DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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SUMMARY GEOCHEMICAL AND GENERALIZED GEOLOGIC MAPS OF THE SPRINGFIELD 1° X 2° QUADRANGLE AND ADJACENT AREA, MISSOURI

By

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DISCUSSION

Geochemical studies of the Springfield 1° x 2° quadrangle, Missouri, are a part of a joint multidisciplinary study by the U.S. Geological Survey and the Division of Geology and Land Survey, Missouri Department of Natural Resources. The objective of the joint study is to assess the mineral-resource potential of the area by integrated geologic, geochemical, and geophysical investigations.

There are no known major mining districts in the Springfield quadrangle. The central Missouri barite-lead-zinc district (Central Missouri District) is just north of the quadrangle, and the Mississippian-hosted Tri-State zinc-lead district centers about 50 km west of the southwest corner of the quadrangle (Map A). Numerous small zinc-lead occurrences in Mississippian and Ordovician carbonate rocks are common in the southern part of the quadrangle. None of the districts adjacent to the quadrangle and none of the small mines or prospects within the quadrangle are currently active.

The geochemical work in the Rolla 1° x 2° quadrangle to the east, completed in 1980, indicated that insoluble residues of carbonate rocks are a useful and informative geochemical sample medium in a carbonate environment (Erickson and others, 1978, 1979). Spectrographic and chemical analyses of residues permit detection of trace amounts of elements whose presence in the barren whole rocks is unsuspected and commonly not detected by conventional whole-rock analytical methods. The resulting map patterns of distributions and abundances of trace elements permit distinction between intrinsic and epigenetic suites of elements, recognition of rock units through which metal-bearing fluids have passed, and delineation of regional mineral trends. The geochemical maps of the Rolla quadrangle, based on analyses of insoluble-residue samples from 62 widely spaced drill holes, were an important part of the total geoscience input that was used to assess the metallic mineral-resource potential of that quadrangle (Pratt, 1981). The same type of geochemical study was done in the Springfield quadrangle.

Only 24 drill holes that penetrate the stratigraphic section to Precambrian basement or a basal Cambrian sandstone were available to us in the Springfield quadrangle. In order to better evaluate the mineral-resource potential of the quadrangle, six core holes to Precambrian basement (map A, NS1 through NS6) were drilled by the U.S. Geological Survey in 1983-1984 in the central and western part of the quadrangle where no drill holes to basement were available. These were deepened a few tens to a few hundred feet in basement rock at the request of W. R. Van Schmus and M. E. Bickford, University of Kansas, under National Science Foundation grant EAR 82-19137.

In addition, samples from 34 drill holes outside but adjacent to the quadrangle boundaries were also analyzed and the results plotted on the geochemical maps.

Bar graphs showing the distribution and abundances in parts per million of metals within each drill hole are included in this pamphlet. The formation boundaries used on the bar graphs are those shown on the stratigraphic log of each drill hole on file with the Missouri Geologic Survey.

Recent carbonate petrologic studies of cores from southwestern Missouri (Palmer, 1983a,b) indicate that the entire Cambrian section above the Bonneterre Formation (Davis Formation, Derby-Doerun, Potosi, and Eminence Dolomites) changes character in central and southern Missouri such that many different carbonate depositional facies occur, including shallow cratonic basin to ramp to platform lithofacies. Palmer informally refers to the Davis through Eminence as the post-Bonneterre Cambrian sequence. His terminology is used here in discussion of the geochemical distribution and abundance of metals.

The samples analyzed are splits of insoluble-residue samples derived from drill core and cuttings archived in the sample library of the Division of Geology and Land Survey, Missouri Department of Natural Resources. The Missouri library is also the repository for the six U.S. Geological Survey cores. None of the holes are company confidential and none intersect economically significant mineralized ground. Each sample is a composite of a 10-foot interval, and samples from each drill hole are contiguous. Each sample was analyzed semiquantitatively for 31 elements by a six-step D.C.-arc optical-emission spectrographic method (Grimes and Marranzino, 1968).

The analytical results for selected elements (lead, Pb; silver, Ag; copper, Cu; molybdenum, Mo; nickel, Ni; cobalt, Co; arsenic, As; and zinc, Zn) in insoluble-residue samples are plotted on the maps in anomalous metal feet (AMF) as defined in the Rolla 1° x 2° quadrangle (Erickson and others, 1978). AMF is a reporting unit derived by normalizing the ratio of a reported anomalous metal content to the minimum anomalous metal content multiplied by the length of the sample interval in feet. The minimum anomalous metal contents of insoluble residues were established by inspection of the data, and, in parts per million, are: As, 200; Zn, 200; Pb, 100; Cu, 100; Ni, 70; Co, 30; Mo, 10; and Ag, 1. Thus reported values of 500 ppm Pb and 3 ppm Ag for a 10-foot sample interval normalize to 50 AMF of Pb and 30 AMF of Ag. The AMF can be summed for an entire drill hole or for each formation or for individual metals.

A list of the analyzed drill holes showing Missouri log number, county, location, and stratigraphically highest and lowest formation analyzed (table 1) allows correlation with the stratigraphic logs on file at the Missouri Division of Geology and Land Survey in Rolla, Mo.

Map A shows the location, total AMF content of insoluble-residue samples, and the stratigraphic distribution of the AMF content for each drill hole analyzed in this study. Drill holes that contain greater than 3,000 AMF are considered to have high metal content and are shown on map A with a shaded pattern.

The distribution of drill holes that contain the highest metal contents suggests the presence of a mineralized zone in post-Bonneterre Cambrian carbonate rocks in the subsurface. This zone extends from the Missouri-Arkansas border northwestward across the Springfield quadrangle. This possible new mineral trend was reported by Erickson and others (1981) and has since been expanded by acquisition of geochemical data from additional drill holes (Erickson and others, 1983). Undoubtedly, new drilling and more closely spaced holes would reveal many barren areas within the postulated trend. Nevertheless, on the basis of our analyses of drill-hole samples available to us, a northwesterly pattern is indicated. Further, the trend appears to follow a northwest structural grain.

Ninety-five percent of the total metal content in the 21 drill holes that define the trend occur in restricted platform-flat, lagoon, and shoal lithofacies of post-Bonneterre Cambrian carbonate rocks as described by Palmer (1983a,b). Most of the "hottest" drill holes are along or near the projection of the Mansfield fault system (double fault near drill hole S8) in the southeastern part of the trend. The highest metal contents in each drill hole occur in dark-gray to black, earthy, fine-grained mixtures of iron sulfide and thermally degraded organic(?) material in expanded stylolites, vugs, and breccia zones in coarse-grained, recrystallized dolomite. Marcasite appears to be a more favorable metal host than pyrite. Ore minerals such as sphalerite, galena, and chalcopyrite were not detected by binocular examination of the insoluble-residue samples. Most of the metals probably occur as discrete small inclusions in iron sulfides.

Several drill holes (S3, S4, S5, S9) along or near the western edge of the trend have moderately high AMF contents in Ordovician or Mississippian rocks. Numerous small inactive surface zinc and (or) lead mines and prospects and numerous occurrences of sphalerite in drill-hole samples of Ordovician rocks are present in the southern part of the quadrangle (Searcy, 1981a,b). None of these occurrences have a significant or extensive trace-metal suite associated with them and none are considered to have high potential for large tonnage zinc-lead deposits.

Several single anomalies in drill holes occur in the northern part of the map area. Most occur in post-Bonneterre Cambrian rocks and probably are related to the Central Missouri District.

Although the Bonneterre Formation is the ore host in the Southeast Missouri Lead District in the adjacent Rolla 2° quadrangle to the east, no significant anomalously high concentrations of metal were detected in the Bonneterre in the drill holes available to us in the map area. Earlier studies (Snyder and Gerdemann, 1968; Pratt, 1981) established that the Bonneterre ore deposits of southeast Missouri occur in dolomite, near the limestone-dolomite interface, and often on the flanks of, or over, subsurface Precambrian highs. Dolomite facies in the Bonneterre (Palmer, 1983a,b) and subsurface Precambrian highs (Kisvarsanyi, 1982) occur in and adjacent to the Springfield quadrangle; however, the subsurface geochemical work to date suggests that the Bonneterre decreases in favorability, regardless of lithology or configuration of the Precambrian surface, away from the St. Francois Mountains (Erickson and others, 1981, p. 931; Erickson and others, 1983). Conversely, in the Springfield quadrangle, post-Bonneterre Cambrian rocks contain most of the high metal anomalies and the most extensive suite of metals (Pb, Zn, Cu, Mo, Ag, As), which suggests that mineralizing fluids were in successively higher stratigraphic units with increasing distance from the St. Francois Mountains.

The distribution and abundance (in AMF) of lead, silver, copper, zinc, molybdenum, arsenic, nickel, and cobalt in insoluble-residue samples of all formations penetrated in each drill hole are shown on maps B through H. The stratigraphic distribution of the metals in each drill hole is shown by bar graphs (see Appendix). Most of the metals occur in post-Bonneterre Cambrian rocks; zinc, however, as might be expected, is common in Ordovician and Mississippian carbonates (40 percent of total zinc AMF). The distribution and abundance patterns of all the metals (maps B through H) suggest the presence of favorable ground for mineral discovery in the southeast part of the northwest-trending belt outlined in map A. The copper, molybdenum, and nickel-cobalt patterns (maps D, E, and F) outline the entire extent of the trend; whereas lead, silver, and arsenic (maps B, C, and G), as well as the rest of the metal suite, are consistently present only in the southeast part of the trend. Each metal shows scattered "highs", mostly in single drill holes outside the principal trend. Copper, however, shows two rather extensive "highs" in the northeast part of the map area--all in post-Bonneterre Cambrian rocks. One "high" is associated with the Central Missouri District and the other with known small copper prospects north of Rolla, Mo. The most copper-rich drill hole is southwest of Springfield, Mo. (map D, S4). Copper is most abundant in the Gasconade Dolomite of Ordovician age, with lesser amounts in the upper part of the post-Bonneterre Cambrian rocks. Zinc (map H) shows a spotty distribution pattern over a wide area, much like the known spotty, surface zinc occurrences in Mississippian and Ordovician rocks throughout southern Missouri. However, map H does show that zinc is present in the southeastern part of the trend and in the Central Missouri District.

Our previous work in the Rolla quadrangle to the east indicated that the distribution of lead and silver best outlines the known ore trends in the Southeast Missouri Lead District (Viburnum Trend and Old Lead Belt) and appears to be the best geochemical parameter for outlining broad target areas for exploration in the Bonneterre Formation (Erickson and others, 1978). Further, the Ag/Pb AMF ratios for barren drill holes in the Viburnum Trend exceeded 0.6 and a ratio greater than 1.0 marked the central part of the trend (Erickson and others, 1981). The Ag/Pb AMF ratio in insoluble residues of post-Bonneterre Cambrian dolomites is greater than 0.6 in all but two of the drill holes in the southeastern part of the trend shown on these maps (drill holes S8 and S28), and the "hottest" drill holes (85 and S35) have ratios of 1.12 and 4.17, respectively. None of the single drill-hole lead anomalies in the northern half of the map area has an Ag/Pb ratio as high as 0.6. These data suggest that, indeed, post-Bonneterre Cambrian dolomites in the southeast part of the trend have the highest potential in the map area for the occurrence of base-metal mineral deposits. However, the presence of unusually high amounts of other metals (Mo, As, Cu, Ni, Co) suggests that if mineral deposits occur in this trend, they would be complex ores--not mineralogically simple Mississippi Valley-type lead-zinc deposits. The data also suggest that the composition (and the source?) of metal-bearing fluids differs from one district to another--though all carbonate-hosted districts in Missouri may still be part of a huge single, but multiple-source, mineralizing system.

The high molybdenum values deserve special comment. The molybdenum AMF values for insoluble residues in this trend are commonly an order of magnitude higher than in the Viburnum Trend (Erickson and others, 1983). Further, molybdenum is the most abundant metal (as much as 915 ppm) in whole-rock samples from most of these drill holes. We previously reported (Erickson and others, 1983) that (1) electron microprobe studies suggest that the molybdenum occurs either as an amorphous molybdenum sulfide or organically complexed molybdenum or both--usually as a black coating or otherwise spatially associated with iron sulfide, (2) about 60 percent of the contained molybdenum is easily dissolved and removed during preparation of standard insoluble residues, and (3) the total molybdenum endowment in southern Missouri must be enormous--probably on the order of tens of millions of tons of molybdenum metal. Continuous 10-foot whole-rock samples over a 110-foot thickness in drill hole S35, digested by a pyrosulfate fusion method and analyzed by atomic absorption, ranged from 115 to 925 ppm and averaged 315 ppm molybdenum. In this same 110-foot section, the maximum metal values (in ppm) for whole rock are Pb, 100; Cu, 100; Ag, 1; Ni, 50; and As and Zn, not detected at 200. Whether or not the molybdenum was transported by the same fluids that brought other metals (Pb, Zn, Cu, Ag, Ni, Co, As) into the trend is unresolved.

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APPENDIX--GEOCHEMICAL LOGS OF DRILL HOLES

The stratigraphic distributions of anomalous contents of selected metals, in parts per million, in insoluble residue samples of carbonate rocks from each drill hole analyzed in this study are shown in the following bar graphs. These bar graphs enable the user to refer to a specific drill hole shown on the geochemical maps to determine stratigraphic position, metal suite and relative abundance of each metal, and intensity, continuity, thickness, and depth from surface of geochemically anomalous zones. Metal contents less than the minimum anomalous contents are not graphed. (See Discussion for listing of minimum anomalous metal contents).

The stratigraphic boundaries on the bar graphs are those shown on the stratigraphic log of each drill hole on file with the Division of Geology and Land Survey, Missouri Department of Natural Resources. Stratigraphic abbreviations are explained at the bottom of table 1.

The vertical axis is depth from surface (in feet), the sample interval is 10 feet, and missing intervals are shown with the symbol √. Values for metal contents of the Reagan and Lamotte Sandstones and Precambrian igneous rocks are from whole-rock analyses. A black circle (●) in the right-hand column indicates that the sample contained 5,000 ppm or more barium.

Table 1.--List of drill holes from which samples have been analyzed in the Springfield quadrangle and adjacent area, Missouri

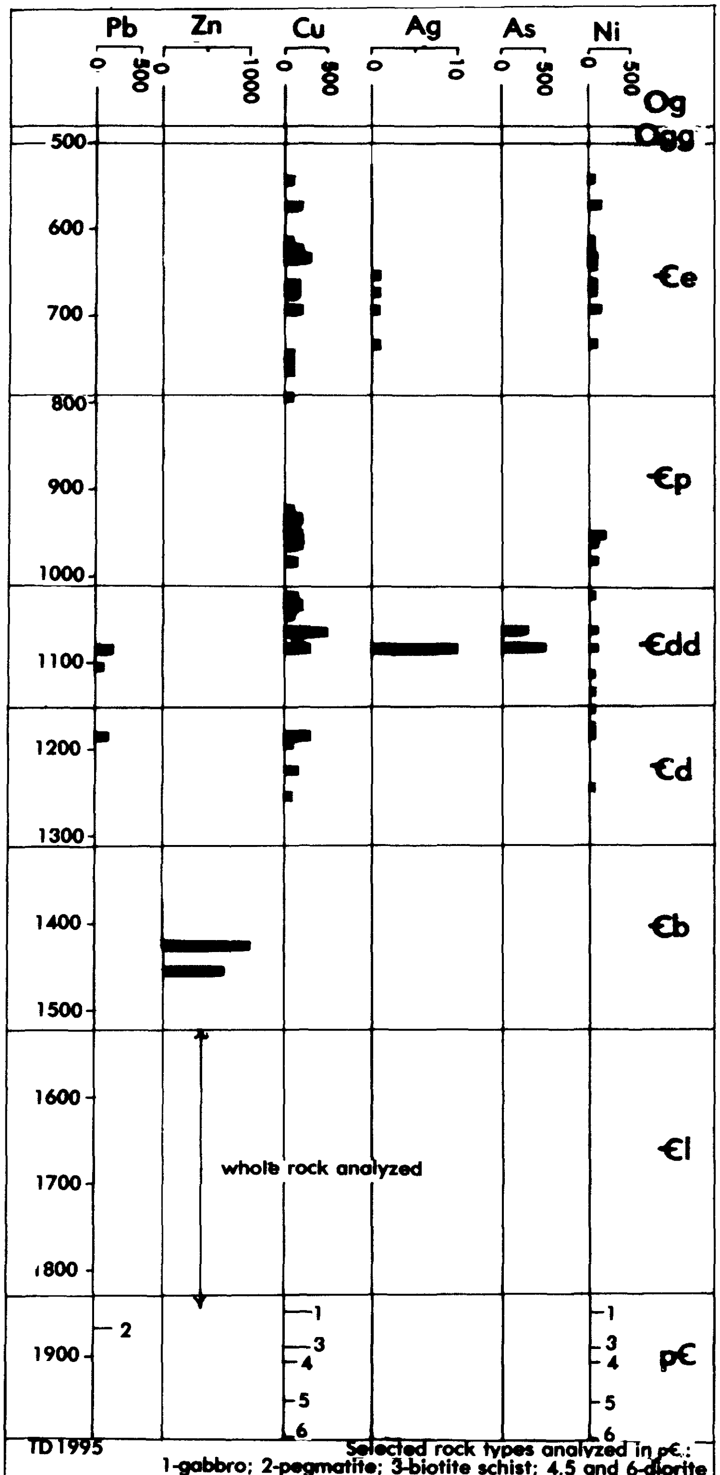
Drill hole number	Missouri log number	County	Location (Section, Township, and Range)	Youngest to oldest stratigraphic units[1] sampled
S1	24544	Laclede	20,33N,14W	Og - pC
S2	24670	----do---	14,33N,15W	Or - pC
S3	24989	Christian	19,27N,21W	M - Cl
S4	27062	Greene	7,28N,22W	M - pC
S5	26938	Lawrence	25,28N,27W	M - Cr
S6	27480	Dallas	5,35N,18W	Og - Cl
S7	26784	Polk	16,35N,23W	Oc - Cl
S8	24483	Wright	16,28N,15W	Oc - Cp
S9	25481	Christian	18,27N,18W	Oc - Cl
S10	26673; 27500	----do---	18,27N,20W	M - Cl
S11	27990	Webster	10,30N,18W	Oc - Cp
S12	4580	Hickory	2,37N,21W	Oj - pC
S14	28322	Laclede	3,34N,16W	Or - pC
S15	2186	----do---	2,36N,17W	Og - Cl
S16	28223	Polk	10,35N,24W	M - Cd
S17	25277	Pulaski	25,36N,12W	Og - Cd
S19	28197	Wright	13,28N,14W	Ce - Cp
S20	26469	Douglas	33,27N,13W	Or - Cl
S21	28473	Camden	5,37N,16W	Ce - Cl
S22	28495	Laclede	33,33N,13W	Og - Cl
S23	28474	Pulaski	31,37N,10W	Og - pC
S24	28477	Laclede	9,35N,14W	Og - pC
S25	28496	Texas	29,29N,10W	Or - Cb
S26	28484; 26468	Douglas	21,26N,14W	Or - Cl
S27	28475; 26464	----do---	27,27N,12W	Or - Cb
S28	26445	----do---	20,25N,13W	Ce - Cl
S29	28481	Hickory	16,38N,20W	Ce - Cr
S30	27412	Miller	3,39N,13W	Or - Cl
S32	27411	Bates	7,38N,30W	Ogg - Cr
S33	27448	Mares	30,40N, 8W	Og - pC
S35	28497	Douglas	35,25N,11W	Og - Cl
S36	26466; 28501	Howell	33,26N, 7W	Og - Cl
S37	28500	Stone	4,26N,22W	Oc - Cr
S38	28503	Camden	18,38N,18W	Cpb - Cr
S40	28505	Miller	15,40N,15W	Cdd - Cl
S41	27402	Benton	5,39N,21W	Cpb - Cr
S42		Pulaski	17,34N,10W	Og - Cl
S43	28506	Camden	14,38N,15W	Og - Cl
S45	28298	Jasper	2,28N,31W	M - pC
S46	28522	Miller	22,40N,13W	Cpb - Cb
S47	28521	Camden	28,39N,18W	Og - Cb
S48	28526	Morgan	27,40N,17W	Og - Cl
S49	28528	Miller	12,40N,14W	Og - Cl
S51	28527	Benton	35,42N,21W	Or - Cb

Table 1.--continued

Drill hole number	Missouri log number	County	Location (Section, Township, and Range)	Youngest to oldest stratigraphic units[1] sampled
52		Webster	27,31N,18W	Oj - pC
53		Polk	18,35N,21W	Oj - pC
54		Howell	17,24N, 8W	Cpb
10	25824	Texas	25,32N,10W	Ogg - Cb
62	2879	Texas	14,33N, 9W	Or - Cl
63	3225	Phelps	11,37N, 8W	Oj - Cl
64	5354	------do-----	22,37N, 9W	Og - Cl
72	26610	Oregon	7,25N, 6W	Cp - pC
77	25822	Douglas	24,27N,15W	Ce - pC
81	24490	Laclede	34,34N,15W	Ce - Cl
85	27496	Ozark	32,23N,12W	Ce - Cl
86	25828	Wright	16,29N,13W	Ce - Cb
89	27471	Vernon	6,34N,29W	Og - pC
95	25825	Douglas	24,26N,17W	Ce - Cl
98	25812	McDonald	28,21N,31W	Ogg - pC
99*	25823	Carroll, Ark.	30,21N,25W	Ogg - pC
100	25827	Taney	15,24N,20W	Ogg - Cl
101	25826	Christian	33,25N,18W	Ogg - Cl
103	17452	Ozark	19,23N,11W	Ogg - Cdd
NS1		St. Clair	12,37N,26W	M - pC
NS2		Cedar	22,34N,26W	M - pC
NS3		Dade	15,31N,26W	M - pC
NS4		Polk	28,32N,22W	M - pC
NS5		Dallas	5,32N,19W	Oc - pC
NS6		Wright	9,31N,15W	Or - pC

*Not in mapped area

[1]Mississippian: M, Undifferentiated
Ordovician: Oc, Cotter Dolomite
Oj, Jefferson City Dolomite
Or, Roubidoux Formation
Og, Gasconade Dolomite
Ogg, Gunter Sandstone Member of Gasconade Dolomite
Cambrian: Ce, Eminence Dolomite
Cp, Potosi Dolomite
Cdd, Derby-Doerun Dolomite
Cd, Davis Formation
Cpb, Post-Bonneterre Cambrian, undifferentiated
Cb, Bonneterre Formation
Cr, Reagan Sandstone
Cl, Lamotte Sandstone
Precambrian: pC, Undifferentiated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Selected rock types analyzed in p€.:
1-gabbro; 2-pegmatite; 3-biotite schist; 4,5 and 6-diorite

