	8	1.9
Na2O	.1713	17*	2	20*	3/ 14	46	1.6
K2O	.1507	20*	19	27*	15*	17	1.0
H2O+	.0421	19*	9	21*	22*	29	1.3
TiO2	.0549	13	<1	57*	14*	16	<1.0
P2O5	.2361	<1	3/ 21	23*	<1	56	<1.0
Elements:							
Ba	.0750	24*	7	46*	10*	14	1.4
Cr	.0969	5	<1	26*	4	65	<1.0
Cu	.0428	<1	3	38*	28*	30	<1.0
Fe	.1590	<1	<1	69*	29*	<1	<1.0
Mn	.3421	27*	<1	33*	40*	<1	2.0
Ni	.0909	<1	47*	33*	9*	11	<1.0
Sr	.1698	<1	3/ 32	32*	14*	23	<1.0
V	.0831	<1	3/ 36	46*	9*	9	<1.0
Y	.0900	<1	25	56*	11*	8	<1.0
Zr	.1065	12	<1	47*	26*	15	<1.0

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

Table 5B.--Components of geochemical variance for sandstone of Pennsylvanian age in Kentucky. [Components given as percentages of total logarithmic variance, V(Log X); *, component significantly different from zero at the 0.05 probability level; see text for explanation of v(m); leaders (--), insufficient data; the first entry of each triplet estimates the variance for lithic and quartzose sandstone combined, the second entry estimates the variance for lithic sandstone only and the third entry estimates the variance for quartzose sandstone only]

Oxides:	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(E)	v(m)1/
SiO2 2/	94.62	57%*	<1%	5%	34%*	3%	9.7
	78.32	30*	2	<1	60*	7	
	7.612	27*	13	<1	34*	25	
Al2O3	.1162	56*	5	<1	28*	11	8.2
	.0181	19*	9	<1	16	56	
	.0435	8	3	<1	42*	47	
Fe2O3	.1880	29*	<1	28*	35*	8	2.4
	.0411	27*	5	20	37	11	
	.1849	<1	44*	<1	42*	14	
FeO	--	--	--	--	--	--	--
	.2105	23	<1	<1	76*	1	
	--	--	--	--	--	--	
MgO	--	--	--	--	--	--	--
	.0956	14	<1	<1	79*	7	
	--	--	--	--	--	--	
CaO	--	--	--	--	--	--	--
	.7952	9	4	<1	83*	3	
	--	--	--	--	--	--	
Na2O	.2715	52*	8	<1	19*	21	6.9
	.1211	7	12	<1	57*	24	
	--	--	--	--	--	--	
K2O	.2033	50*	19*	6	10*	15	3.7
	.0314	26*	<1	<1	37*	37	
	.1110	2	41*	5	6	45	
H2O+	.0936	37*	<1	<1	39*	23	5.8
	.0221	16*	4	<1	3/ 26	54	
	.0848	19	<1	36*	7	38	
TiO2	.1051	50*	<1	<1	33*	17	9.5
	.0326	11	<1	6	73*	11	
	.0689	6	18	<1	37*	40	

Table 5B.--Cont.

Oxides (cont.):	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(E)	v(m) 1/
P205	.1753	14	18*	<1	30*	39	<1.0
	.1075	2	<1	5	70*	23	
	.1675	<1	23*	15	<1	62	
Elements:							
Ba	.1213	64*	9*	<1	23*	5	8.5
	.0391	19	<1	<1	75*	6	
	.0449	16	44*	<1	21*	19	
Co	--	--	--	--	--	--	--
	.0739	<1	<1	<1	90*	9	
	--	--	--	--	--	--	
Cr	.1026	<1	13	<1	69*	19	<1.0
	.0634	10	<1	13	66*	11	
	.1617	<1	3/ 29	4	49*	18	
Cu	.0427	19*	10	6	42*	23	1.4
	.0268	<1	16	51*	26*	6	
	.0399	<1	3/ 22	3	34*	44	
Ga	--	--	--	--	--	--	--
	.0533	3/ 26	<1	<1	61*	13	
	--	--	--	--	--	--	
Mn	.4746	47*	6	<1	46*	2	5.5
	.3422	3/ 17	9	<1	73*	1	
	.2173	23*	<1	19	53*	6	
Ni	.0883	36*	1	<1	51*	12	4.6
	.0401	7	<1	10	74*	10	
	.0902	3/ 15	4	<1	62*	19	
Sc	--	--	--	--	--	--	--
	.0453	9	<1	20	62*	9	
	--	--	--	--	--	--	
Sr	.1749	42*	3/ 12	<1	32*	14	5.0
	.1064	11	3	<1	80*	6	
	.0991	<1	43*	<1	3/ 19	38	