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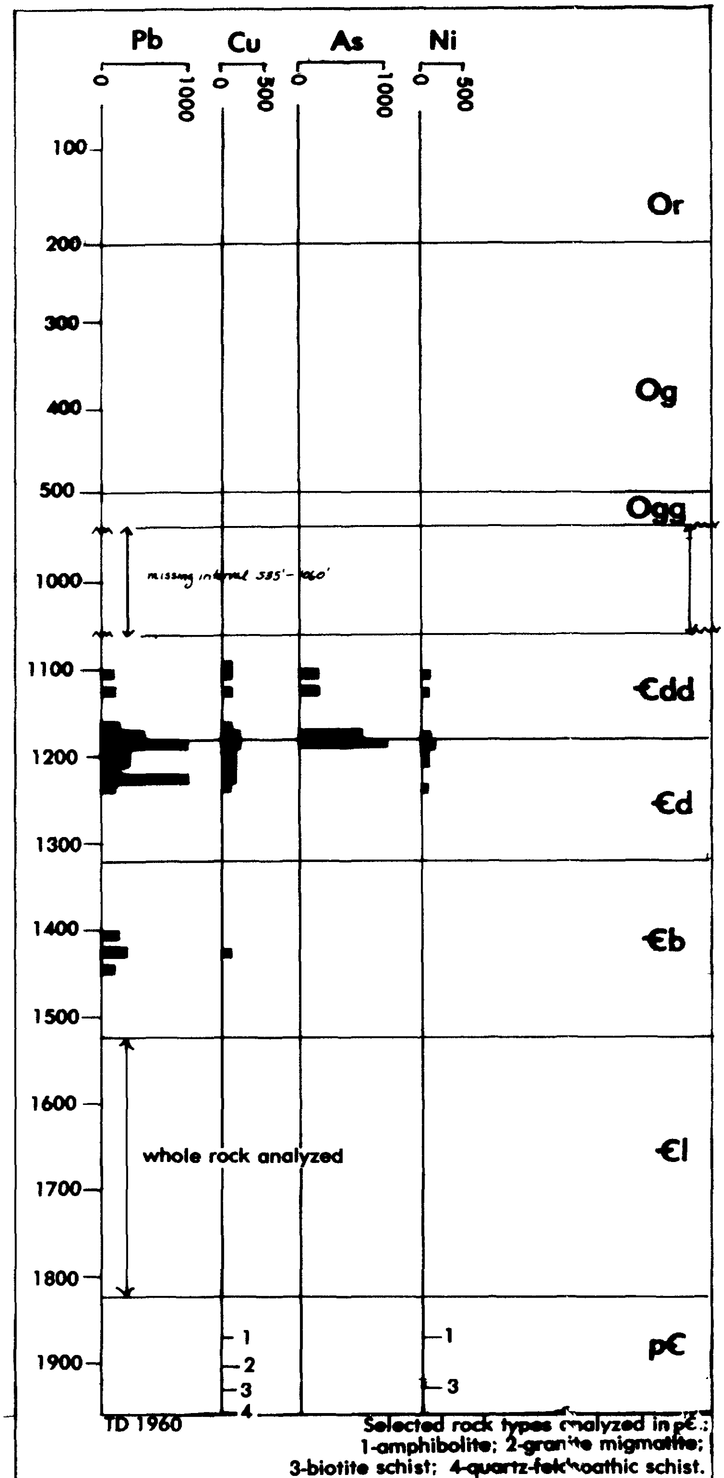
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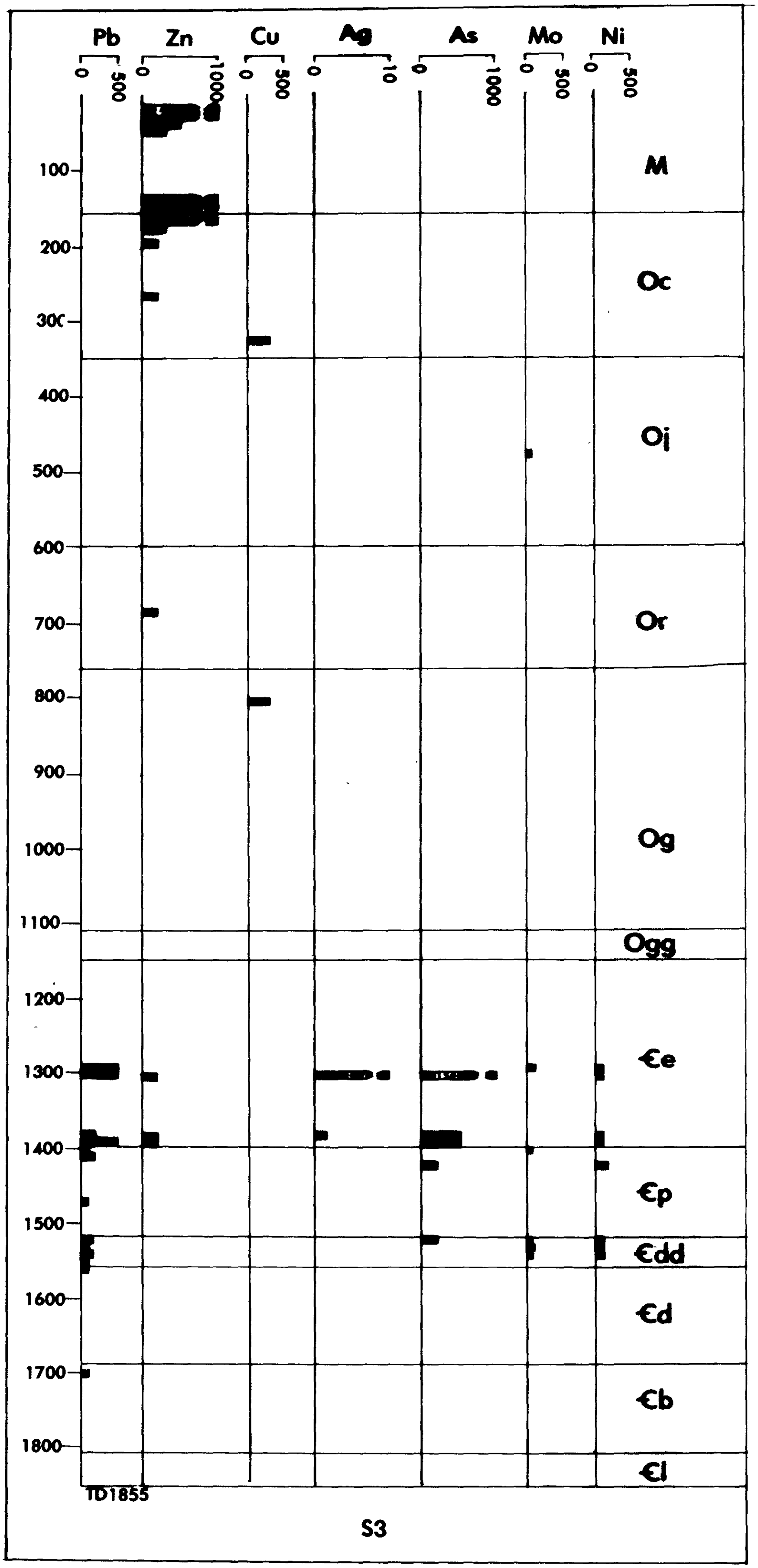
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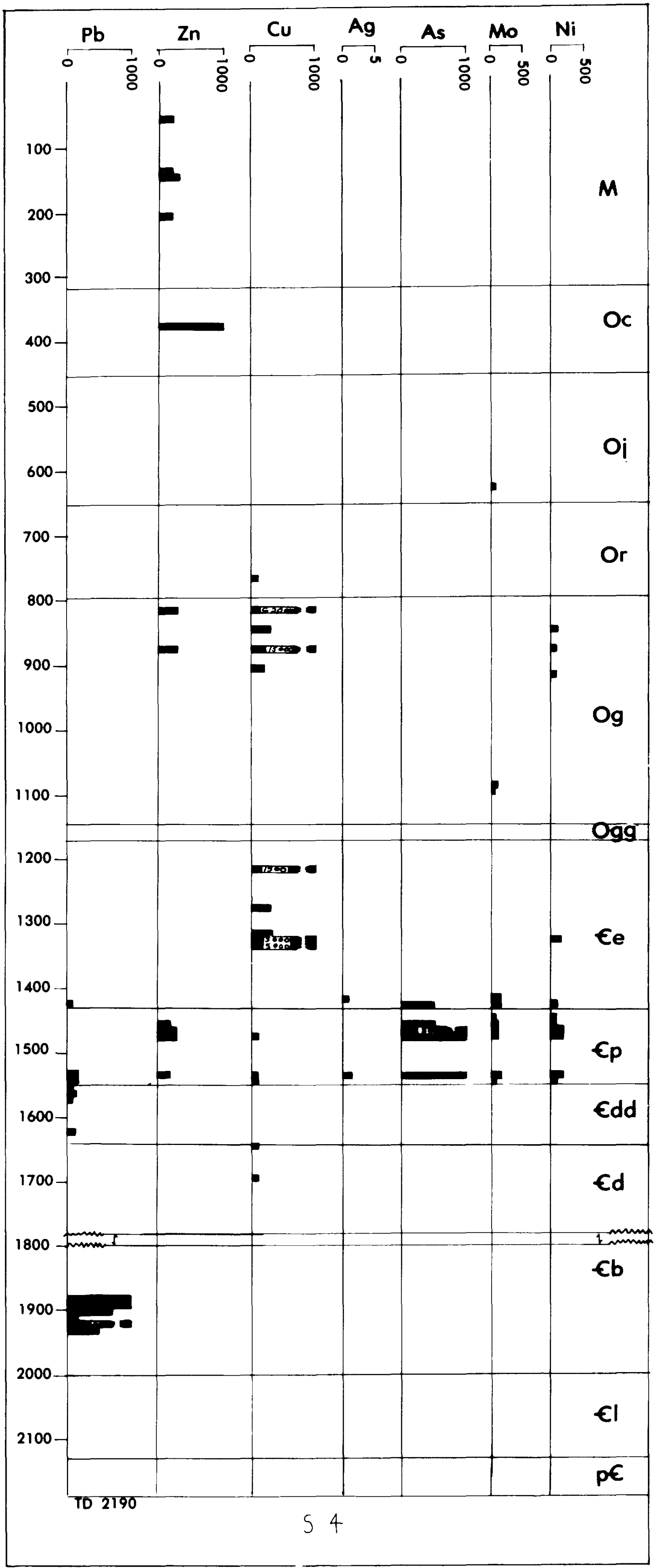
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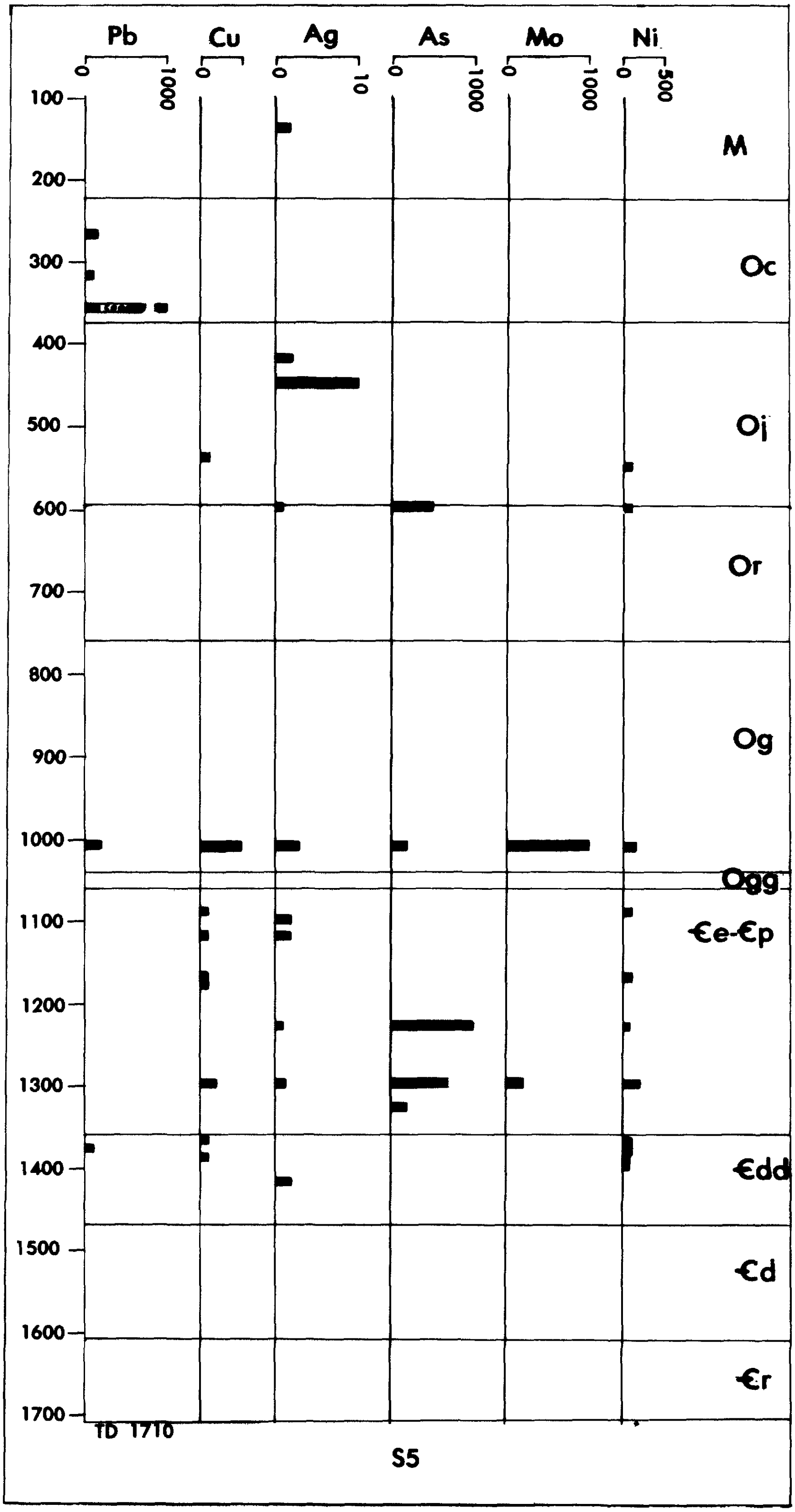

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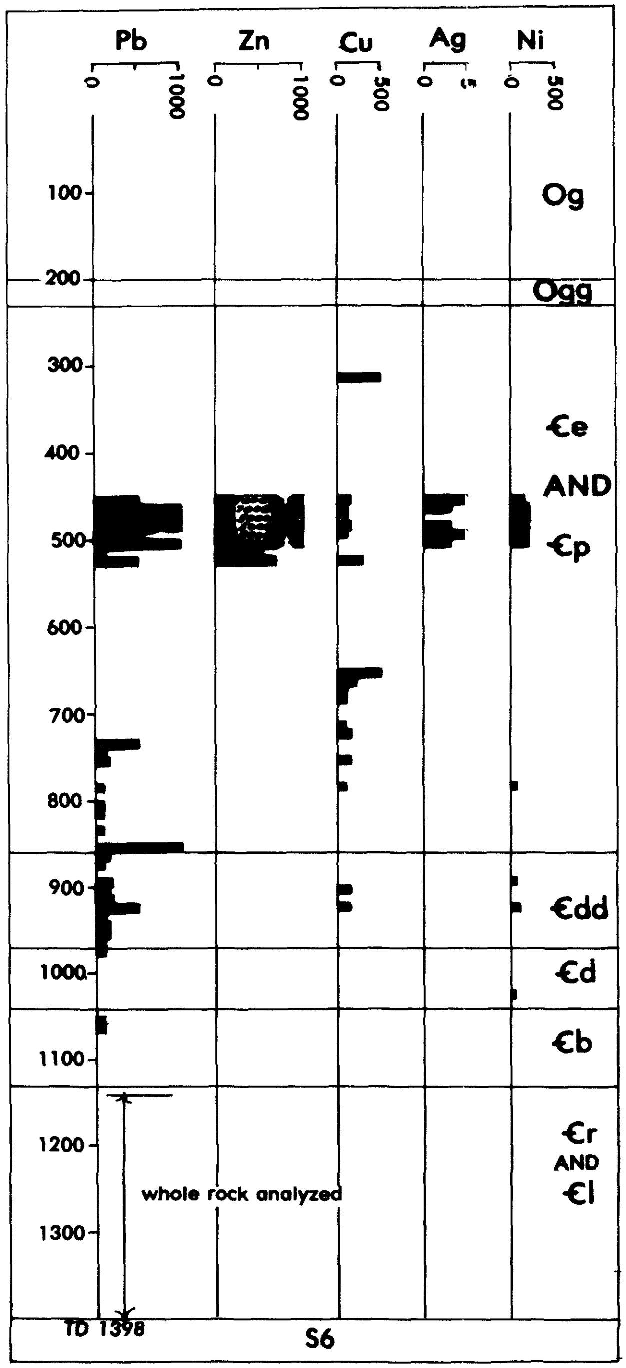

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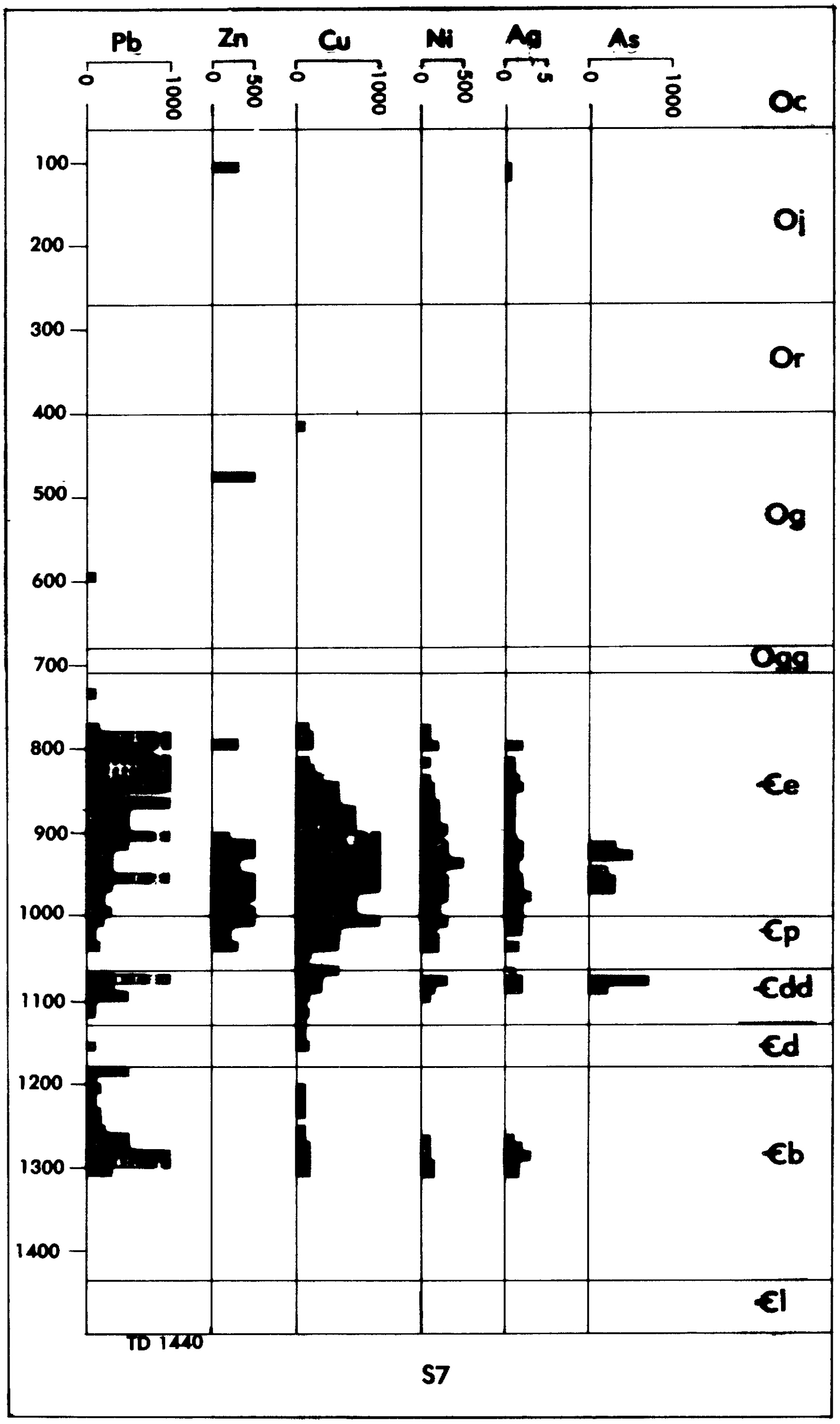
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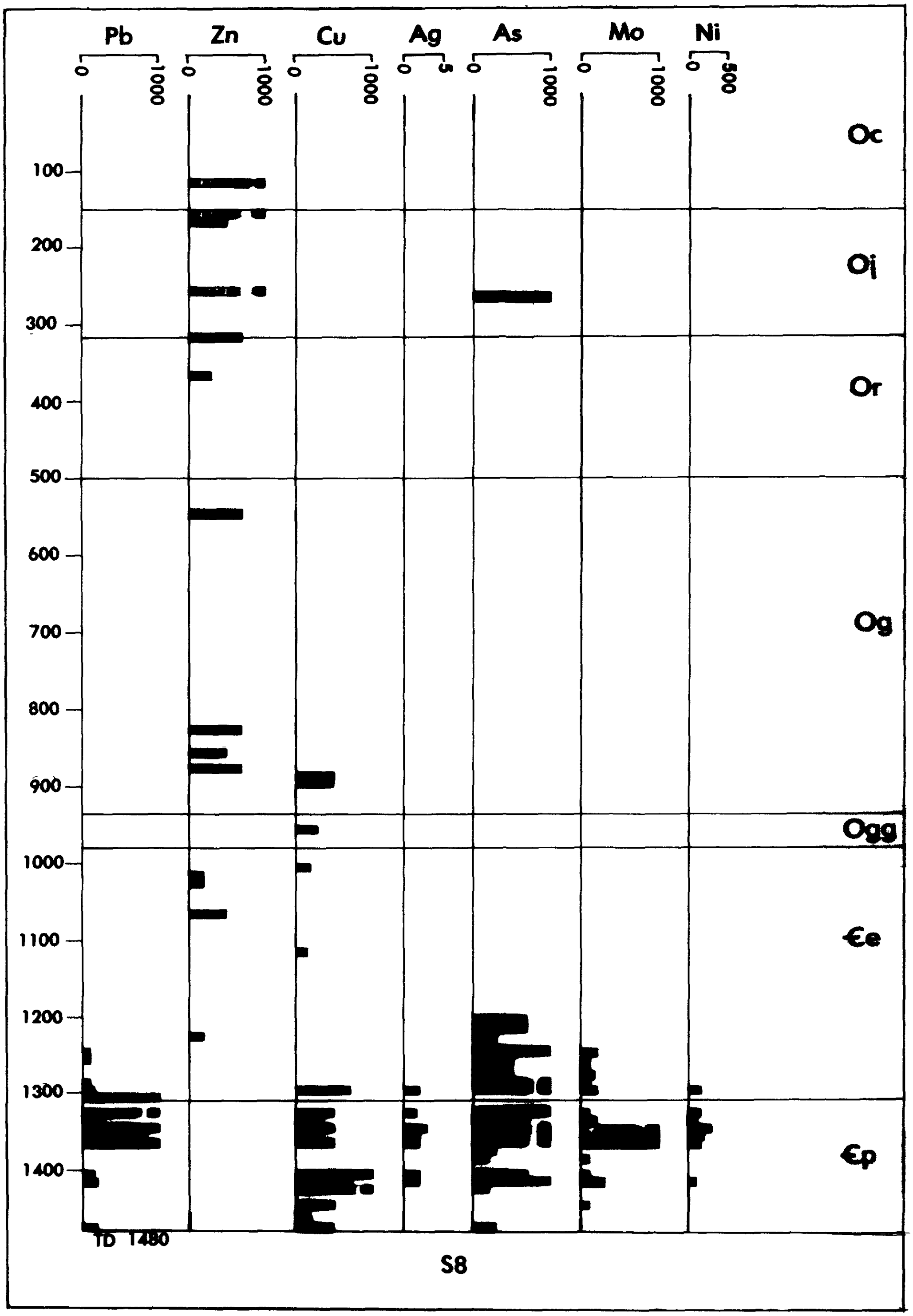
S7



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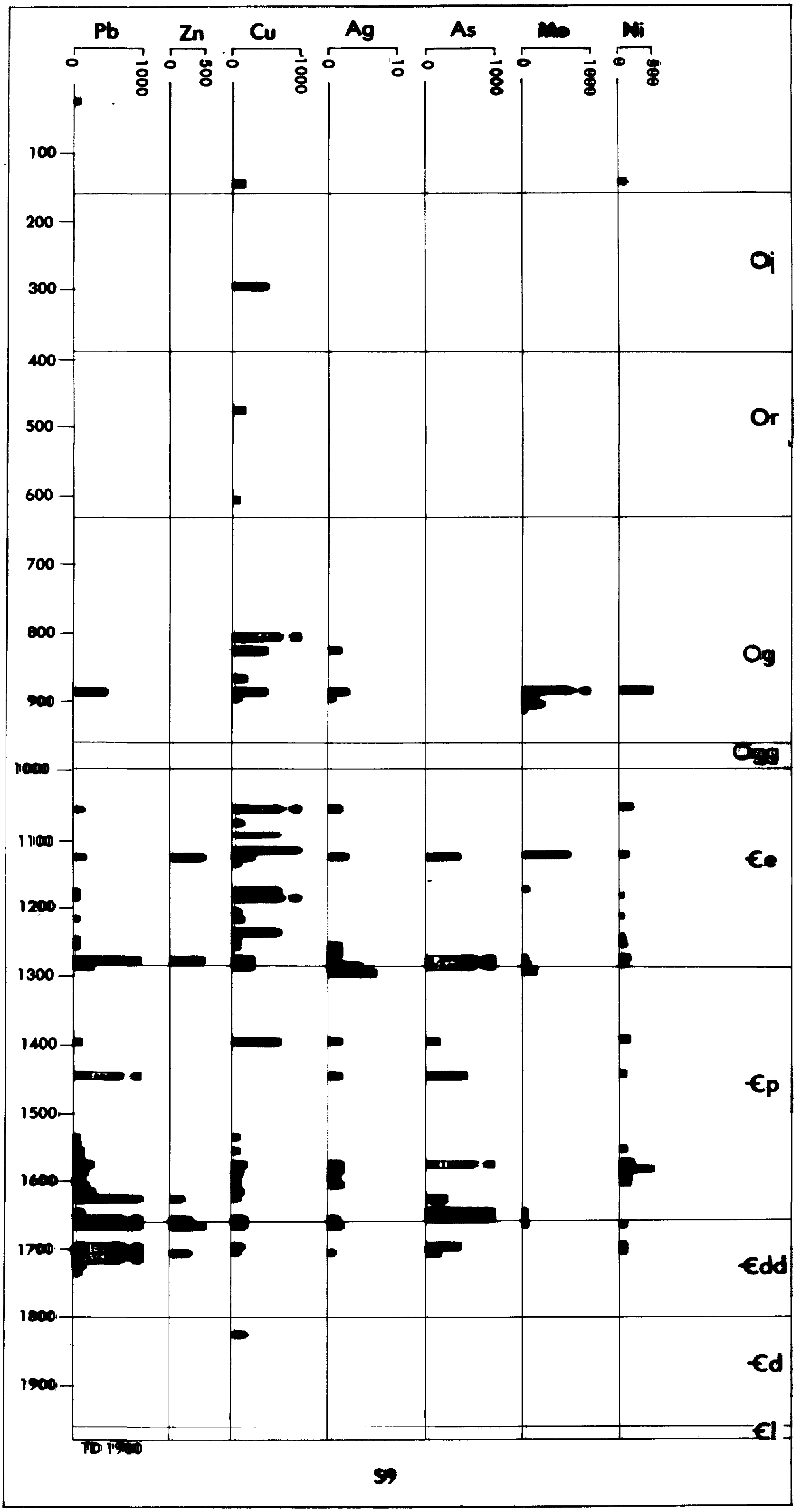
S8



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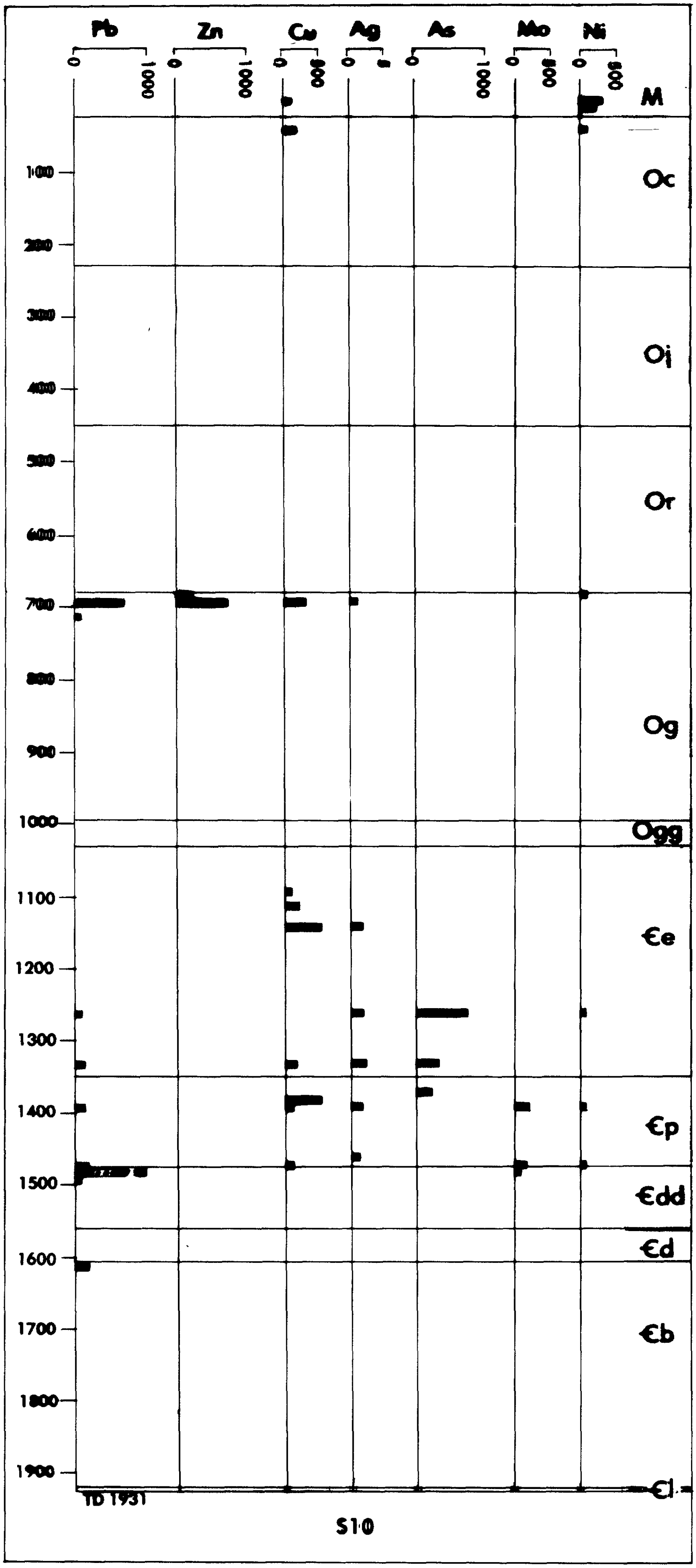

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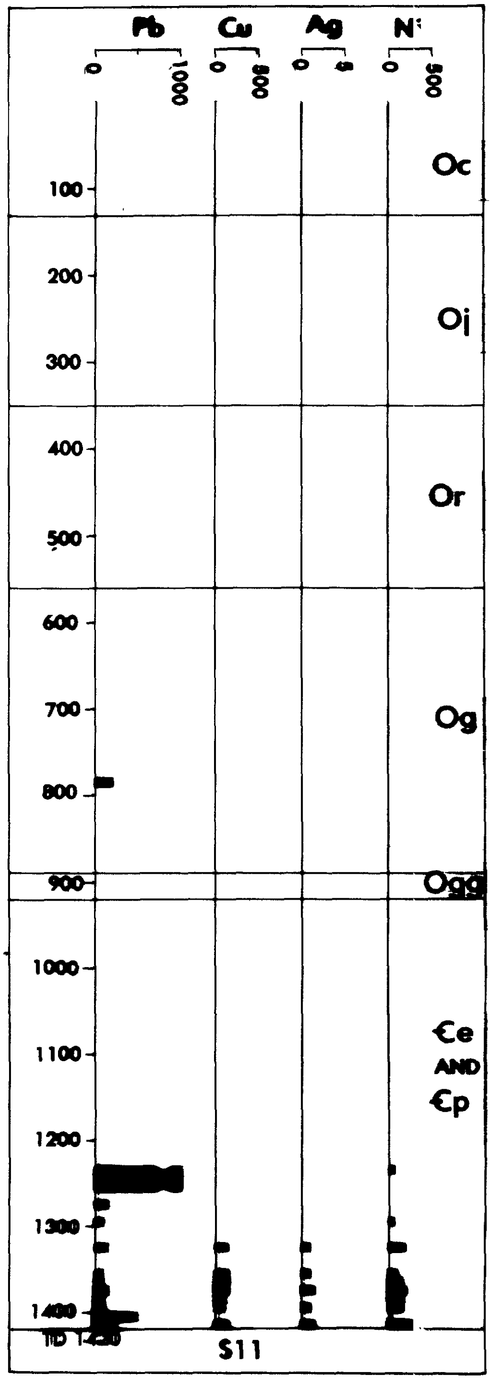

Pb Cu Ag Ni
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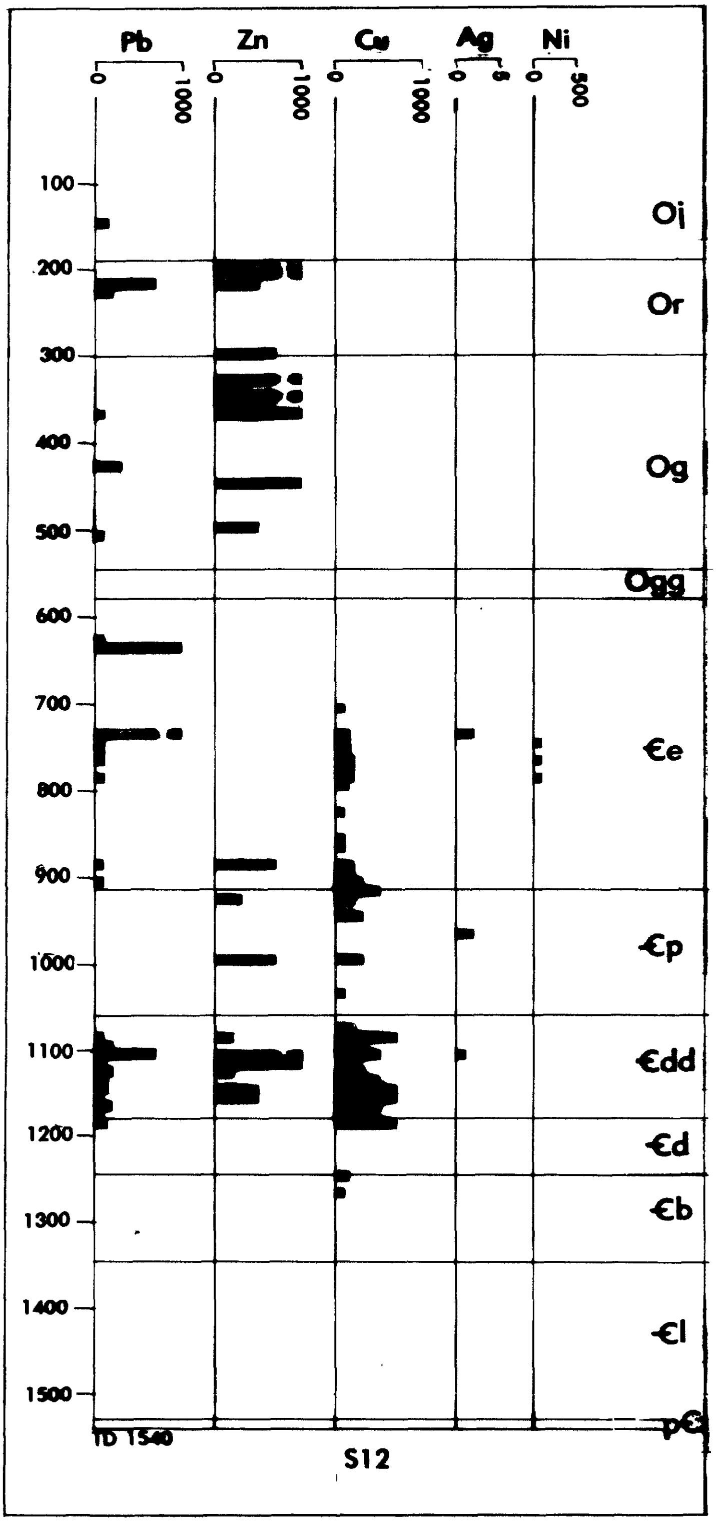
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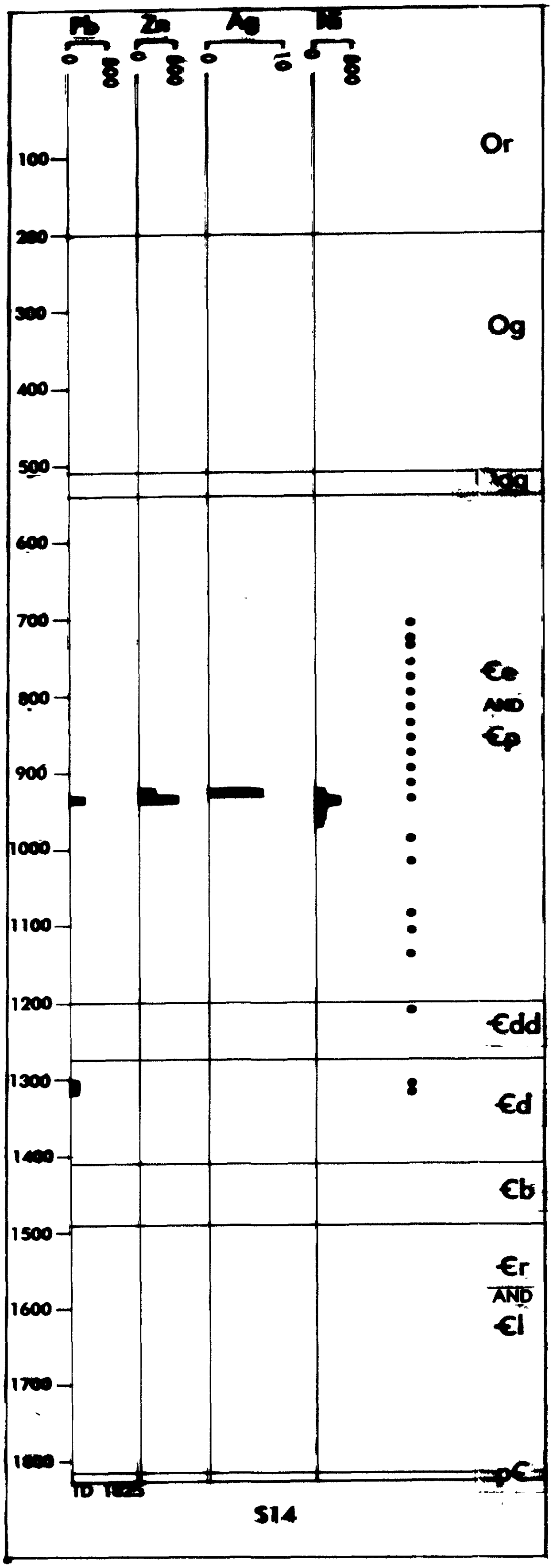
S12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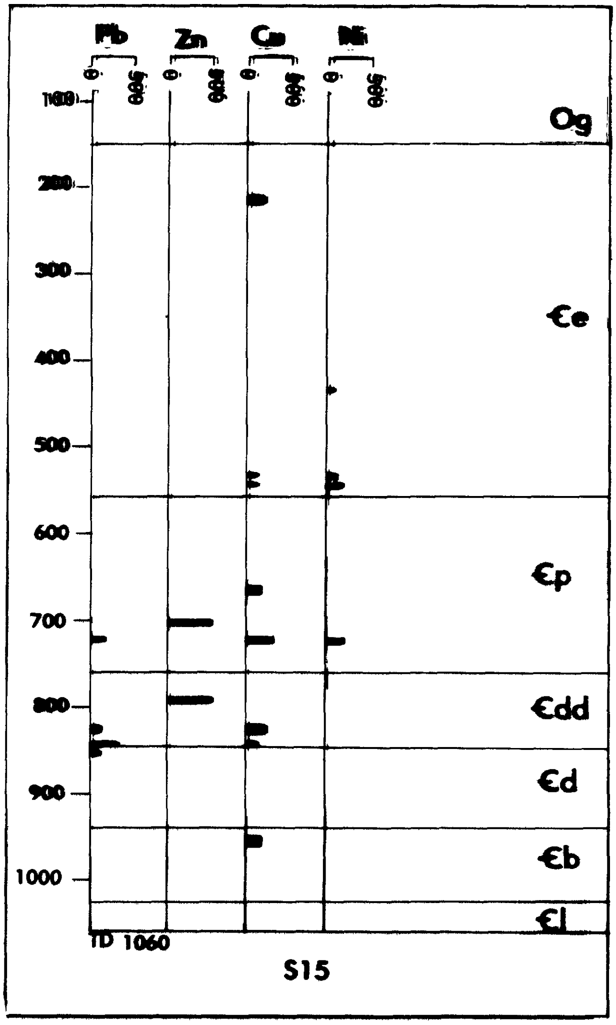
S14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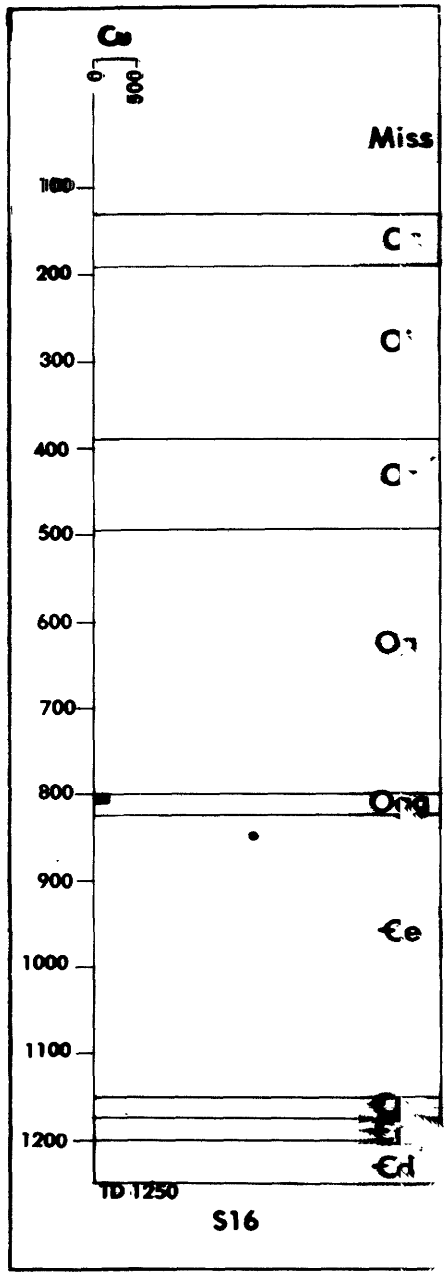
S15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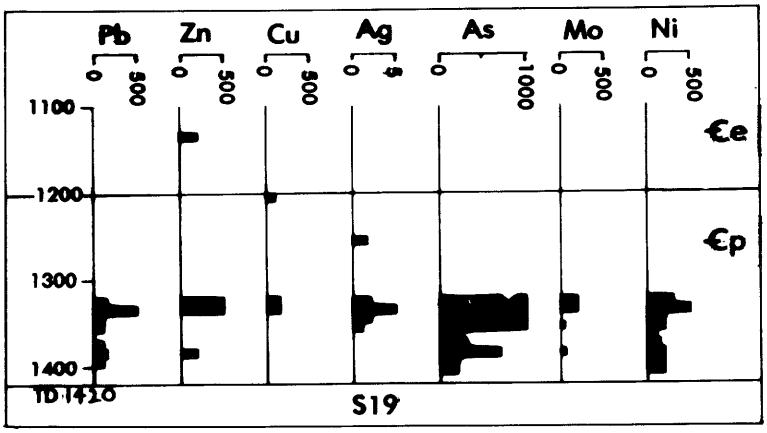
S16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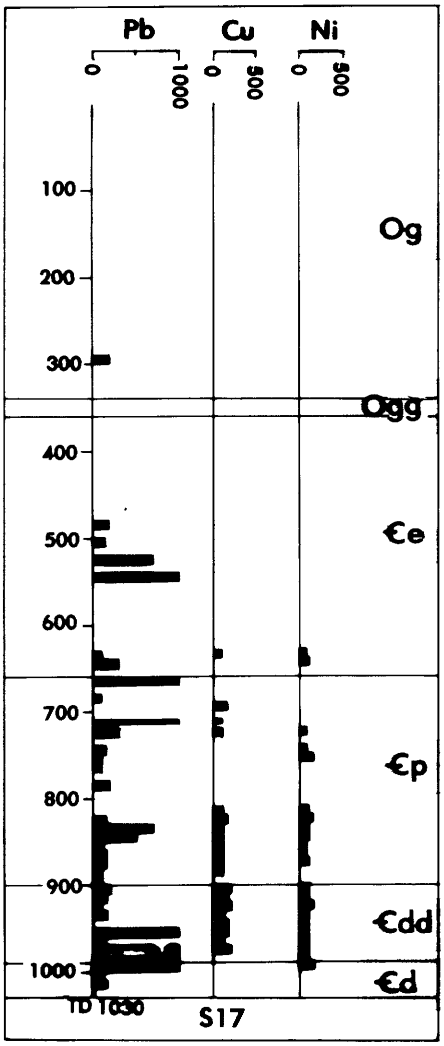
S19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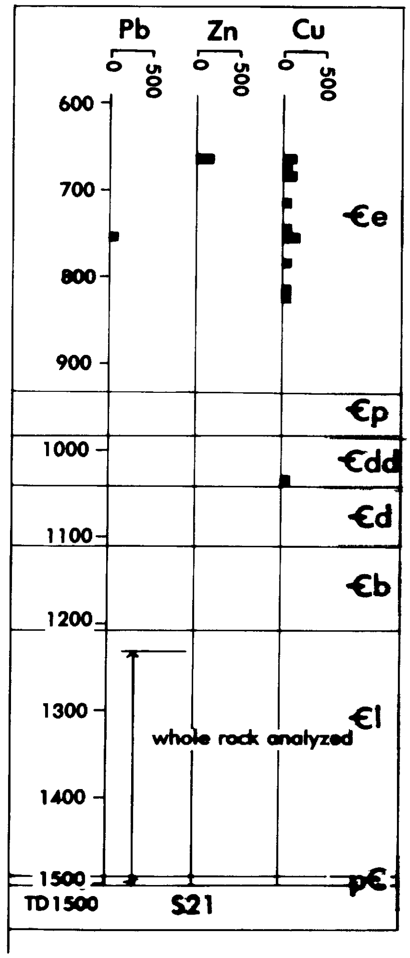
S17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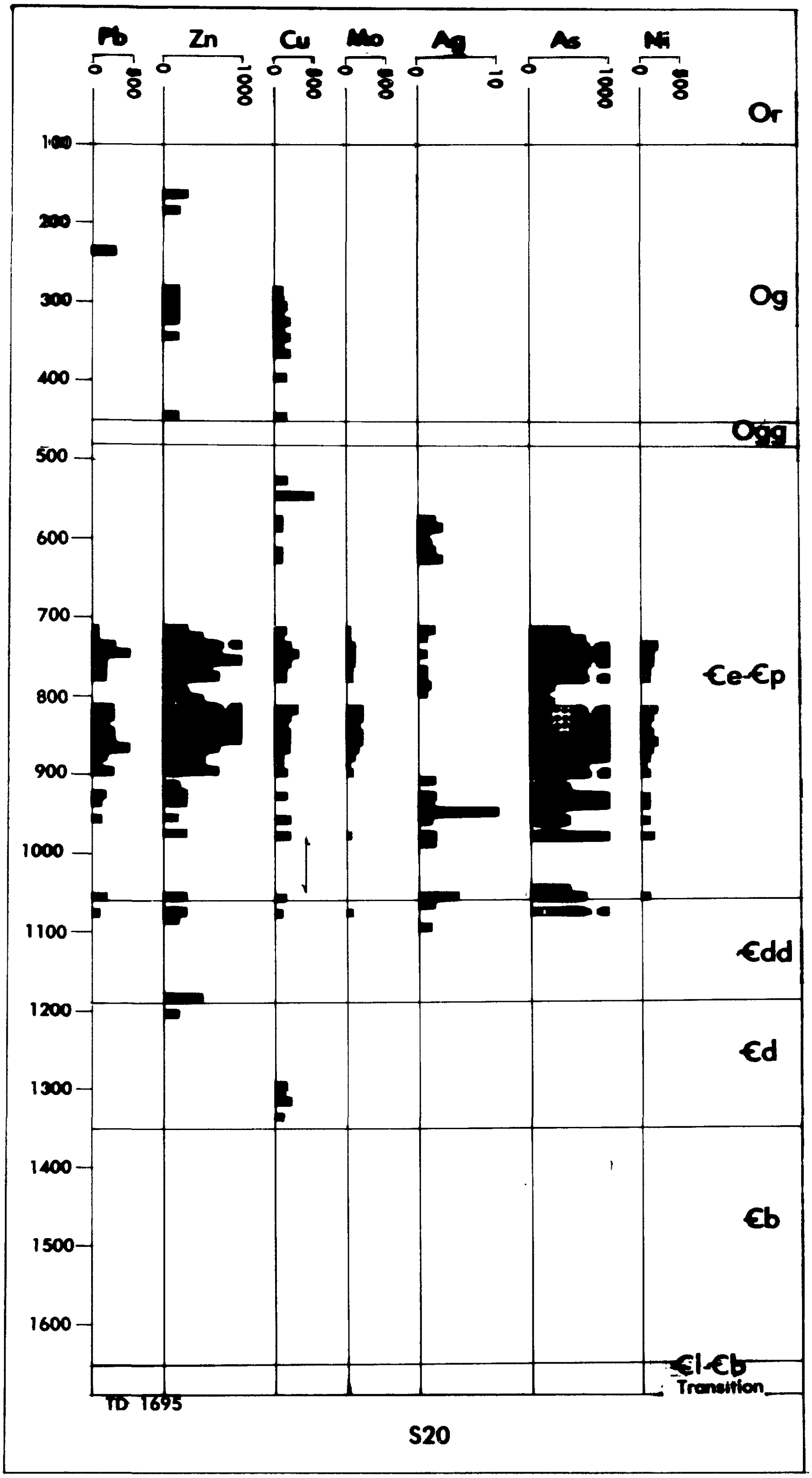
S21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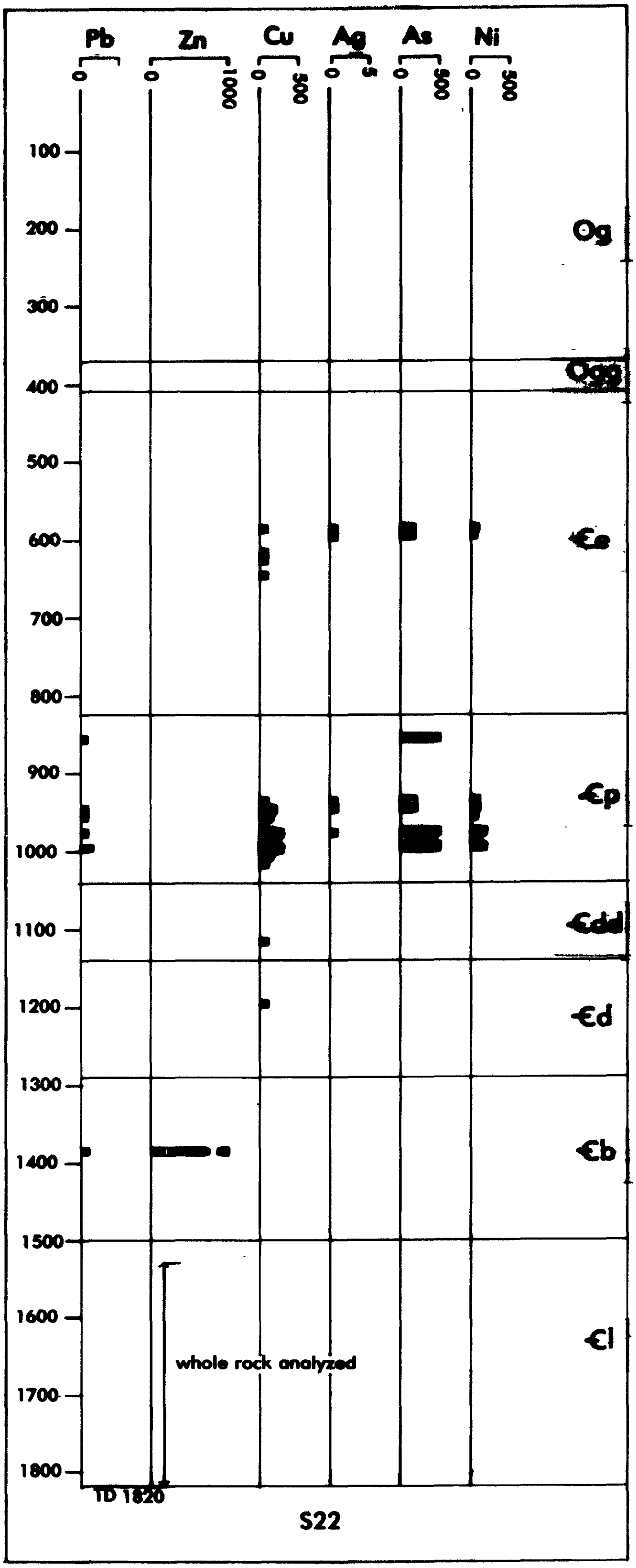
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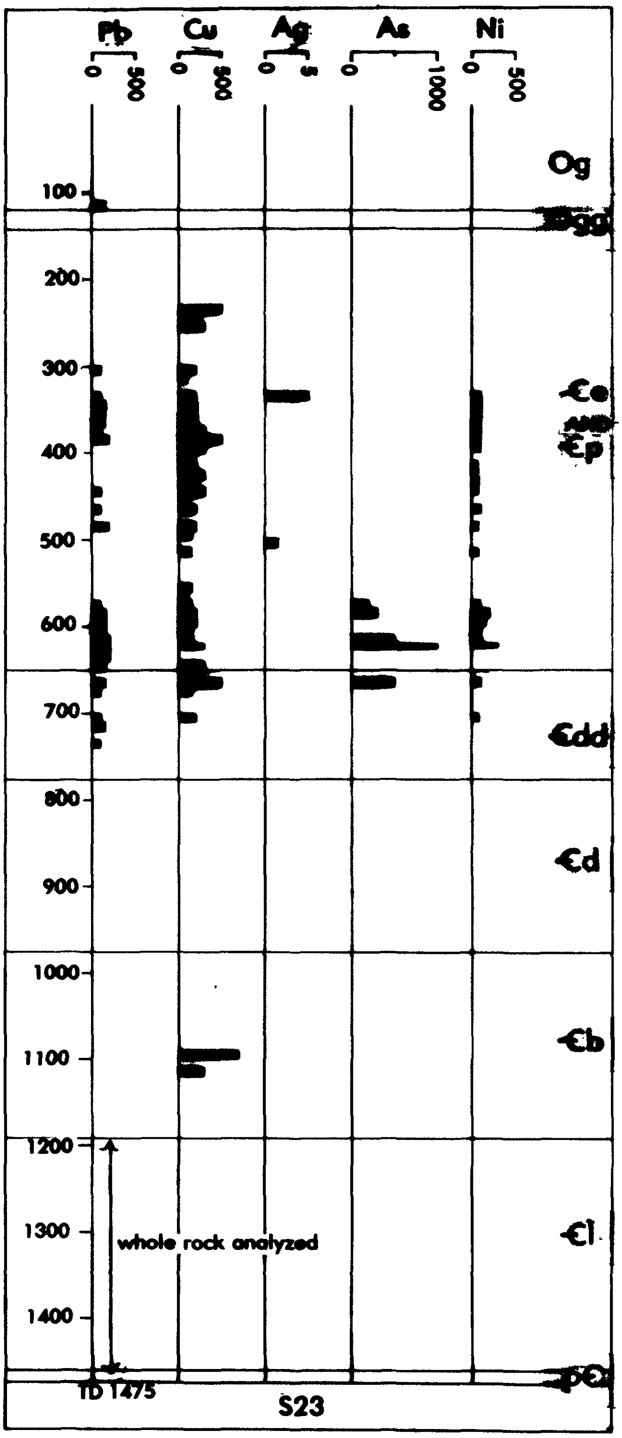
S22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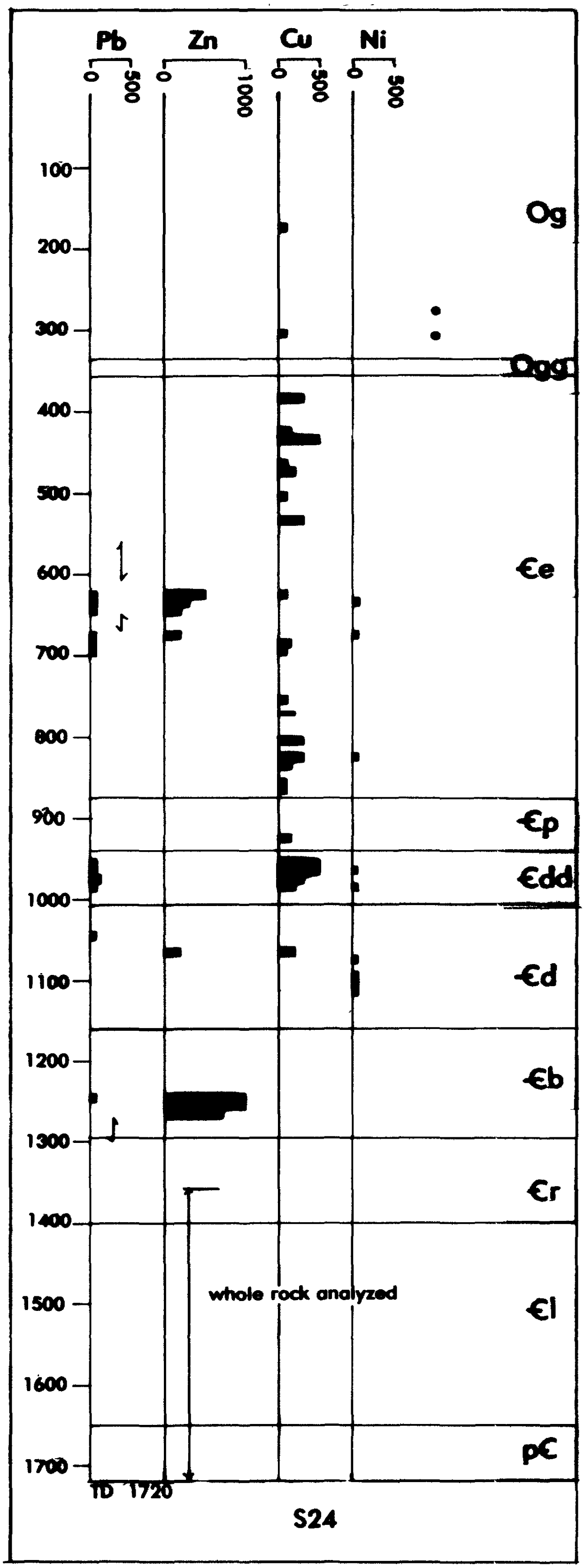
S23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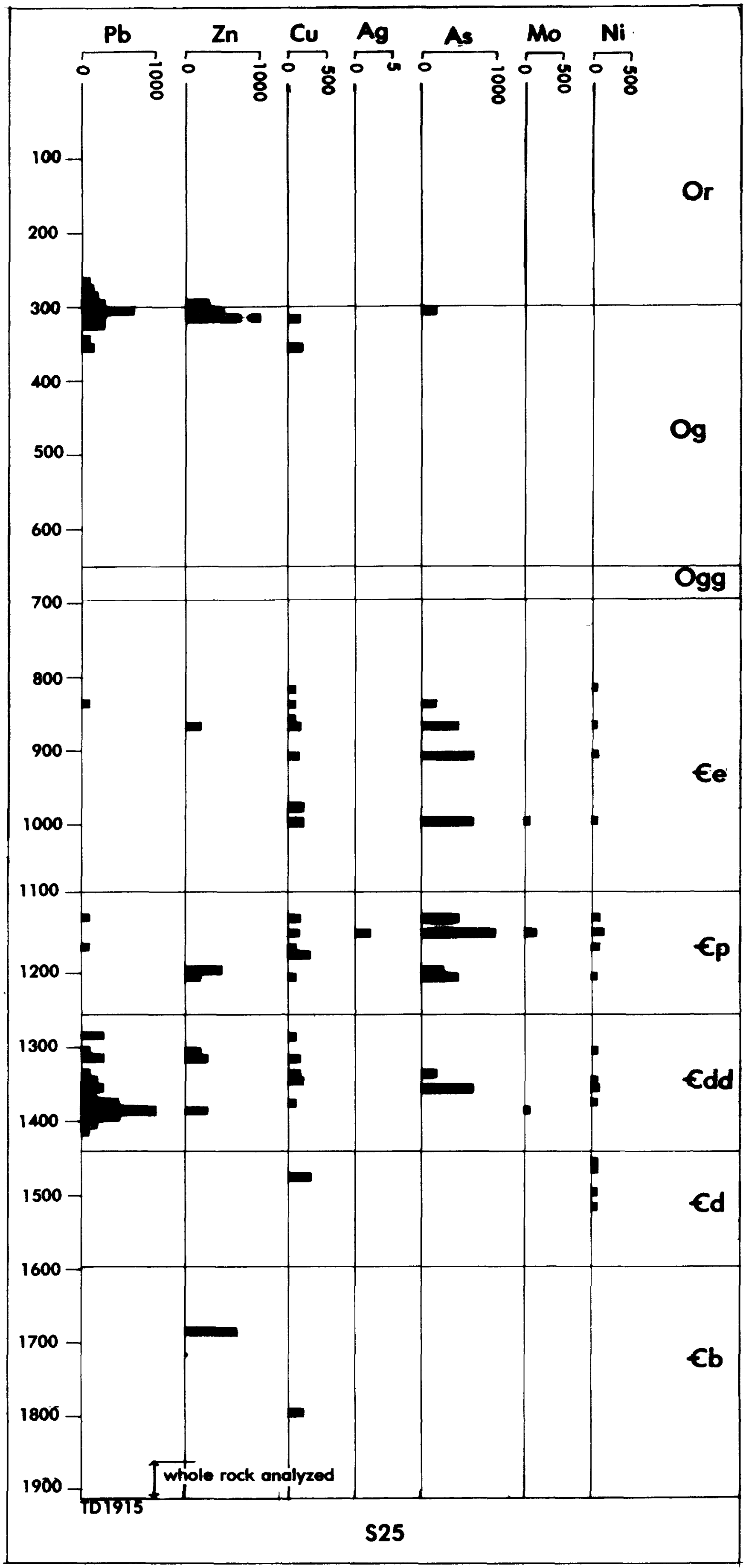
S24