Table 5B.--Cont.

Elements (cont.):	Total V(Log X)	Between Areas V(A)	Between Quads V(B)	Between Localities V(C)	Between Samples V(D)	Between Replicates V(E)	v(m)1/
V	.1256	49*	3	<1	43*	5	6.8
	.0519	7	<1	<1	88*	6	
	.0475	14	<1	6	64*	17	
Y	.1117	43*	<1	2	40*	14	6.7
	.0776	6	1	30	52*	12	
	--	--	--	--	--	--	
Zr	.1492	17*	14	9	50*	9	1.1
	.1162	5	<1	34	54*	7	
	.1707	<1	51*	<1	38*	11	

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

Table 6A.--Summary geochemical statistics for the Knifely and associated sandstones 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]

	GM	GD	GE	Ratio
Oxides:				
SiO_2, % 1/	84	3.1	0.7	22:22
Al_2O_3, %	6.6	1.18	1.04	22:22
Fe_2O_3, %	1.9	1.72	1.08	22:22
FeO, %	.26	1.81	1.08	22:22
MgO, %	.38	1.88	1.14	22:22
CaO, %	.16	3.13	1.56	16:22
Na_2O, %	.60	3.57	1.74	18:22
K_2O, %	1.2	1.36	1.08	22:22
H_2O+, %	1.8	1.47	1.34	22:22
TiO_2, %	.43	1.56	1.14	22:22
P_2O_5,	460	1.70	1.49	22:22
CO_2, %	<.05	--	--	2:22
Elements:				
B	27	1.67	1.33	16:22
Ba	2/ 280	2.04	1.25	22:22
Co	3.7	2.32	1.39	14:22
Cr	39	1.34	1.18	22:22
Cu	9.9	1.51	1.32	22:22
Ga	4.7	1.87	1.33	8:22
Mn	120	2.26	1.14	22:22
Mo	<20	--	--	1:22
Ni	17	1.44	1.08	22:22
Pb	2.1	3.11	1.50	4:22
Sc	6.1	1.70	1.21	11:22
Sr	52	1.75	1.27	22:22
V	51	1.35	1.11	22:22
Y	18	1.61	1.23	11:22
Zr	140	1.93	1.27	22:22

1/ Computed on untransformed data. GM, GD, and GE are the arithmetic mean, standard deviation, and standard error, respectively.
2/ Sample M-K221 (Cane Valley quadrangle) contained 3600 ppm Ba.

Table 6B.--Summary geochemical statistics for sandstone of Upper Mississippian age in Kentucky. [Data are in parts per million except where noted as percent (%); GM, geometric mean; M, Median; 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