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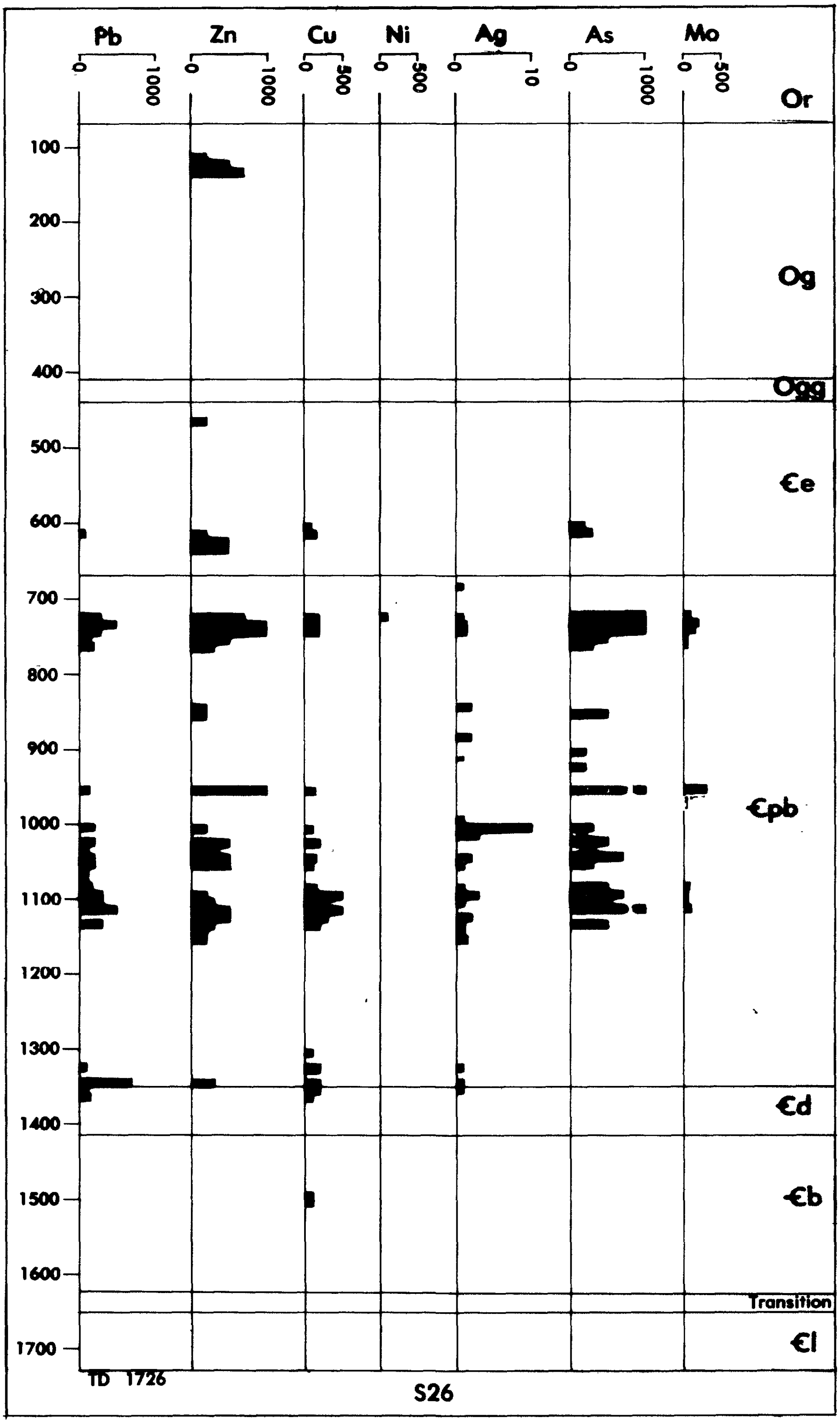
S25