	Sandstone GM	Sandstone GD	Sandstone GE	Sandstone Ratio	Calcareous Siltstone 1/ M	Calcareous Siltstone 1/ Ratio
Oxides:						
SiO2 % 2/	90.0	5.3	1.6	112:112	61.0	8:8
Al2O3 %	2.8	1.72	1.36	112:112	7.4	8:8
Fe2O3 %	1.2	2.28	1.35	110:112	1.7	8:8
FeO %	.15	4.12	1.29	68:112	2.3	8:8
MgO %	.18	3.44	1.35	76:112	1.7	8:8
CaO %	3/ .12	6.34	1.47	67:112	11	8:8
Na2O %	.17	3.07	1.91	76:112	.59	8:8
K2O %	.38	2.42	1.45	101:112	.90	8:8
H2O+ %	1.1	1.59	1.29	112:112	2.0	8:8
TiO2 %	.28	1.67	1.24	112:112	.82	8:8
P2O5 %	.037	2.87	2.31	98:112	.10	8:8
CO2 %	<.05	--	--	14:112	9.8	8:8
Elements:						
B	20	1.54	1.37	53:112	<20	4:8
Ba	97	1.85	1.27	112:112	210	8:8
Co	1.7	2.60	1.46	48:112	10	8:8
Cr	37	2.03	1.78	112:112	60	8:8
Cu	7.5	1.60	1.30	112:112	24	8:8
Ga	3.1	1.80	1.33	24:112	<10	4:8
La	<50	--	--	1:112	<50	0:8
Mn	71	3.71	1.10	112:112	1500	8:8
Nb	3.7	2.53	1.18	4:112	<20	0:8
Ni	10	1.90	1.26	108:112	24	8:8
Pb	4/ 4.8	1.71	1.41	27:112	<7	2:8
Sc	4.7	1.44	1.31	50:112	12	8:8
Sr	27	2.43	1.58	96:112	240	8:8
V	14	1.86	1.22	107:112	45	8:8
Y	10	2.07	1.22	80:112	44	8:8
Zr	130	2.03	1.34	112:112	260	8:8

Table 6B.--Cont.

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

Sandstone:

	GD	Shetlerville-Salem (16)	Pleasant Green Hill-Honey Grove (16)	South Union-Rockfield (16)	Clarkson-Flaherty (16)	Cumberland City-Barthell (16)	Billows-Parrot (16)	Wrigley-Tygarts Valley (16)
MgO %	2.41	<0.1	0.14	0.17	<0.1	0.45	0.44	0.26
Na2O %	2.38	.1	.20	.14	.15	.17	.48	<.1
K2O %	2.22	.22	.13	.53	.76	.47	.44	.72
H2O+ %	1.53	.78	1.2	1.2	.87	1.6	1.6	.98
Ba	1.73	50	120	100	110	120	90	150
Mn	3.16	32	190	26	22	49	95	390

1/ In the Sawyer Quadrangle only.
2/ Computed on untransformed data. GM, GD, and GE are the arithmetic mean, standard deviation, and standard error, respectively.
3/ CaO is bimodal with modes at approximately <0.1% and 7.8% CaO; the lower mode reflects clay-bound calcium and the upper reflects a calcite concentration of about 12%.
4/ Sample M-T111 (Barthell quadrangle) contained 190 ppm Pb and was excluded from the sandstone summary.

Table 6C.--Summary geochemical statistics for sandstone 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; M, median; Ratio, number of analyses in which constituent was determined to total number of analyses; leaders (--) indicate insufficient data]