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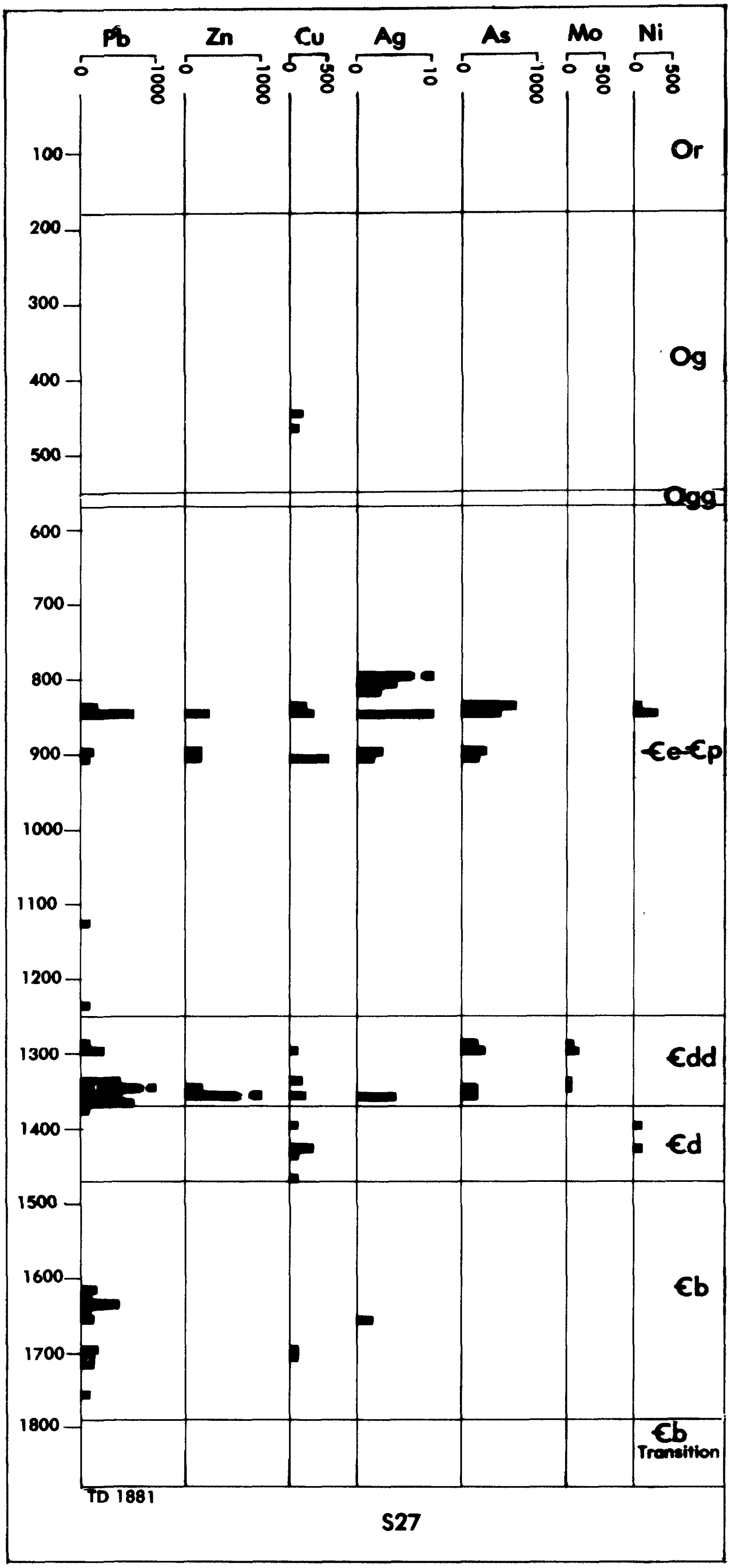
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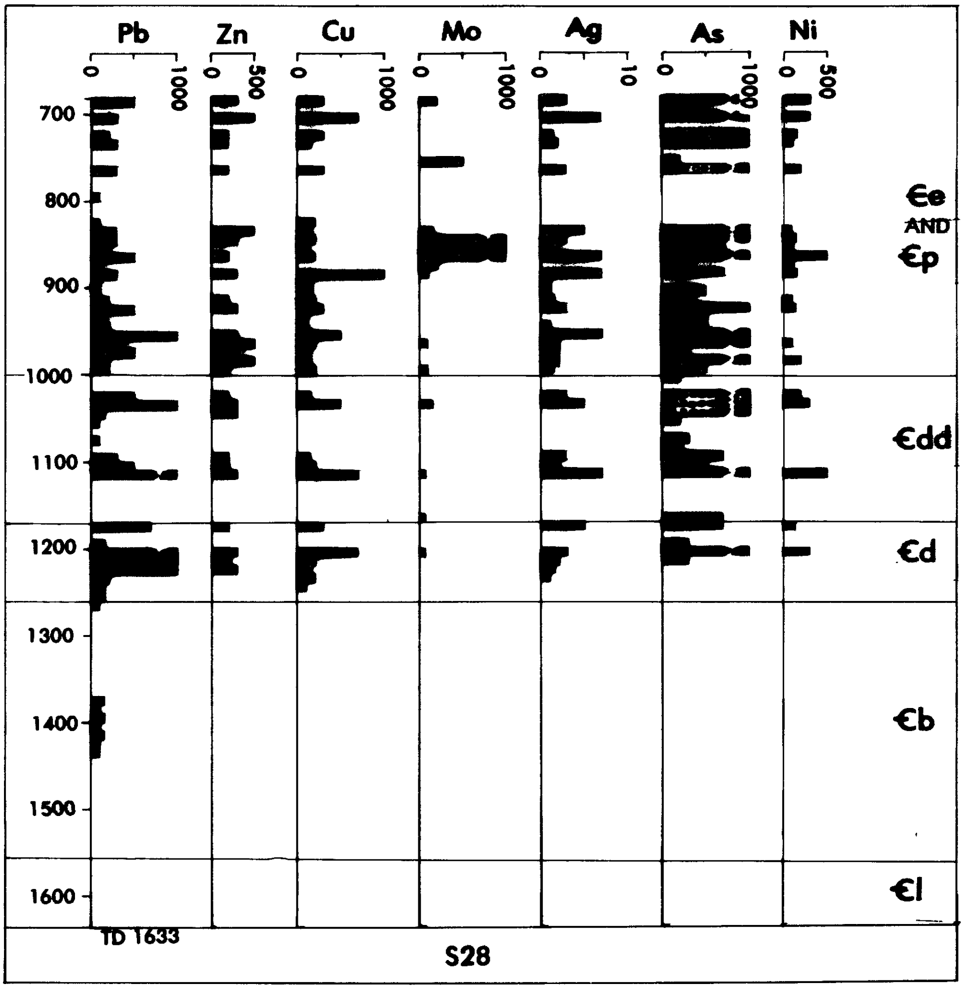
S27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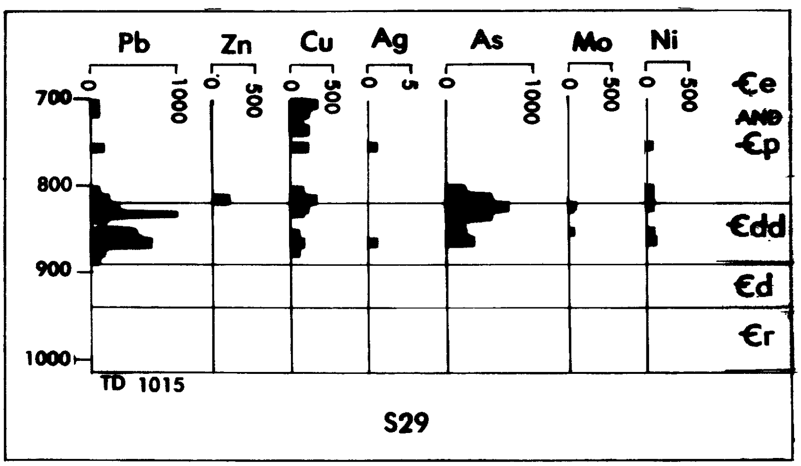
S28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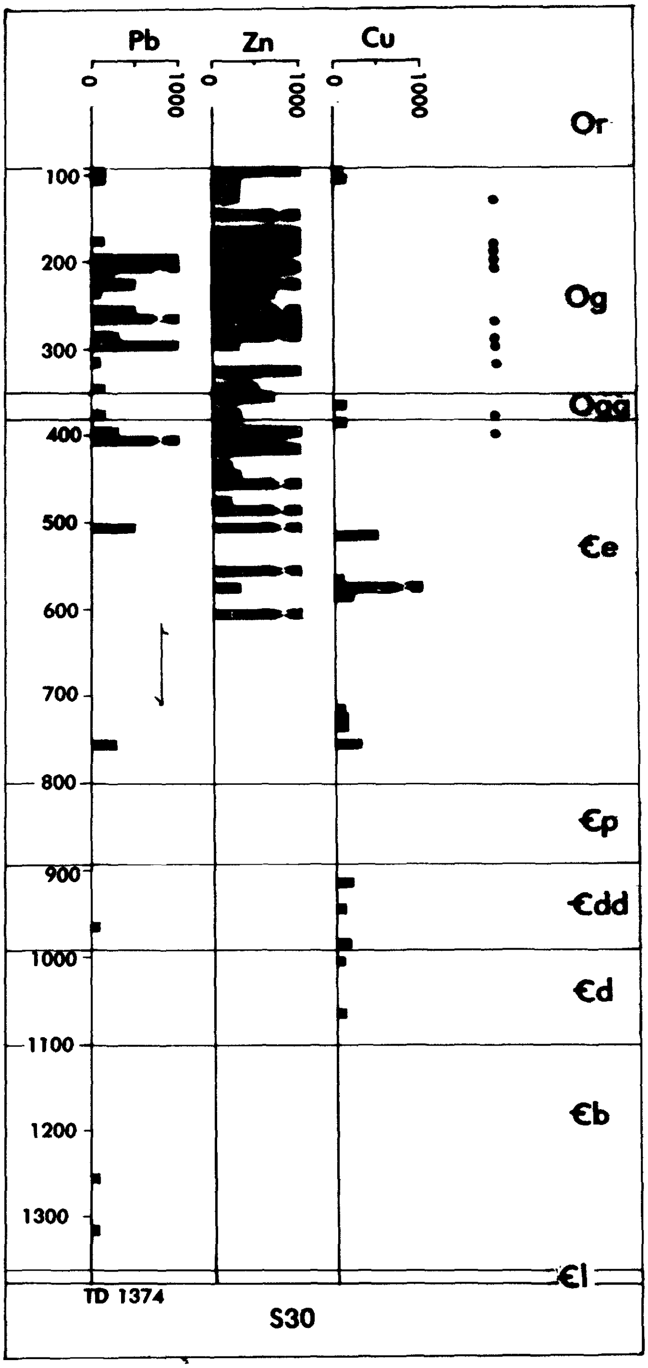
S29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TD 1374
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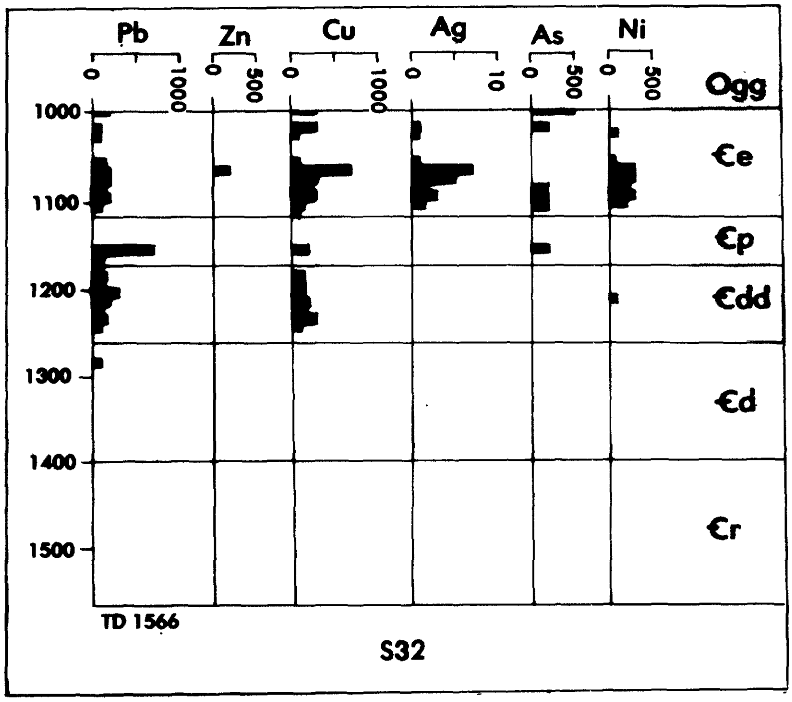
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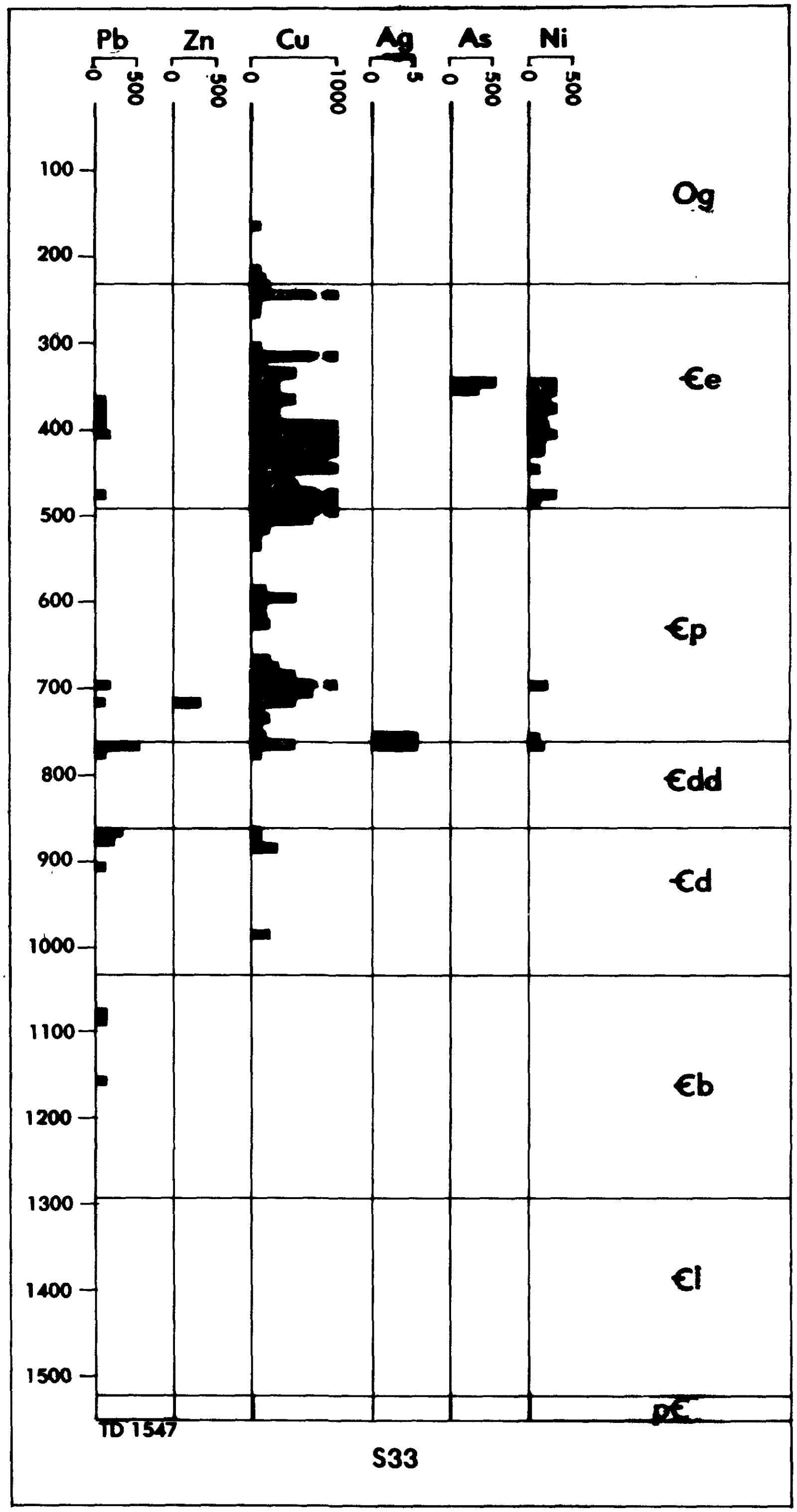
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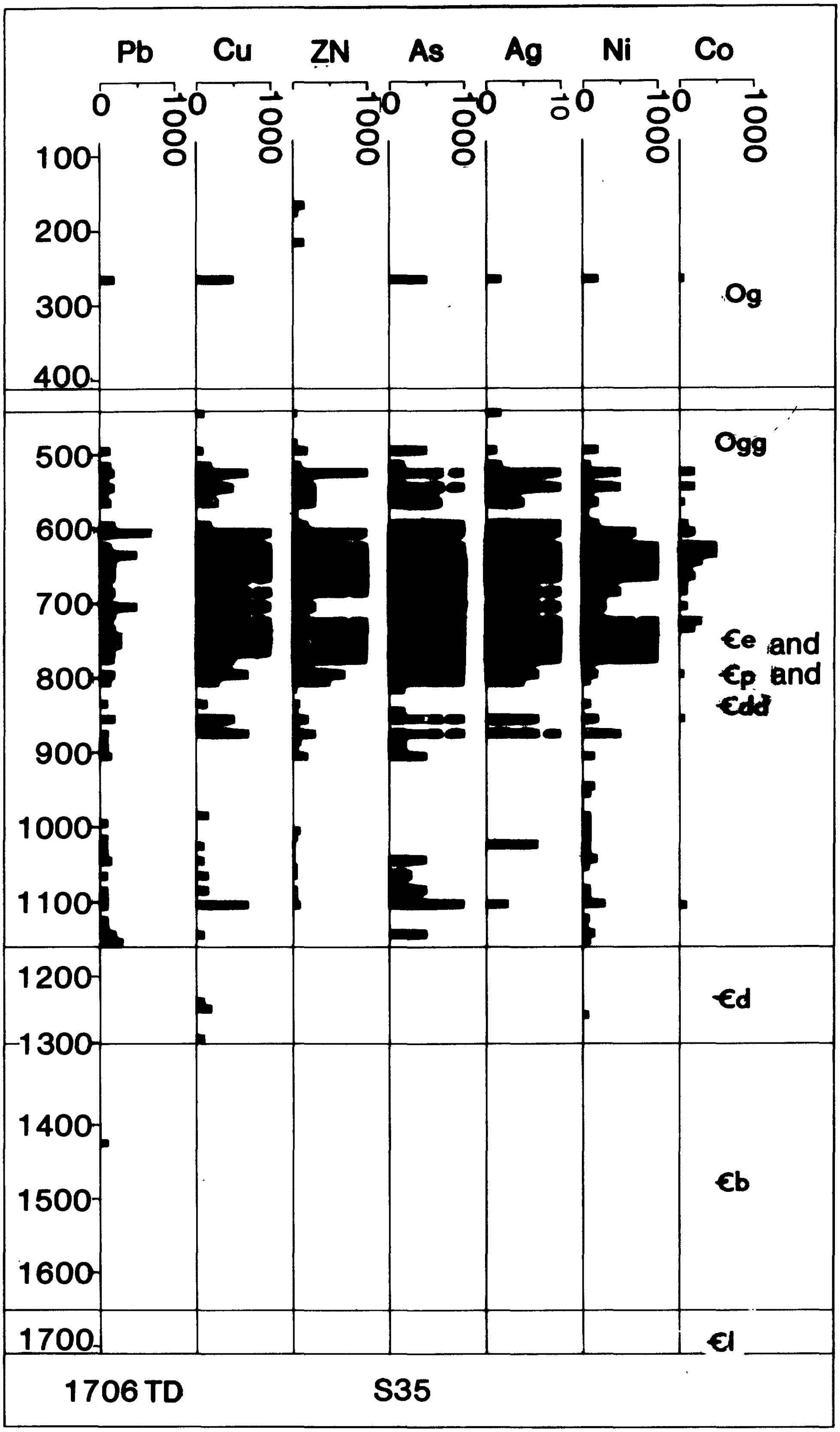
S33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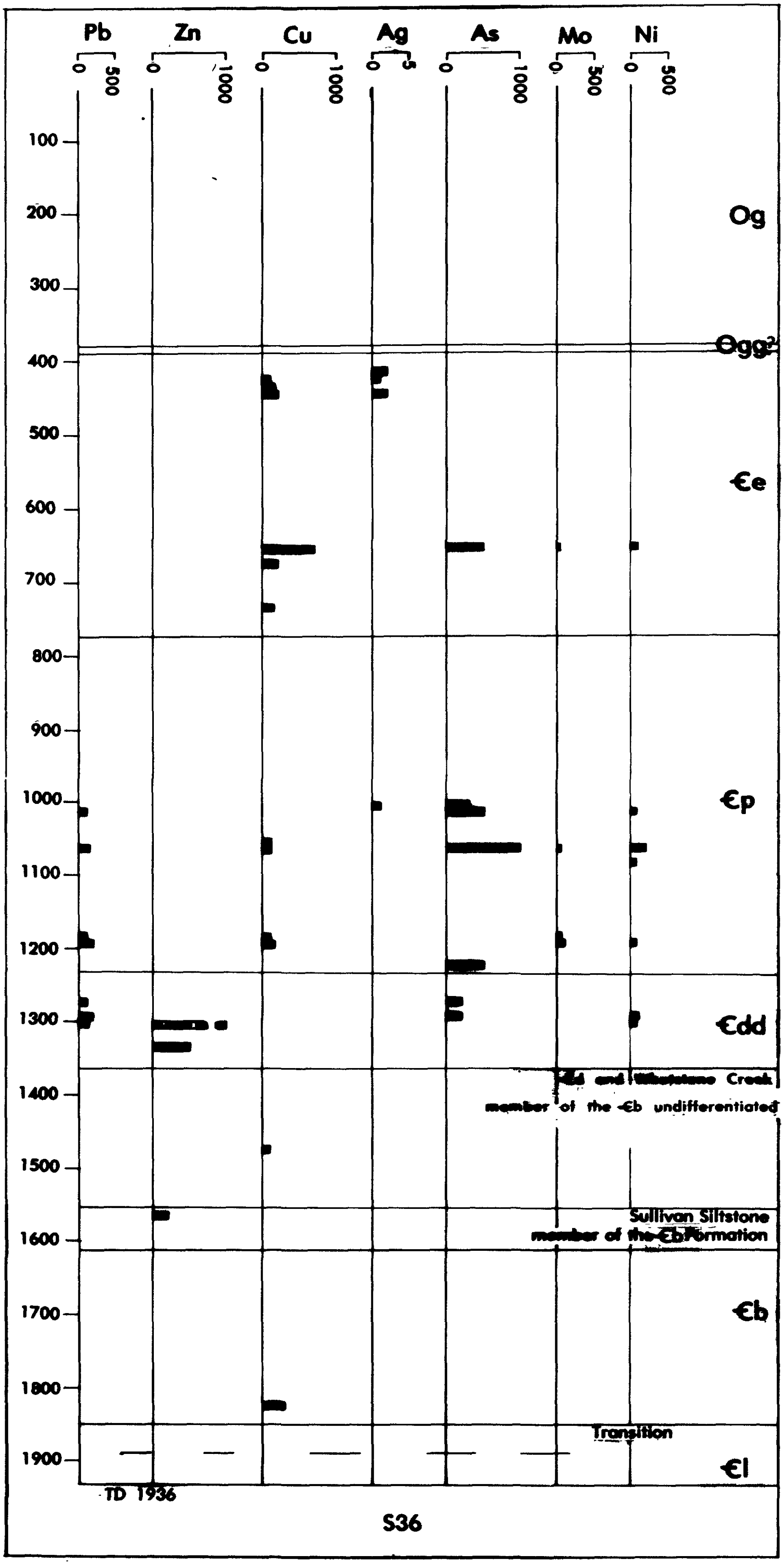
S35



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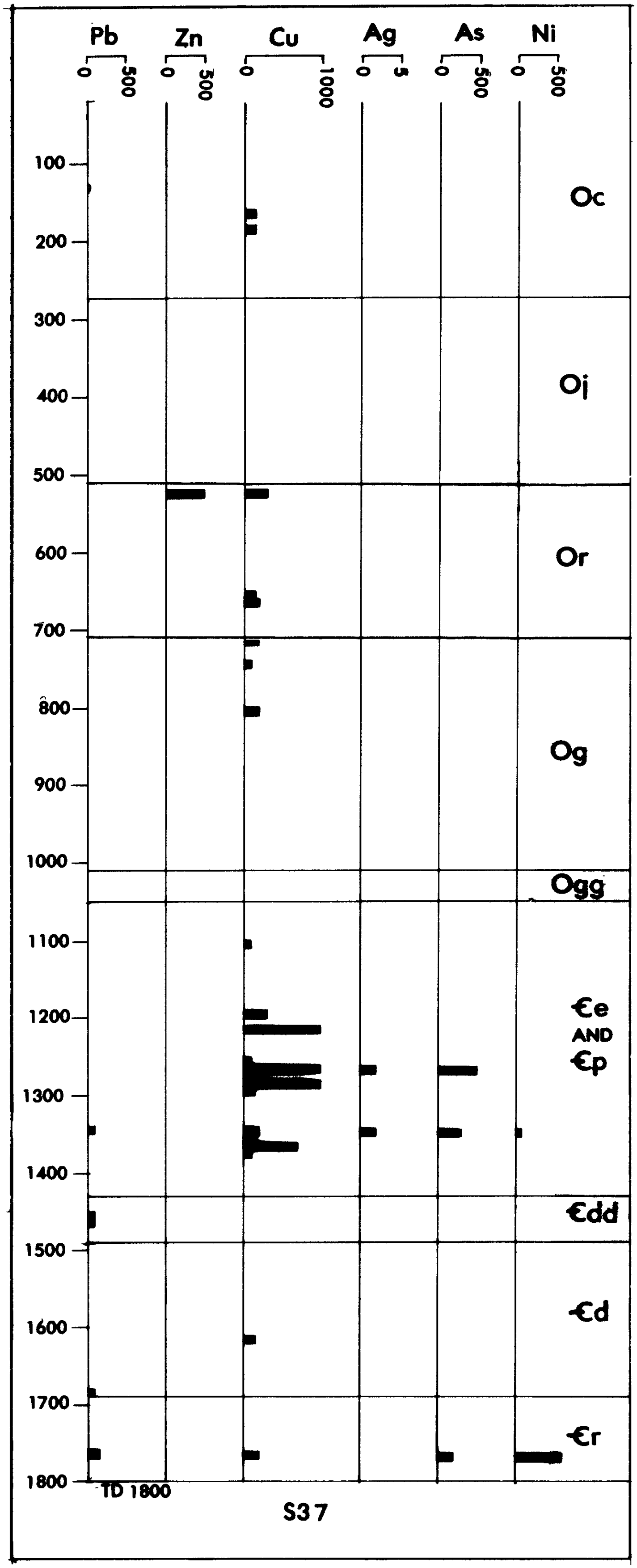
S36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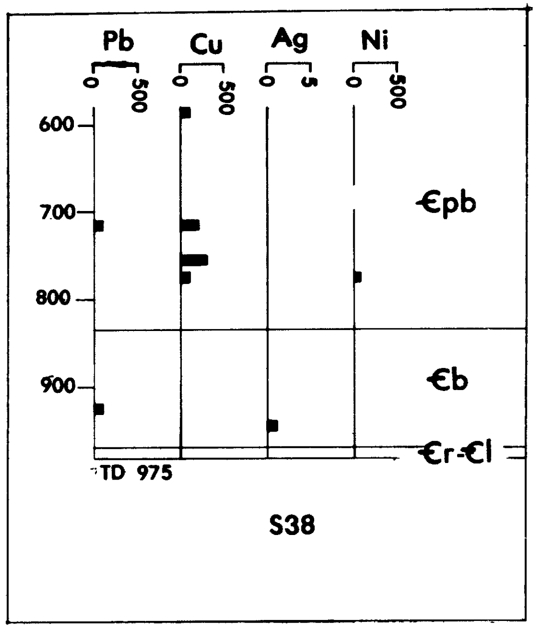
S37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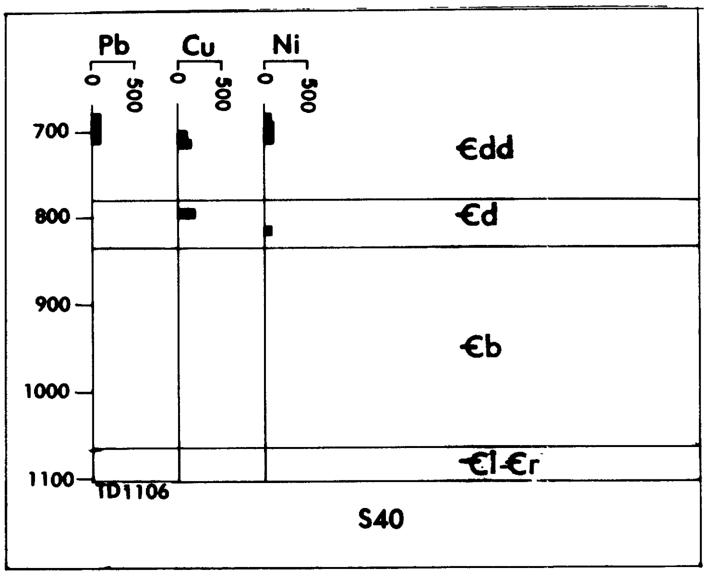
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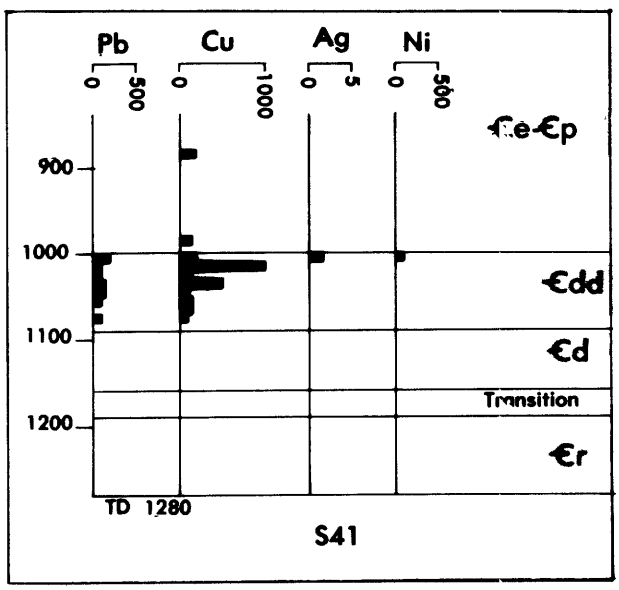
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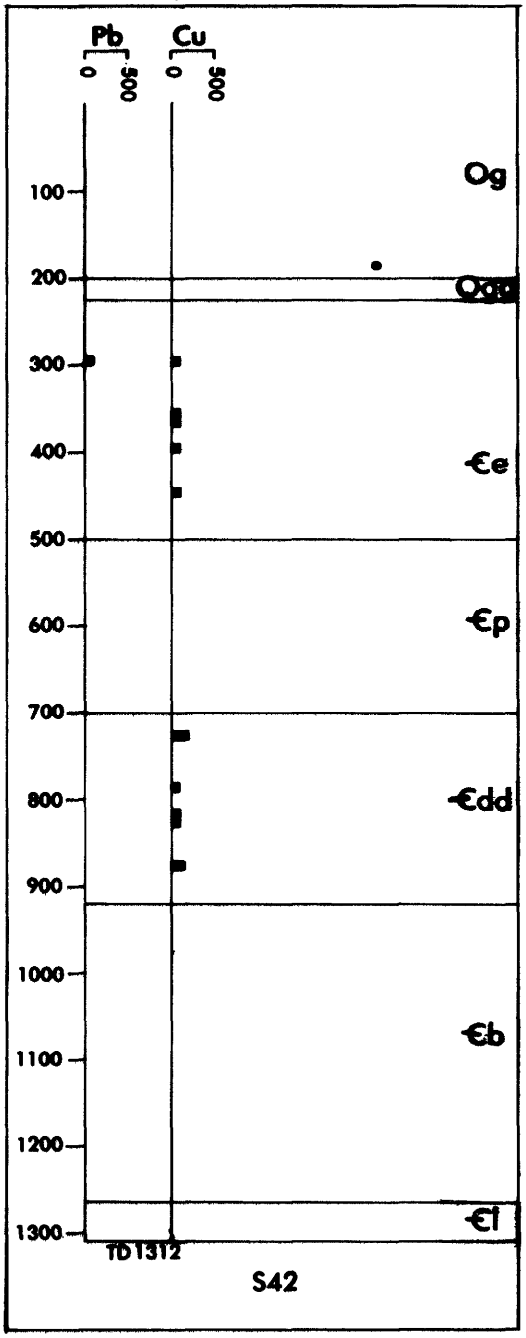
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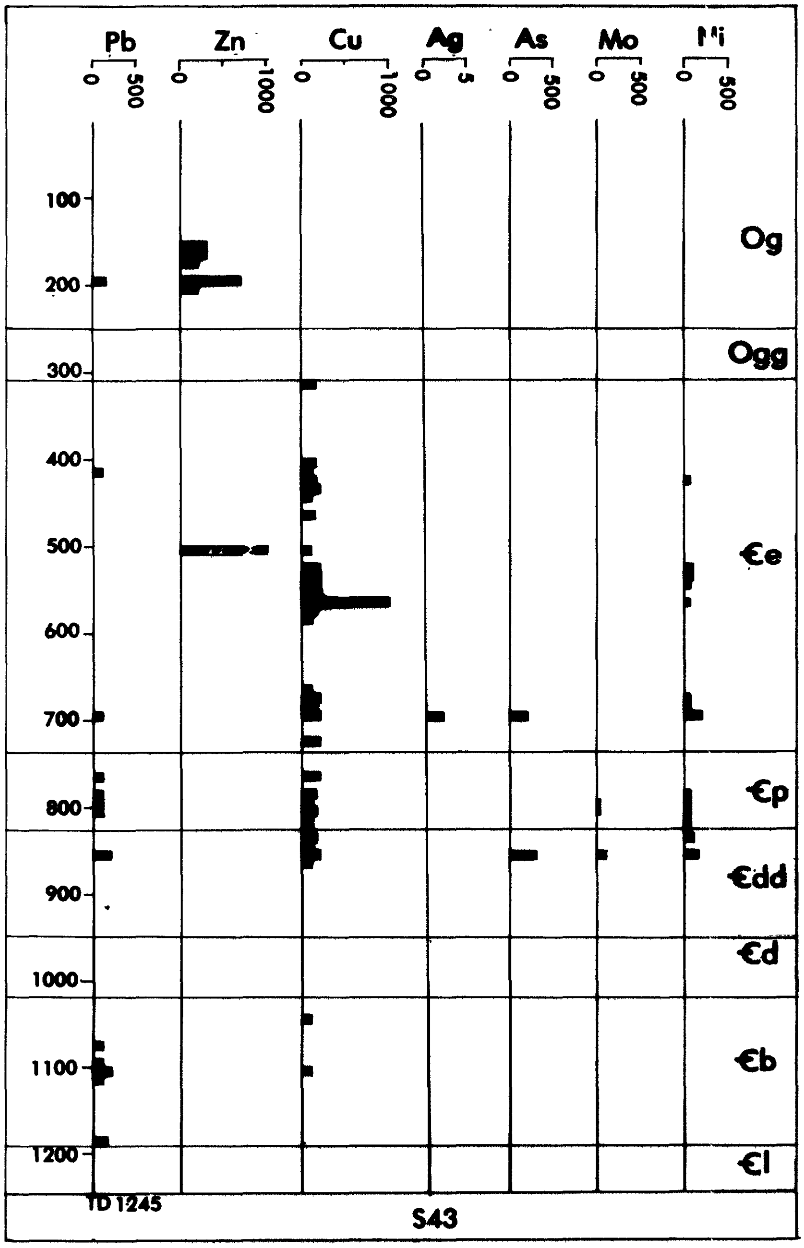
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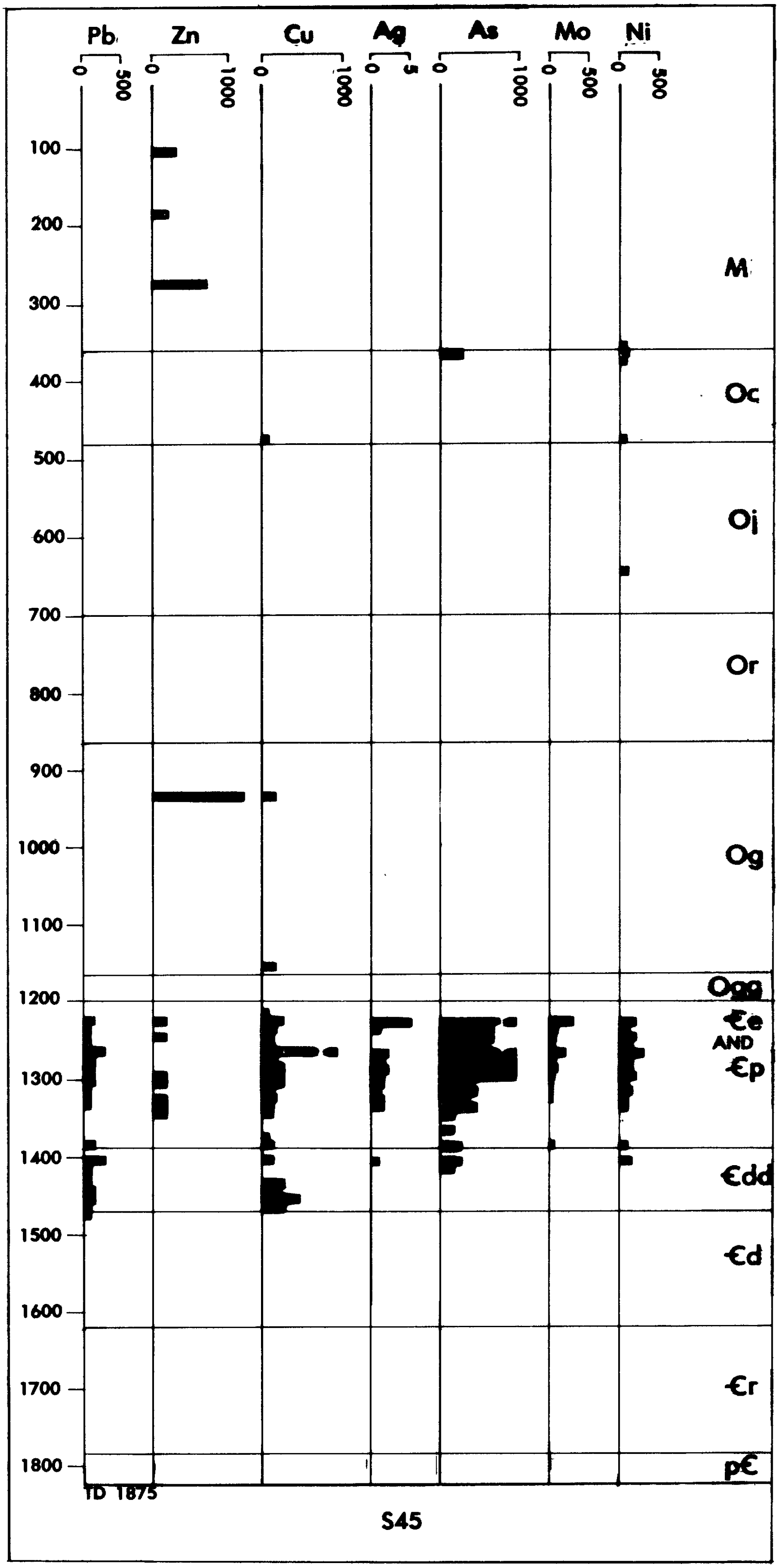