Part I. Statewide summary

	Quartzose sandstone			Lithic sandstone			Fe-rich sandstone		Quartzose + Lithic ss			
	GM	GD	Ratio	GM	GD	Ratio	M	Ratio	GM	GD	GE	Ratio
Oxides:												
SiO_2, % 1/	93.0	2.7	68:68	78.0	7.8	68:68	78.0	10:10	85.0	9.4	2.8	136:136
Al_2O_3, %	2.6	1.55	68:68	9.3	1.33	68:68	1.6	10:10	4.9	2.08	1.30	136:136
Fe_2O_3, %	.84	2.46	67:68	2.3	1.57	68:68	16	10:10	1.4	2.38	1.33	135:136
FeO, %	.092	2.17	31:68	.36	2.46	62:68	<.1	3:10	.18	3.14	1.44	93:136
MgO, %	.084	1.90	28:68	.43	1.71	65:68	<.1	1:10	.18	2.90	1.28	93:136
CaO, %	.089	1.72	28:68	.26	5.67	55:68	<.1	5:10	.12	5.31	1.52	83:136
Na_2O, %	.12	3.02	38:68	.82	2.00	67:68	.11	7:10	.33	3.60	1.73	105:136
K_2O, %	.36	2.11	64:68	1.6	1.47	68:68	.12	7:10	.75	2.59	1.49	132:136
H_2O+, %	.91	1.77	68:68	2.2	1.36	68:68	2.6	10:10	1.4	1.88	1.40	136:136
TiO_2, %	.26	1.67	68:68	.63	1.43	68:68	.080	10:10	.41	1.88	1.36	136:136
P_2O_5, %	.034	2.50	62:68	.087	1.94	68:68	.040	10:10	.05	2.51	1.83	130:136
CO_2, %	<.05	--	0:68	<.05	--	12:68	<.05	0:10	<.05	--	--	12:136
Elements:												
B	21	1.42	38:68	23	1.67	43:68	<20	3:10	22	1.57	1.40	81:136
Ba	83	1.57	68:68	280	1.45	68:68	55	10:10	150	2.10	1.20	136:136
Co	1.2	2.49	18:68	5.7	1.79	61:68	2	6:10	2.8	2.72	1.32	79:136
Cr	24	2.34	68:68	33	1.62	68:68	13	10:10	28	2.03	1.38	136:136
Cu	5.8	1.52	68:68	10	1.41	68:68	8	10:10	7.8	1.61	1.26	136:136
Ga	6.3	1.35	7:68	10	1.49	63:68	<5	0:10	5.5	2.15	1.28	70:136
La	<50	--	0:68	39	1.26	9:68	<50	0:10	34	1.30	1.26	9:136
Mn	35	2.82	68:68	280	3.05	68:68	53	10:10	99	4.45	1.25	136:136
Mo	<8	--	0:68	<8	--	0:68	<8	1:10	<8	--	--	0:136
Nb	<20	--	0:68	17	1.21	16:68	<20	0:10	22	1.11	1.21	16:136
Ni	6.4	1.80	63:68	15	1.48	68:68	6.5	10:10	9.9	1.94	1.27	131:136
Pb	5.8	1.60	24:68	8.1	1.58	44:68	11	8:10	6.9	1.63	1.40	68:136
Sc	4.4	1.33	23:68	8.5	1.41	63:68	<5	5:10	5.9	1.64	1.29	86:136
Sr	25	1.87	63:68	90	1.78	68:68	25	8:10	47	2.41	1.43	131:136
V	12	1.59	66:68	40	1.52	68:68	8.5	9:10	22	2.13	1.20	134:136
Y	8.5	1.81	45:68	23	1.69	68:68	<7	5:10	14	2.10	1.33	113:136
Zr	87	2.36	68:68	190	1.96	68:68	37	10:10	130	2.37	1.31	136:136

Table 6C.--Cont.

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

Quartzose sandstone:

	GD	Shetlerville-Salem (16)	Honey Grove-Kelly (10)	Mammoth Cave-Tell City (8)	Vox - Sawyer (10)	London-Parrot (8)	Lancer-Matewan (2)	Haldeman-Wrigley (14)
SiO2, % 1/	2.4	94.0	92.0	93.0	94.0	91.0	85.0	93.0
Mn	2.56	28	22	20	14	68	120	60

Lithic sandstone:

	GD	Hanson (8)	Mammoth Cave-Tell City (4)	Vox-Sawyer (4)	London-Parrot (6)	White Oak-Carrie (14)	Lancer-Matewan (14)	Haldeman-Wrigley (2)	Argillite-Rush (16)
SiO2, % 1/	7.4	85.0	84.0	82.0	84.0	80.0	75.0	74.0	76.0
Al2O3, %	1.32	7.6	7.5	9.9	7.8	9.4	11	13	9.3
Fe2O3, %	1.49	1.8	1.5	2.7	1.9	1.9	2.8	3.5	3.2
K2O, %	1.42	1.1	1.0	1.8	1.1	1.7	1.9	2.2	1.9
H2O+, %	1.37	1.7	1.9	2.6	2.1	2.2	2.5	3.4	2.7

1/ Computed on untransformed data. GM, GD, and GE are the arithmetic mean, standard deviation, and standard error, respectively.