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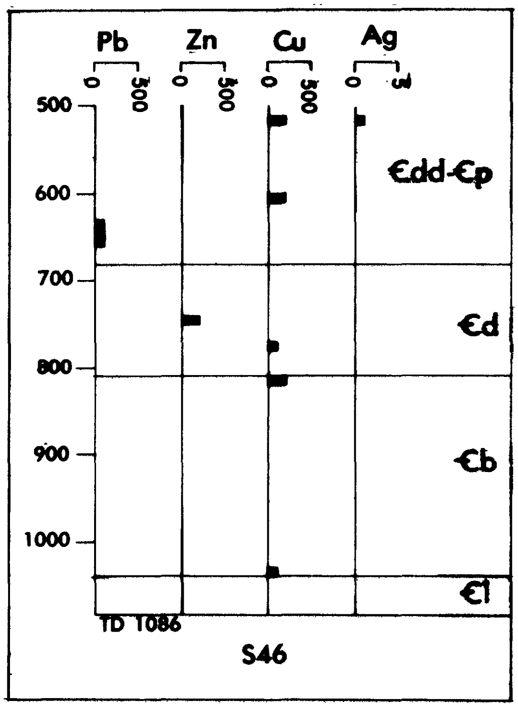
S45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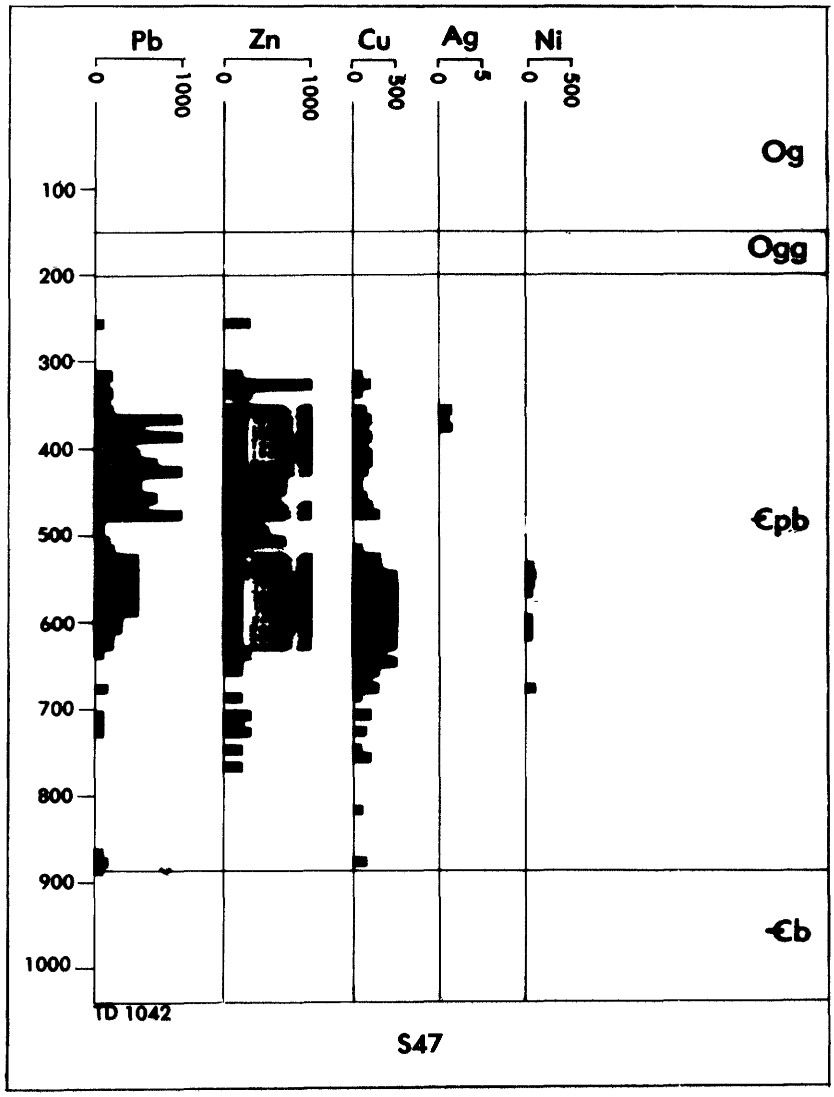
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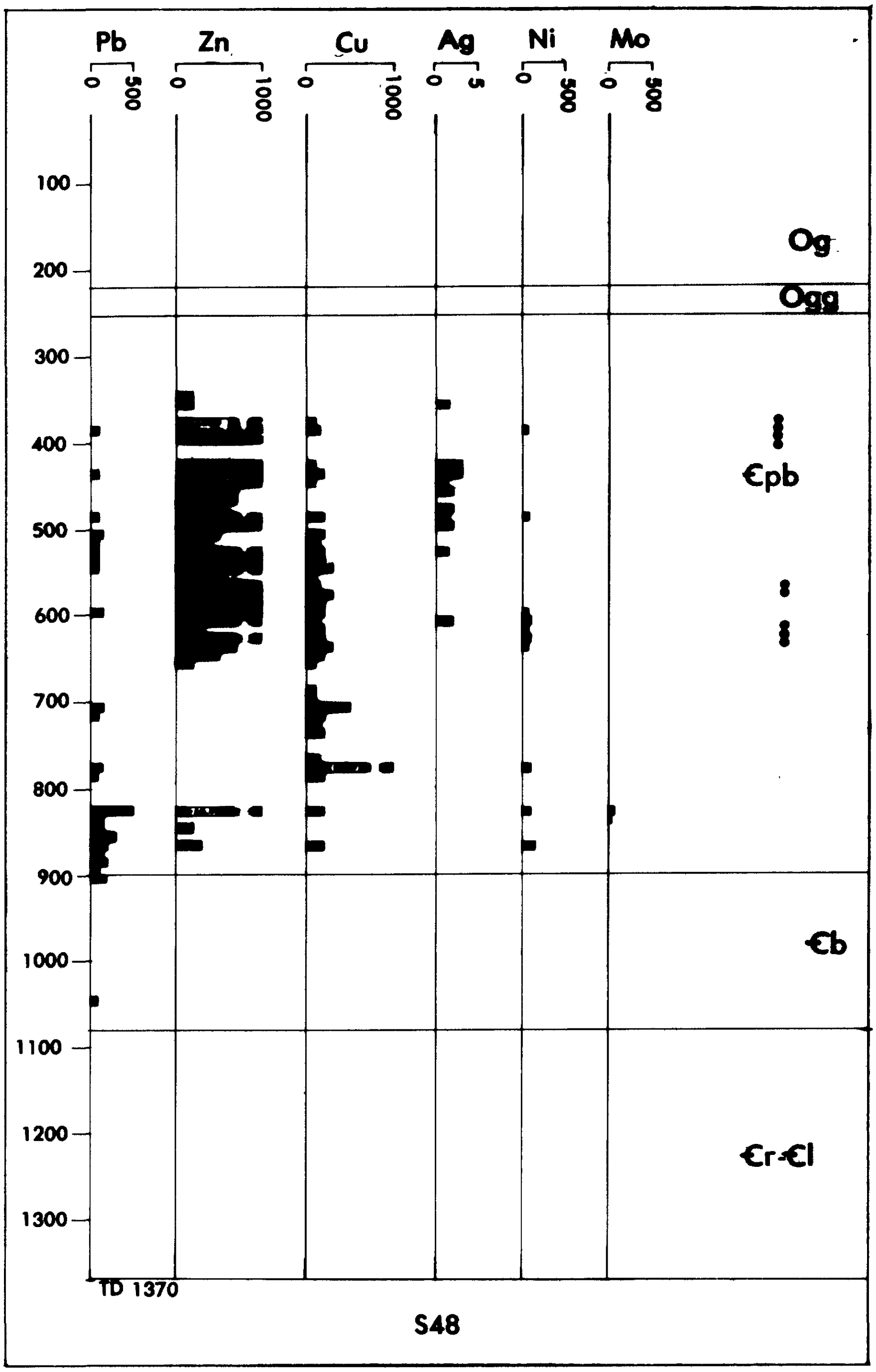
S47



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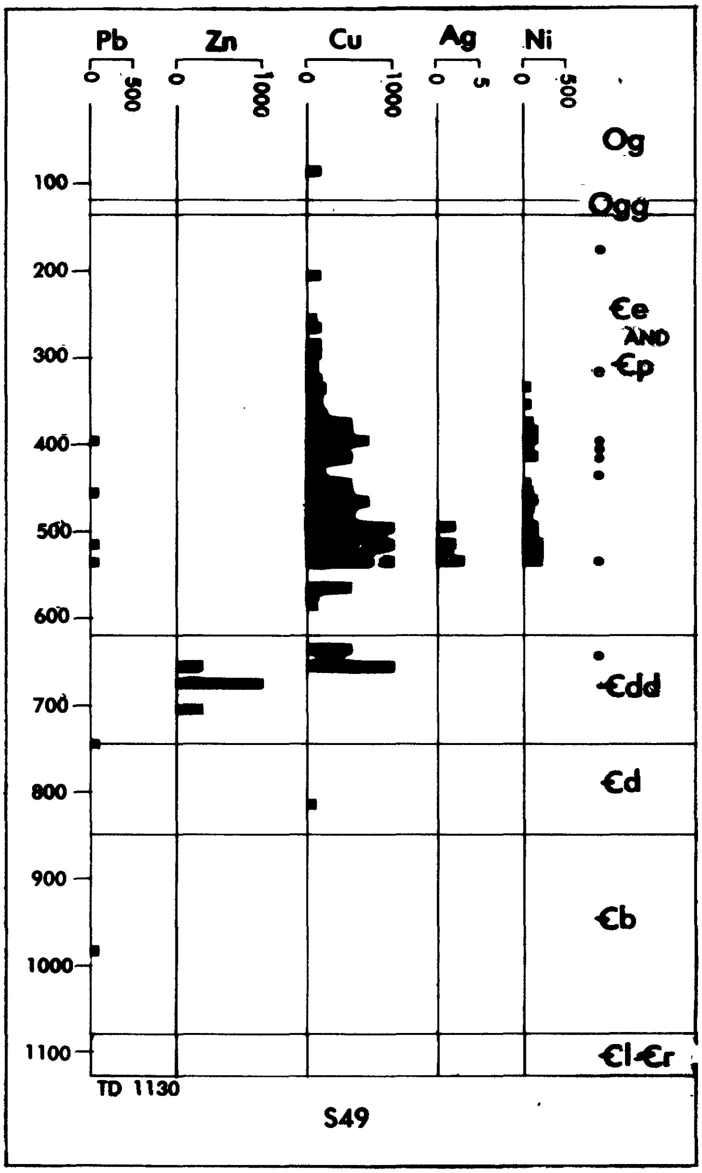
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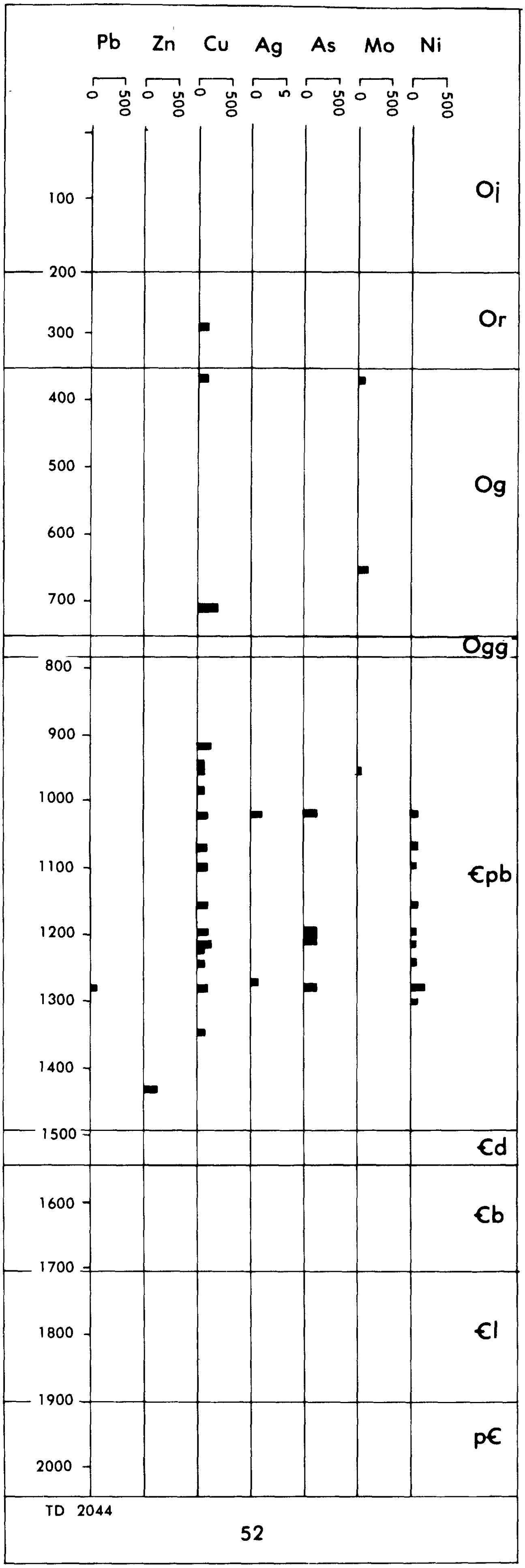
S49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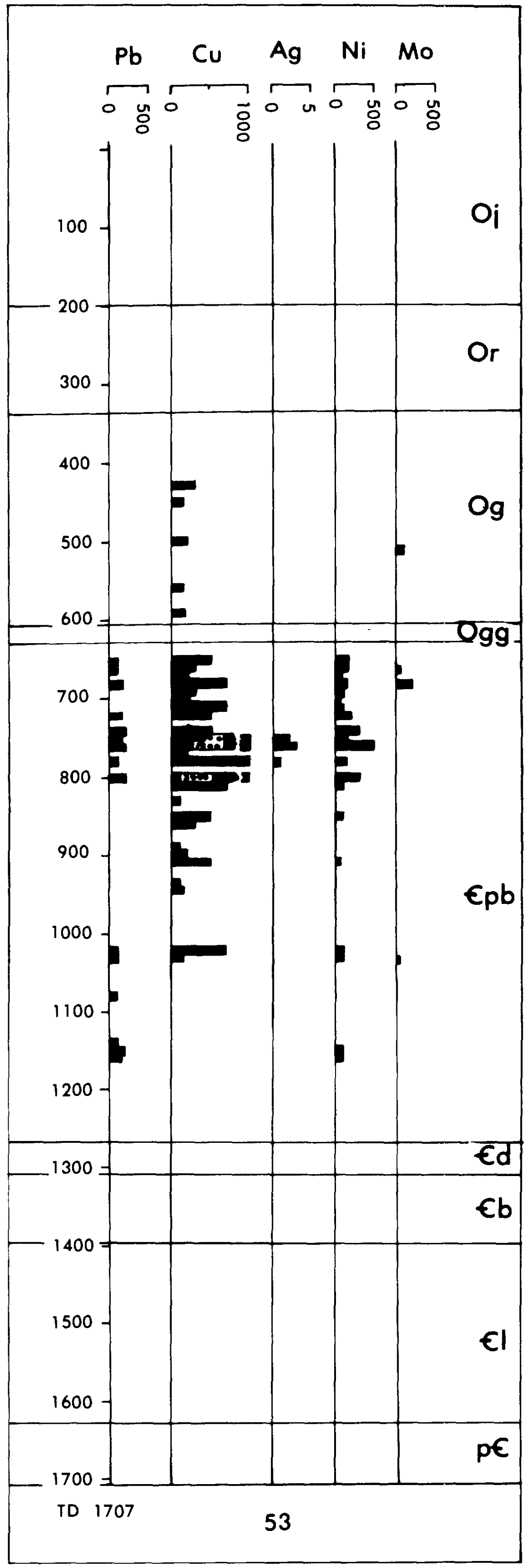
52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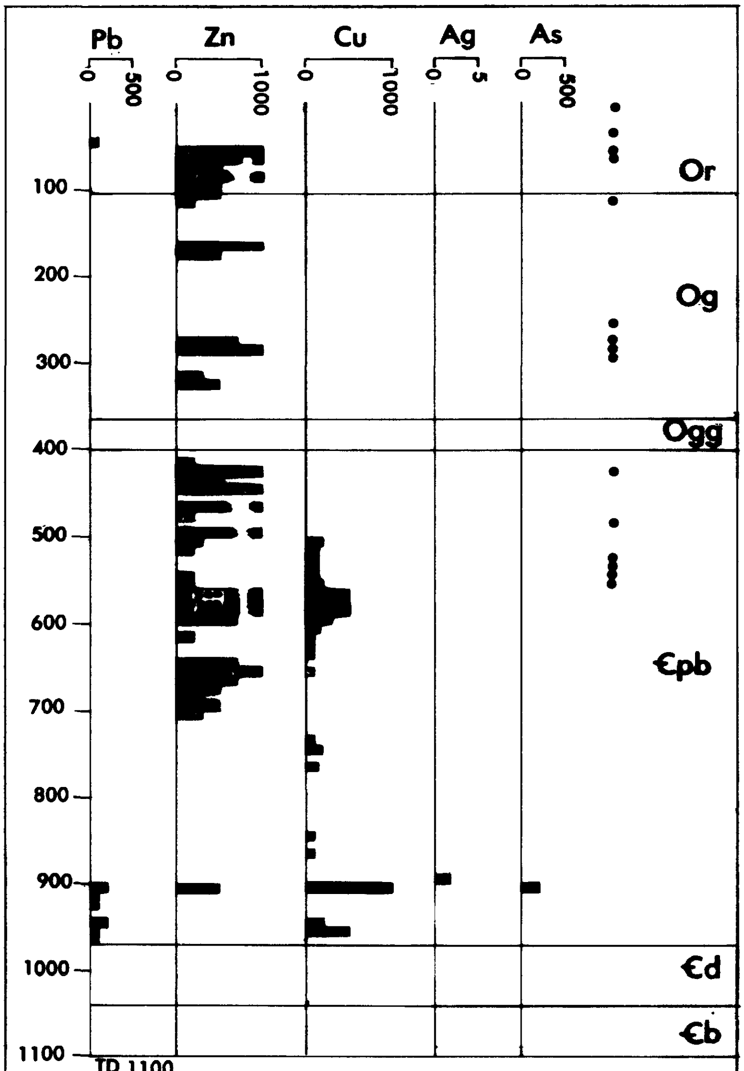
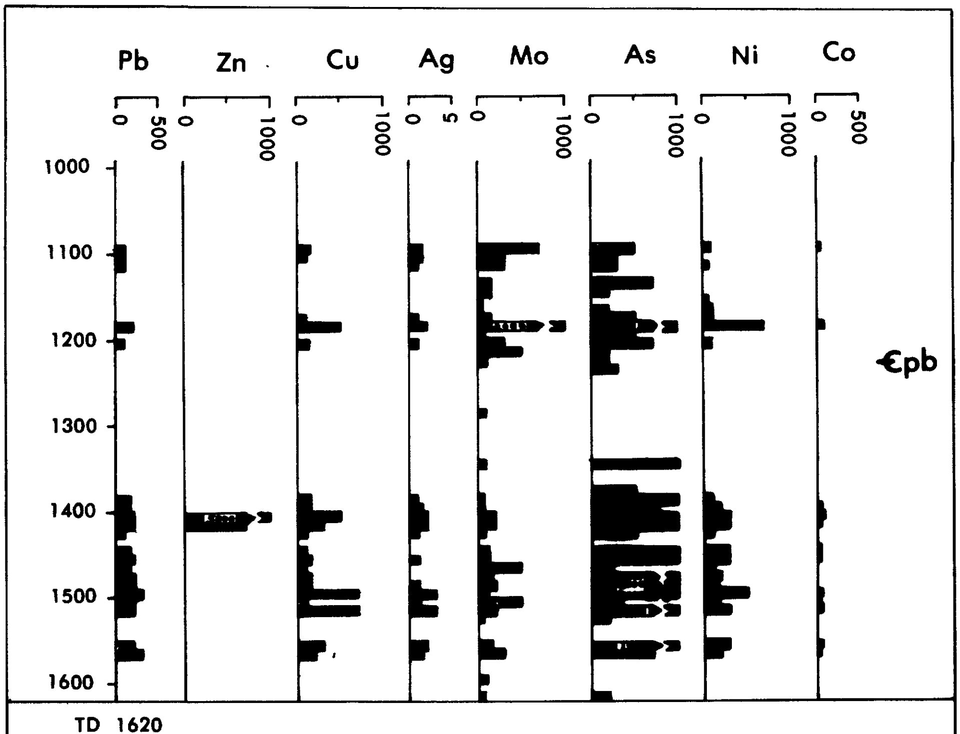
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Oj
Or
Og
Ogg
€pb
€d
€b
€l
p€
TD 1707
53



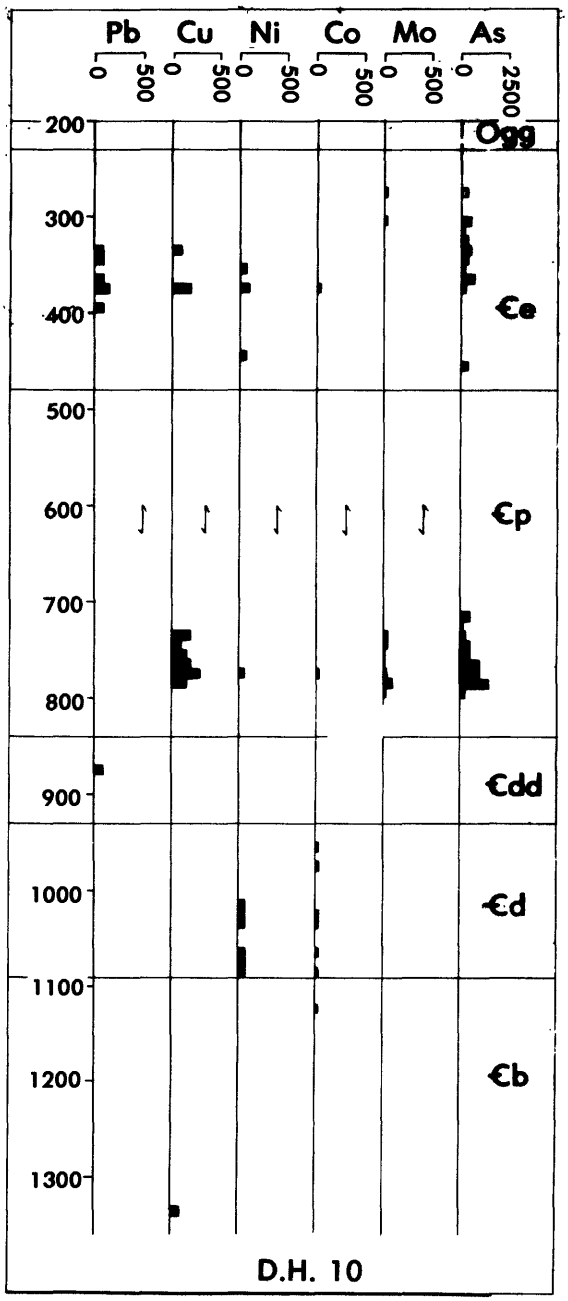
Pb
Zn
Cu
Ag
As
0 500
0 1000
0 1000
0 5
0 500
100
200
300
400
500
600
700
800
900
1000
1100
Or
Og
Ogg
€pb
€d
€b
TD 1100

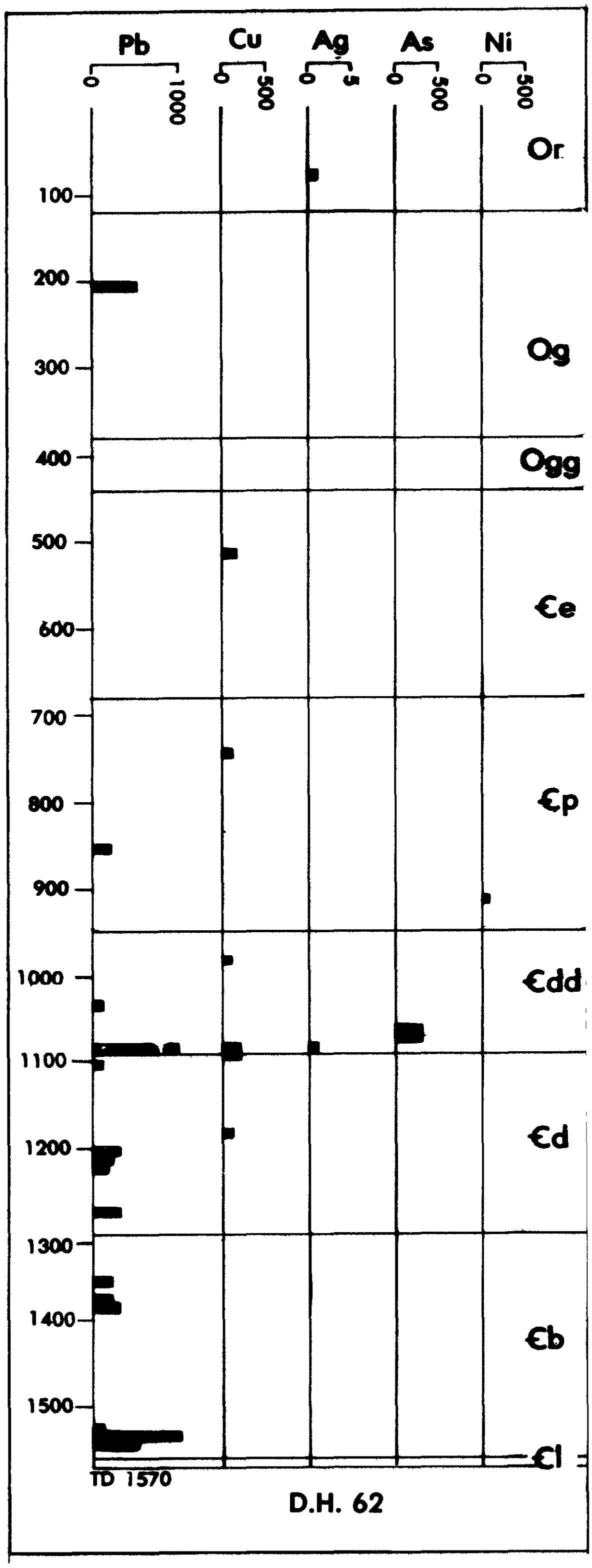
S51

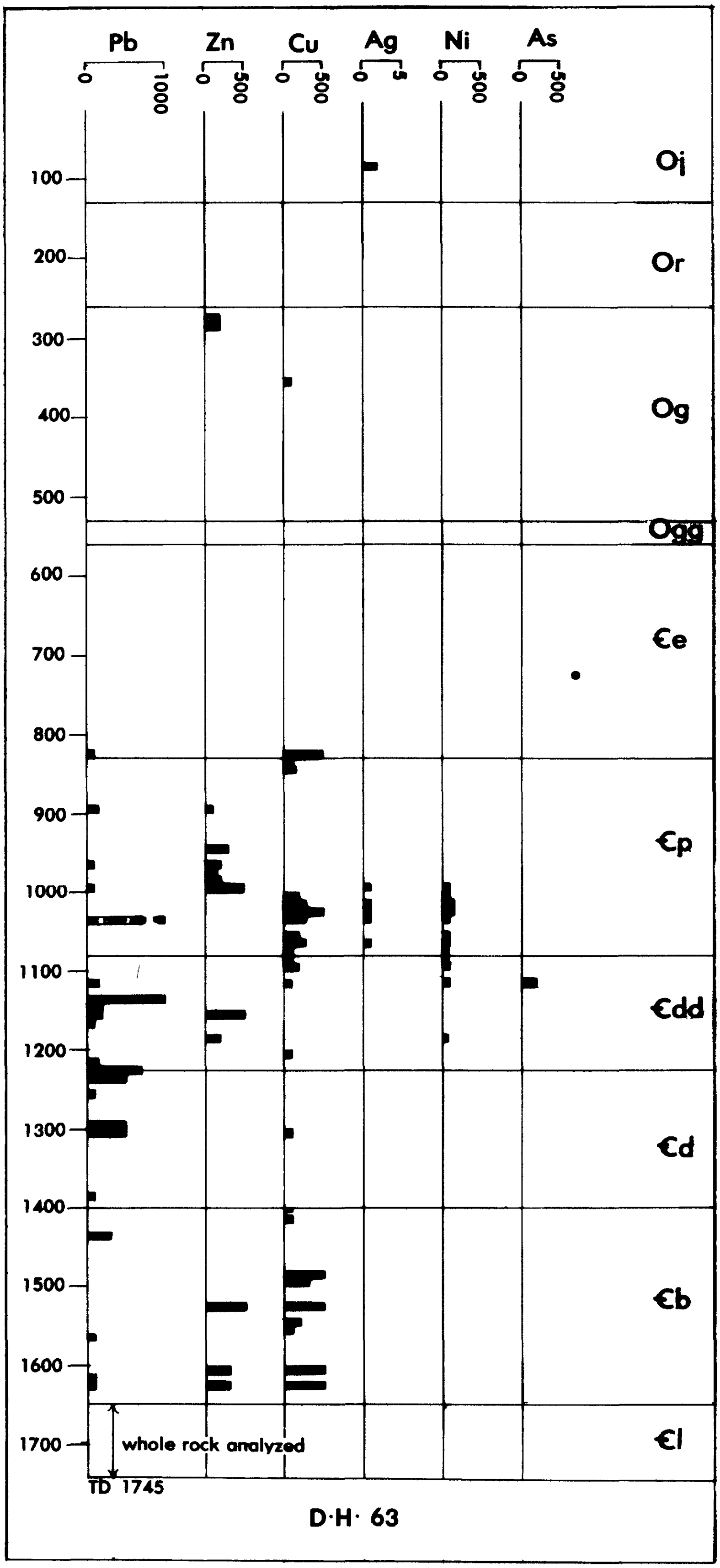


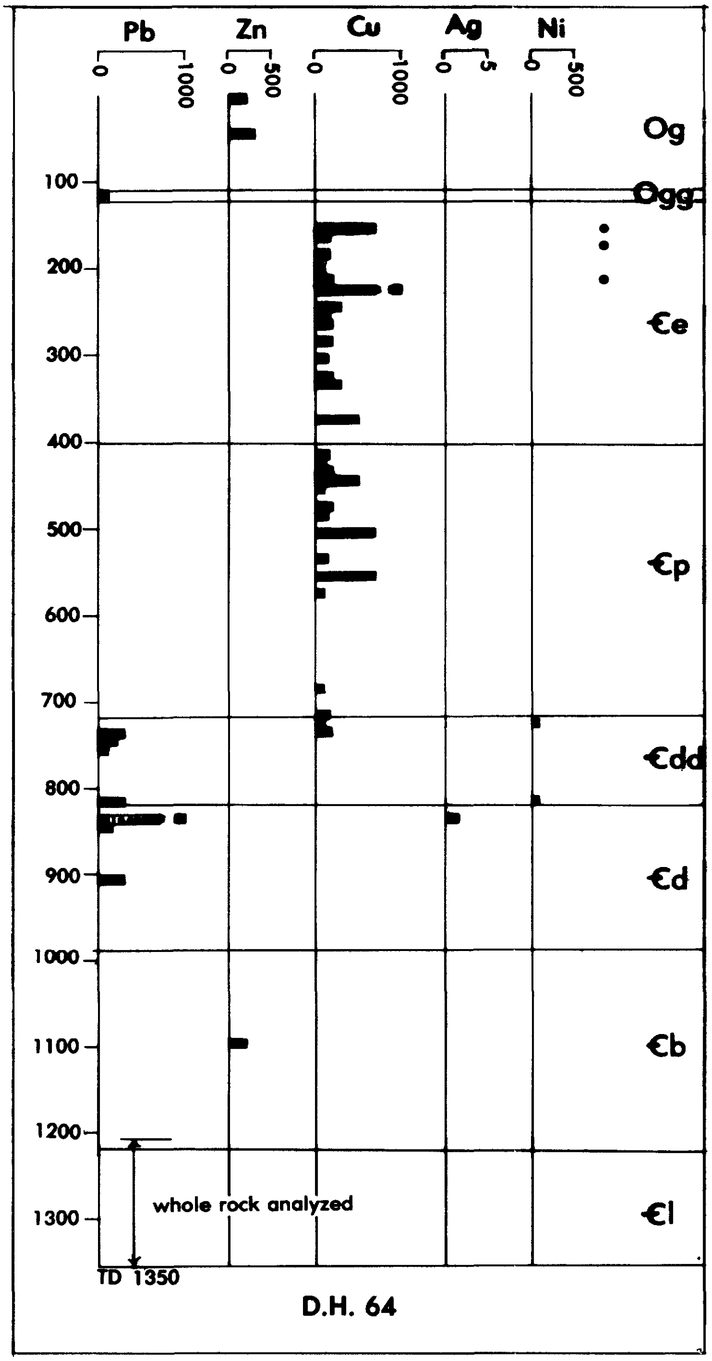
Pb
Zn
Cu
Ag
Mo
As
Ni
Co
0 500
0 1000
0 1000
0 5
0 1000
0 1000
0 1000
0 500
1000
1100
1200
1300
1400
1500
1600
€pb
TD 1620

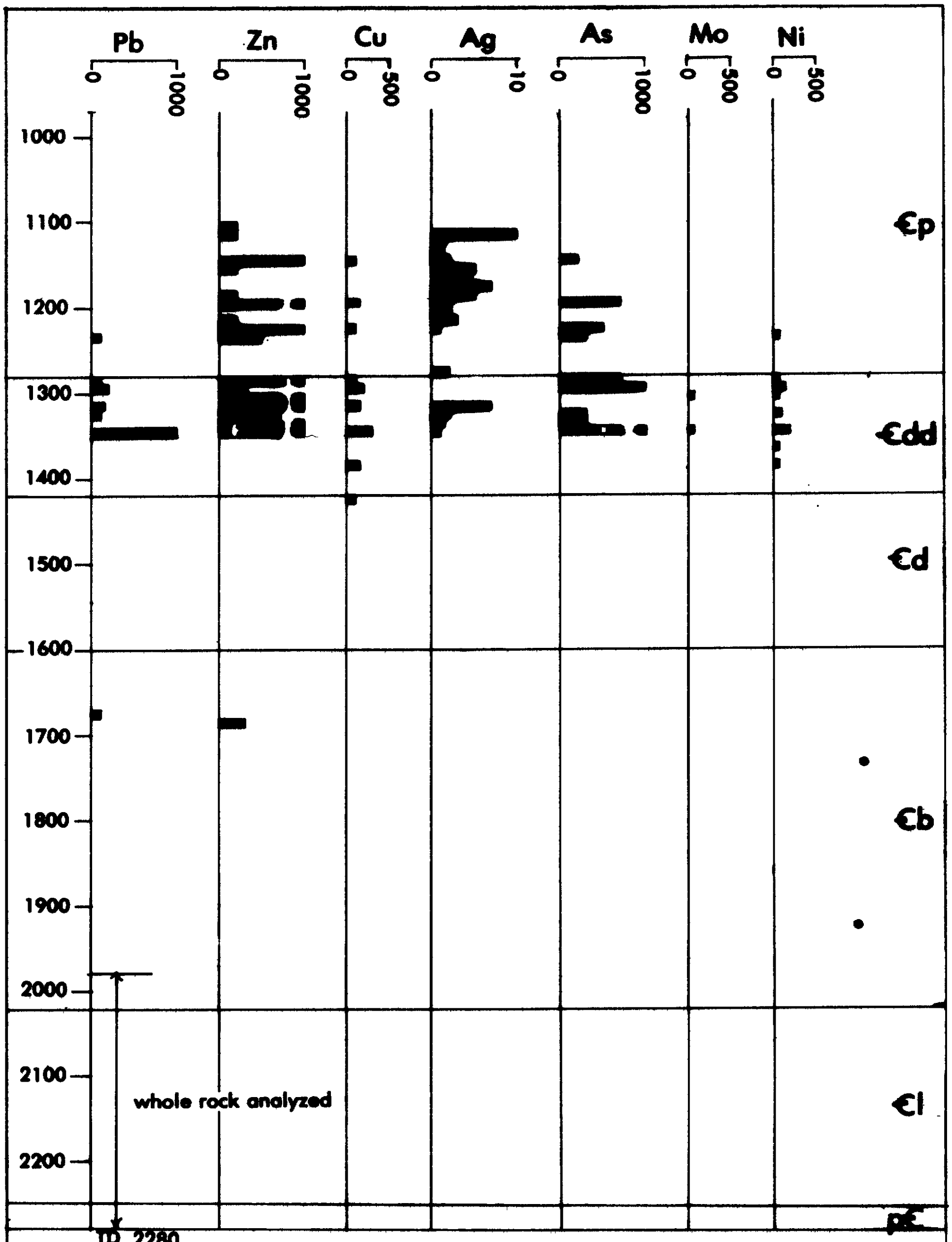
54


Pb Cu Ni Co Mo As
0 500 0 500 0 500 0 500 0 500 0 2500
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Ogg
Ce
Cp
Cdd
Cd
Cb
D.H. 10


Pb Cu Ag As Ni
0 1000 0 500 0 5 0 500 0 500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Or
Og
Ogg
Ce
Cp
Cdd
Cd
Cb
Cl
TD 1570
D.H. 62


Pb
Zn
Cu
Ag
Ni
As
0
1000
0
500
0
500
0
5
0
500
0
500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Oj
Or
Og
Ogg
Єe
Єp
Єdd
Єd
Єb
Єl
whole rock analyzed
TD 1745
D·H· 63

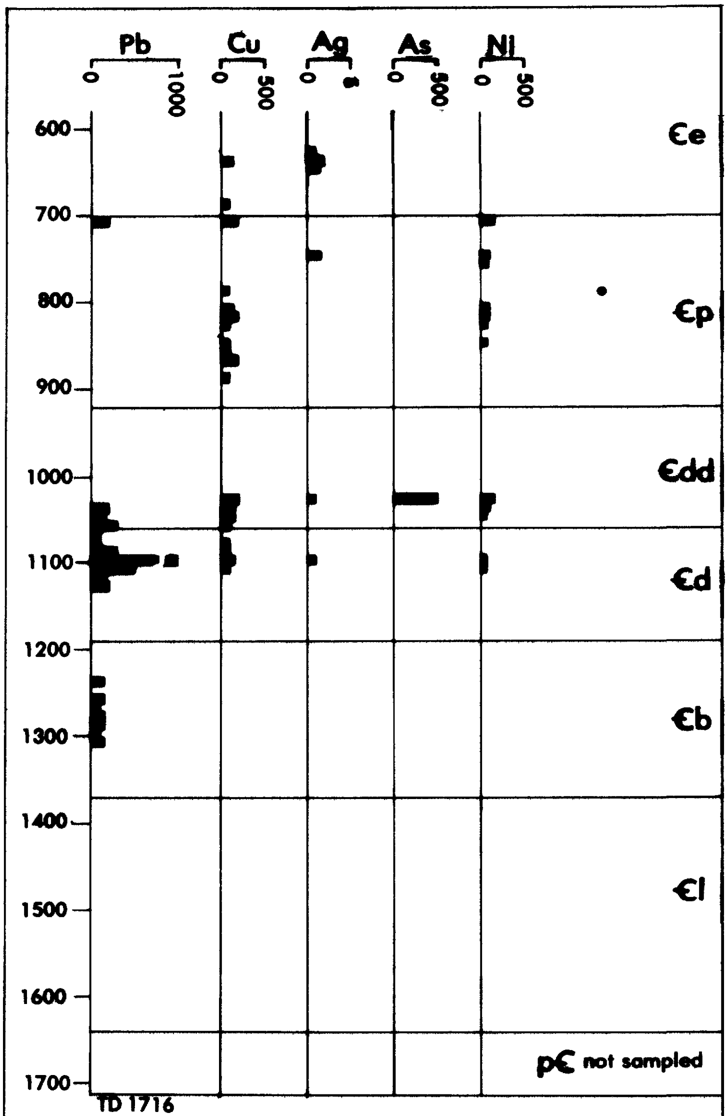

Pb
Zn
Cu
Ag
Ni
0
1000
0
500
0
1000
0
5
0
500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Og
Ogg
Єe
Єp
Єdd
Єd
Єb
Єl
whole rock analyzed
TD 1350
D.H. 64



Pb
Zn
Cu
Ag
As
Mo
Ni
0
1000
0
1000
0
500
0
10
0
1000
0
500
0
500
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
€p
€dd
€d
€b
€l
p€
whole rock analyzed
TD 2280

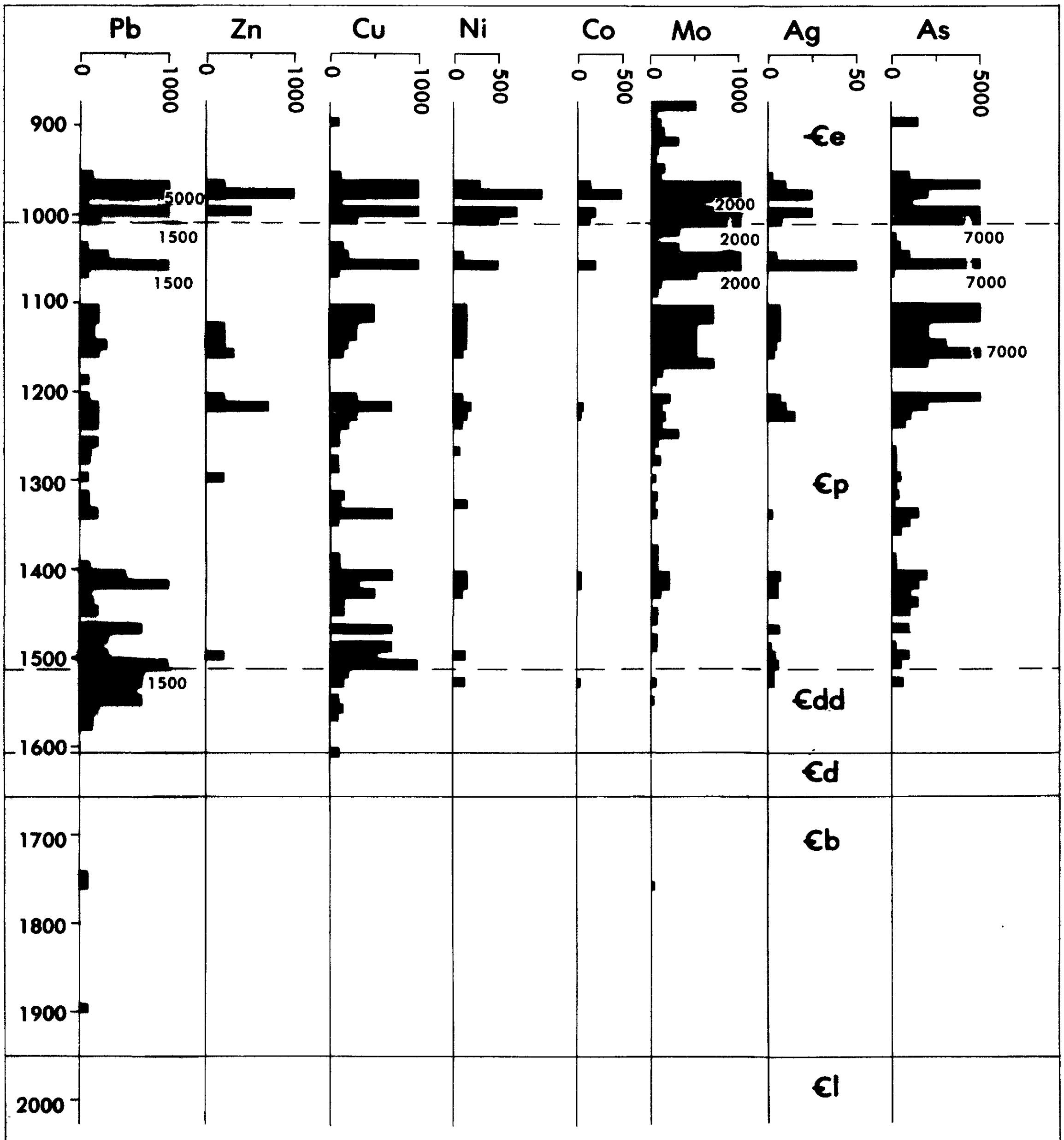
D.H. 72


Pb
Cu
Ni
Mo
Ag
As
0
1000
0
1000
0
500
0
1000
0
25
0
5000
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
1500
7000
1500
3000
€e
€p
€dd
€b
€l
p€
D.H. 77



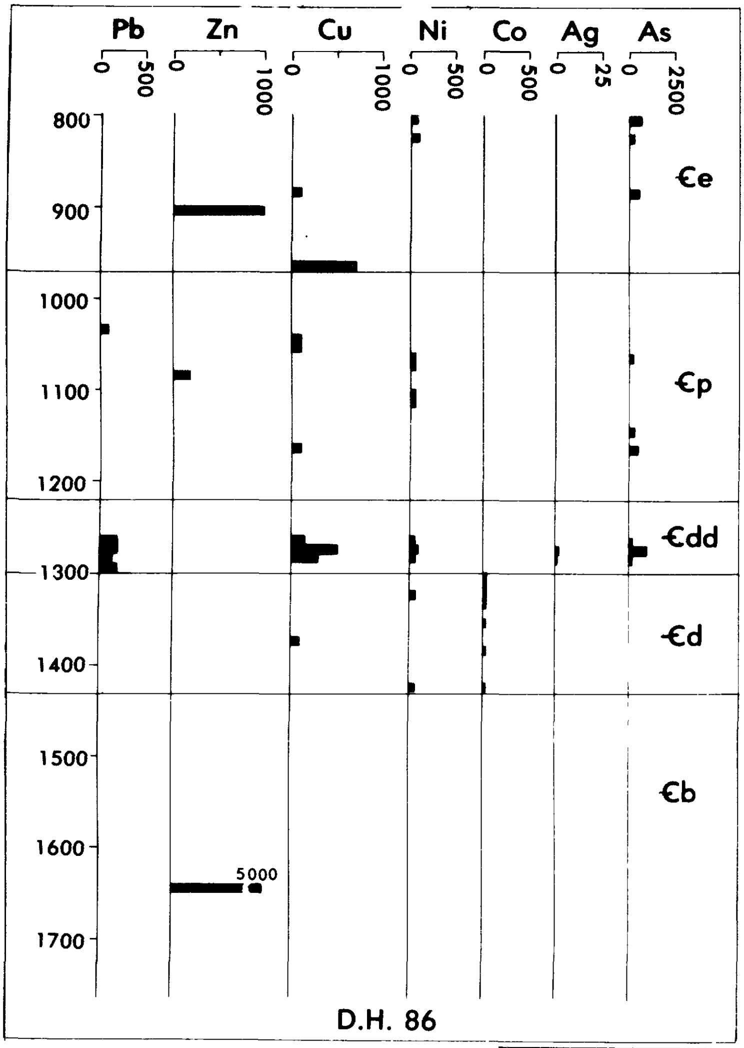
Pb
0
1000
Cu
0
500
Ag
0
As
0
500
Ni
0
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
TD 1716
€e
€p
€dd
€d
€b
€l
p€ not sampled

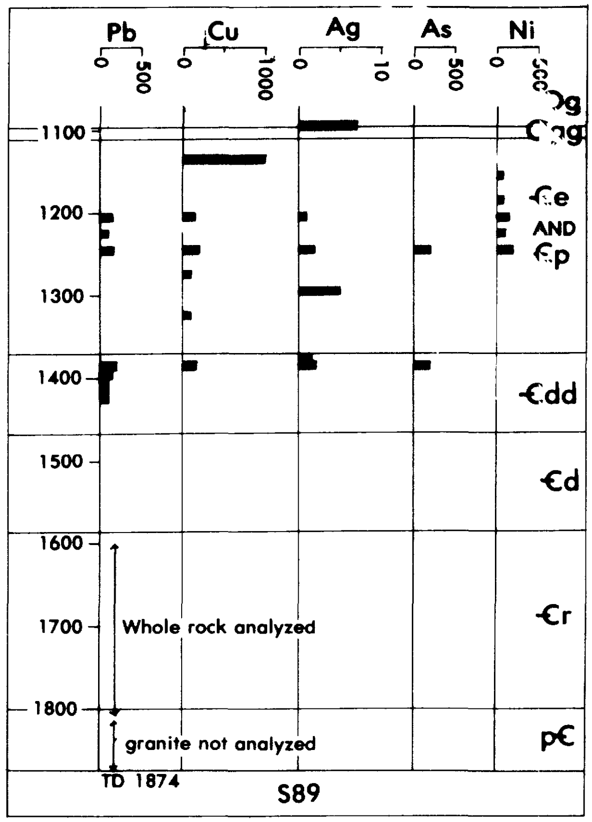
D.H. 81

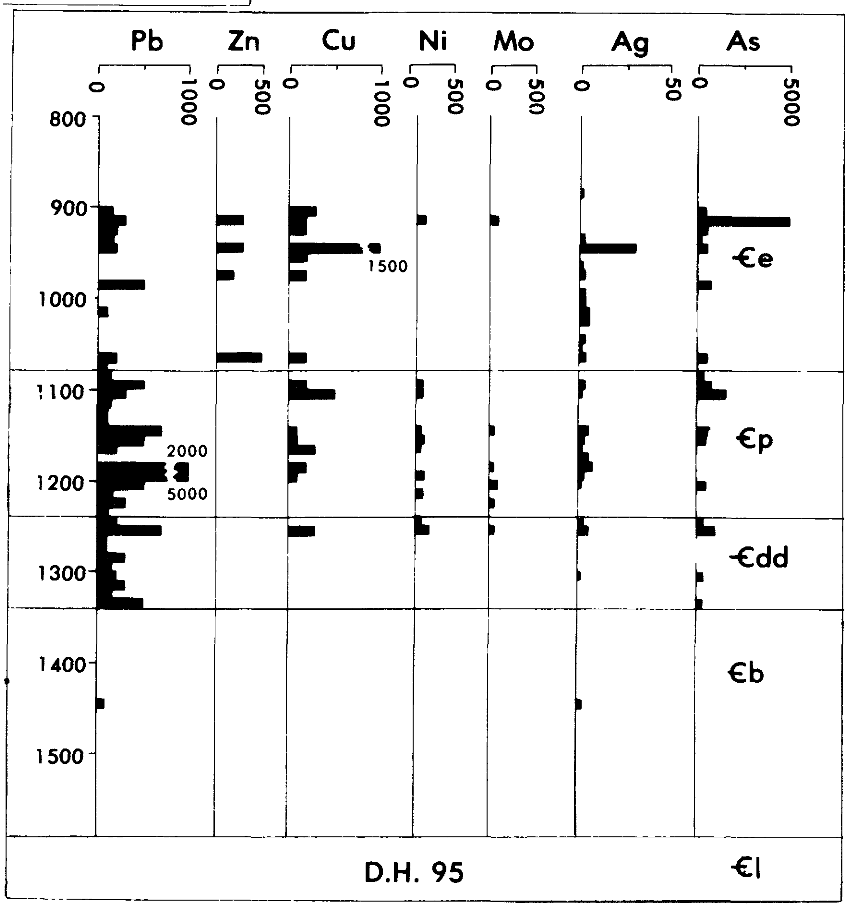


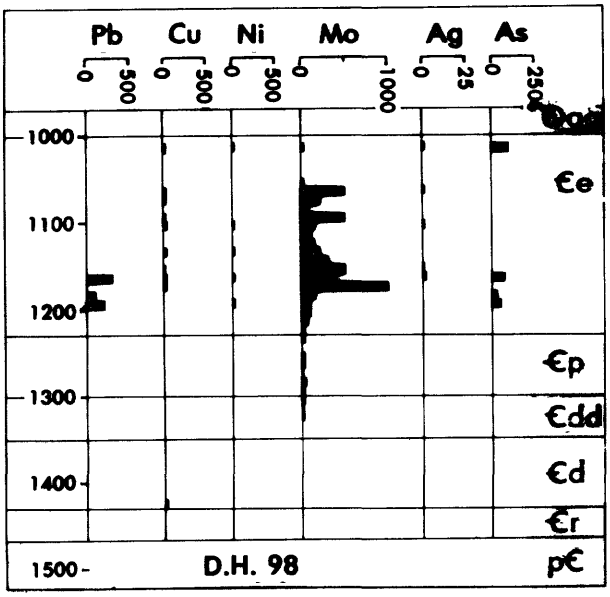
Pb
Zn
Cu
Ni
Co
Mo
Ag
As
0
1000
0
1000
0
1000
0
500
0
500
0
1000
0
50
0
5000
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
5000
1500
1500
1500
2000
2000
2000
7000
7000
7000
€e
€p
€dd
€d
€b
€l

D.H. 85

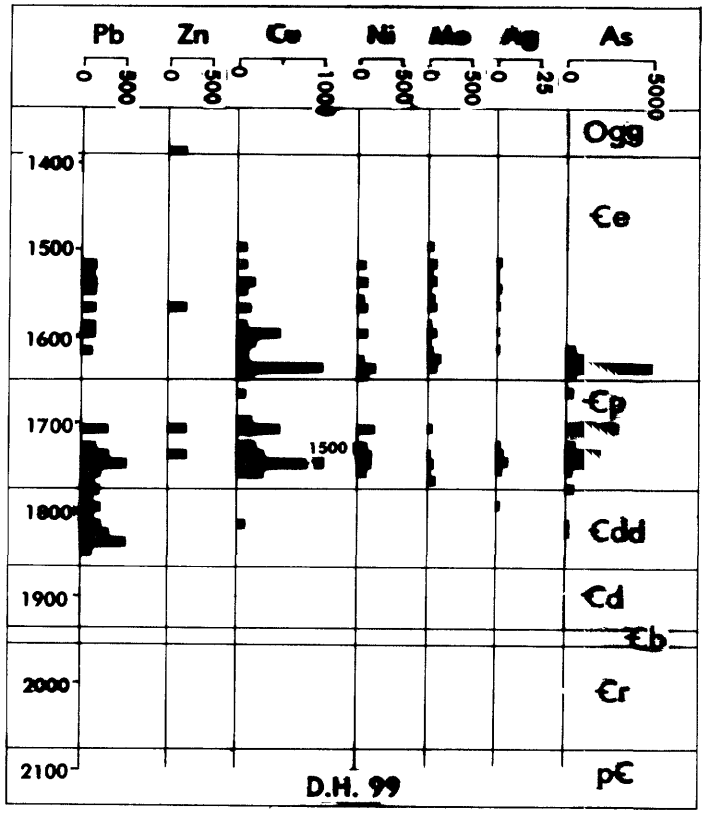

Pb Zn Cu Ni Co Ag As
0 500
0 1000
0 1000
0 500
0 500
0 25
0 2500
800
900
1000
1100
1200
1300
1400
1500
1600
1700
€e
€p
€dd
€d
€b
5000
D.H. 86


Pb Cu Ag As Ni
0 500
0 1000
0 10
0 500
1100
1200
1300
1400
1500
1600
1700
1800
€e
AND
€p
€dd
€d
€r
p€
Whole rock analyzed
granite not analyzed
TD 1874
S89

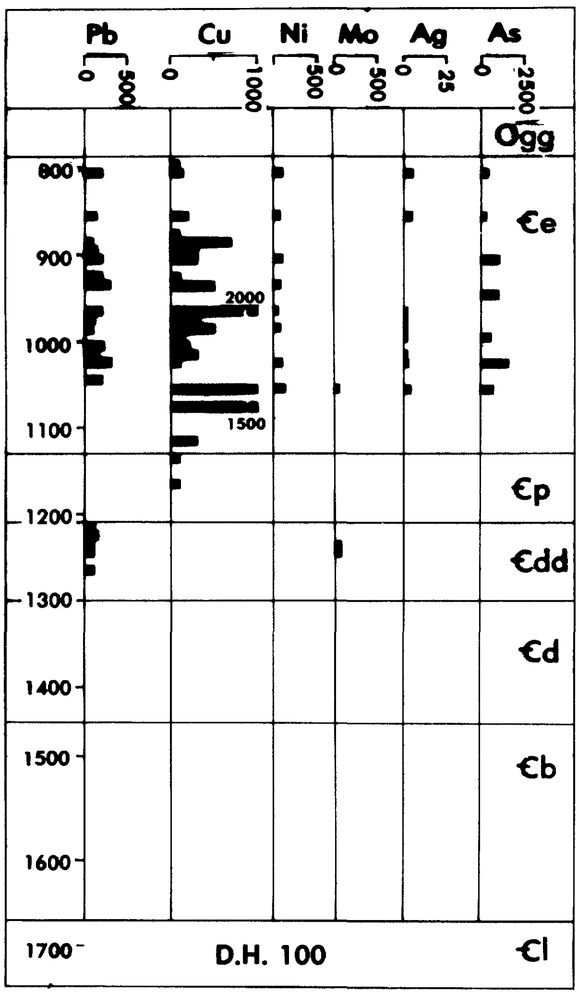

Pb Zn Cu Ni Mo Ag As
0 1000
0 500
0 1000
0 500
0 500
0 50
0 5000
800
900
1000
1100
1200
1300
1400
1500
1500
2000
5000
€e
€p
€dd
€b
€l
D.H. 95



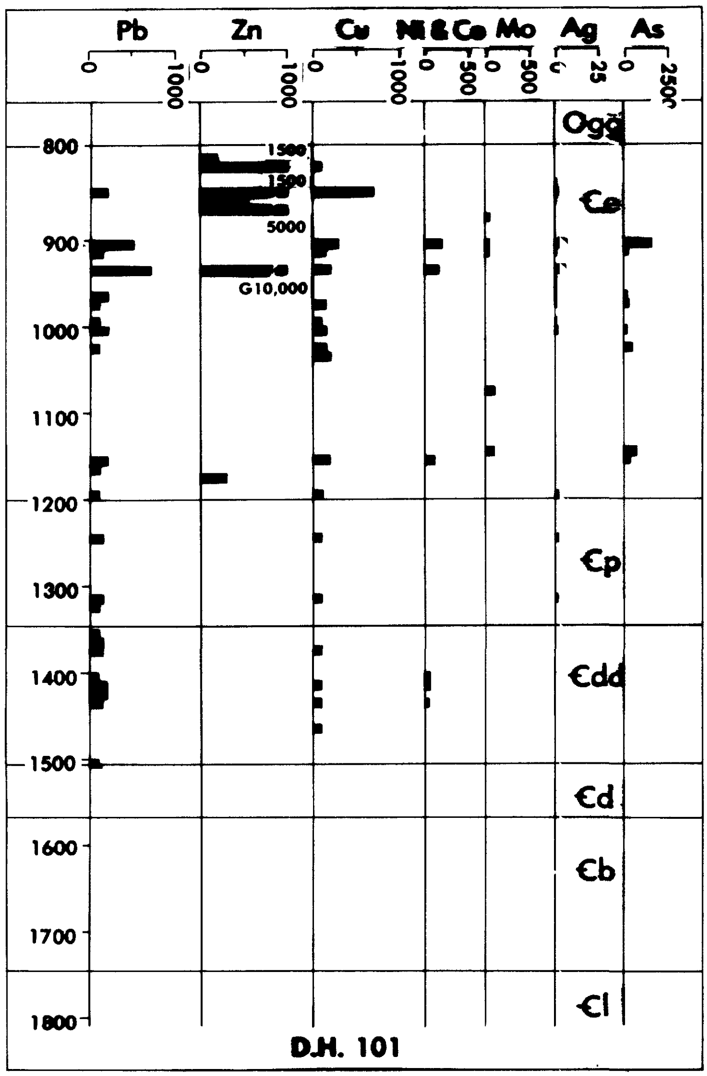
Pb
Cu
Ni
Mo
Ag
As
0 500
0 500
0 500
0 1000
0 25
0 2500
Ogg
€e
€p
€dd
€d
€r
p€
1000
1100
1200
1300
1400
1500
D.H. 98



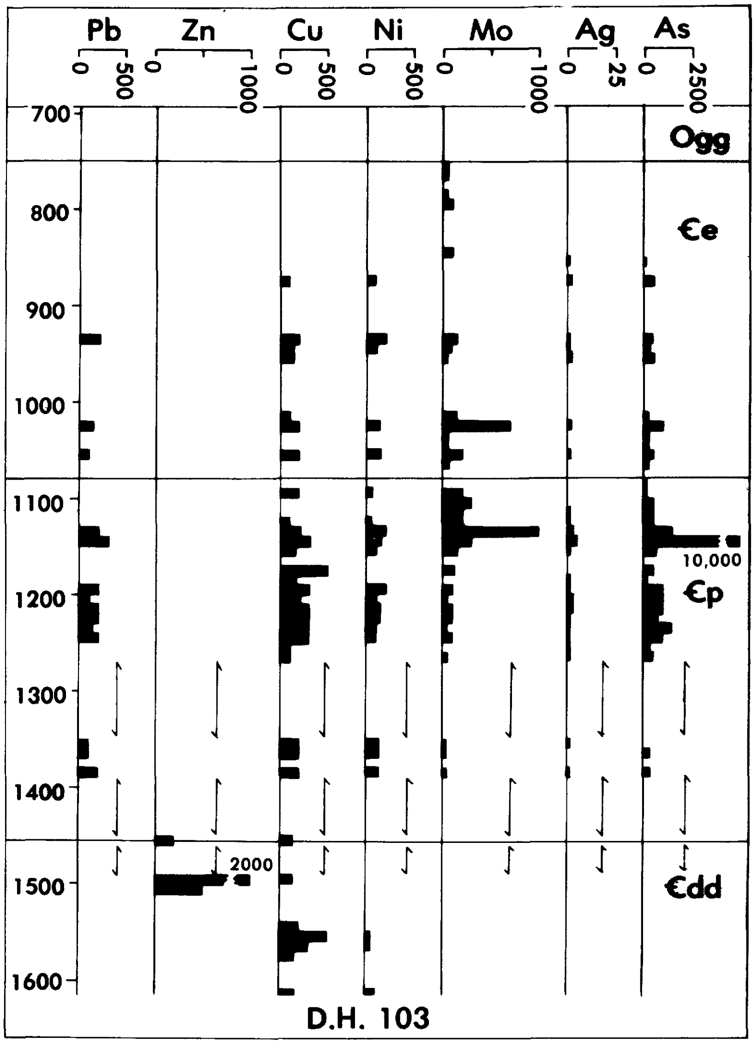
Pb
Zn
Cu
Ni
Mo
Ag
As
0 500
0 500
0 1000
0 500
0 500
0 25
0 5000
Ogg
€e
€p
€dd
€d
€b
€r
p€
1500
1400
1500
1600
1700
1800
1900
2000
2100
D.H. 99

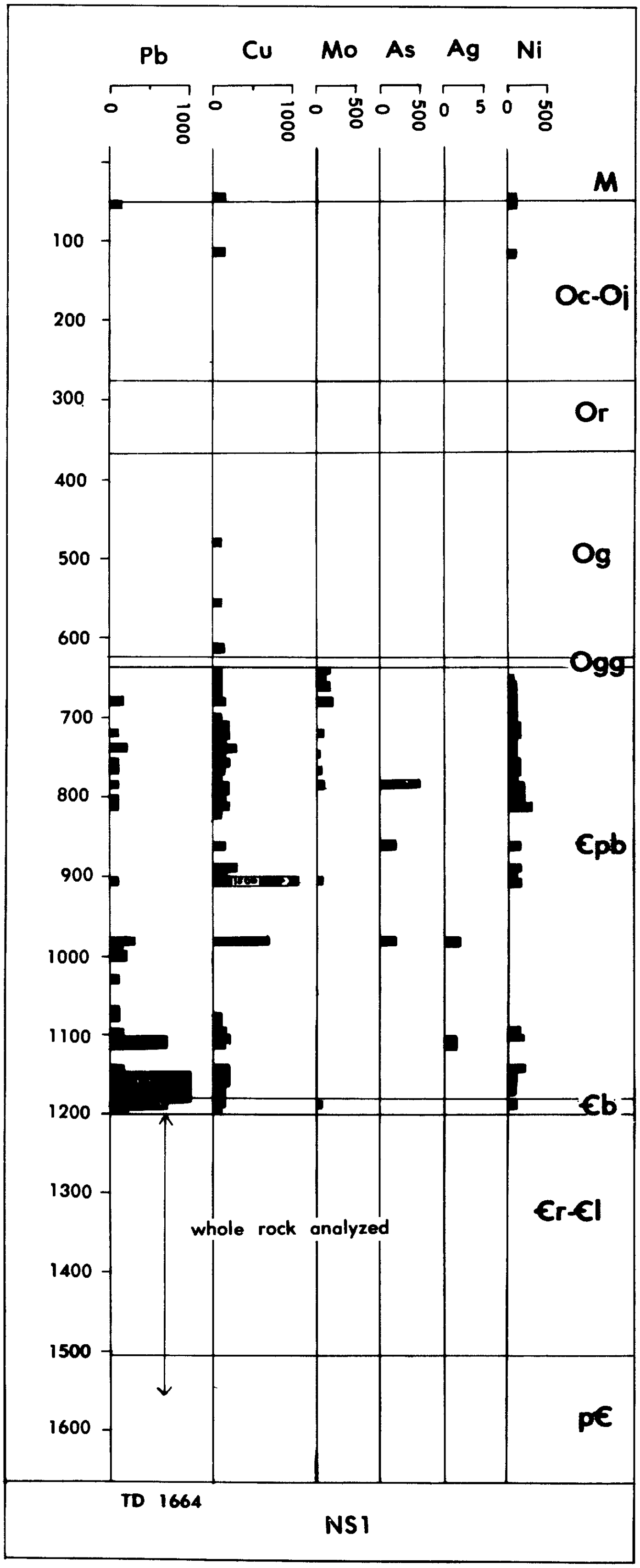


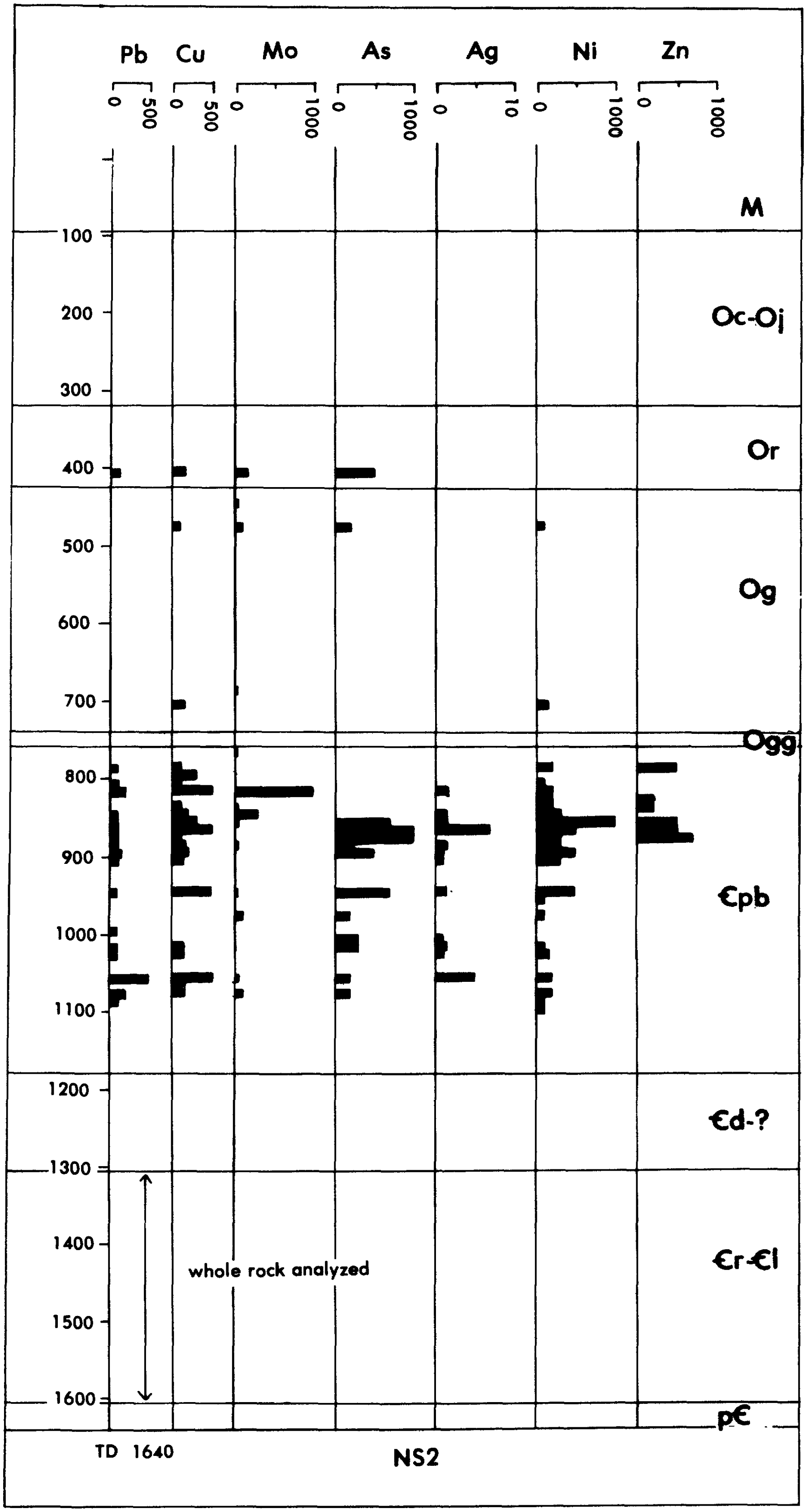
Pb
Cu
Ni
Mo
Ag
As
0 500
0 1000
0 500
0 500
0 25
0 2500
Ogg
€e
€p
€dd
€d
€b
€l
2000
1500
800
900
1000
1100
1200
1300
1400
1500
1600
1700
D.H. 100

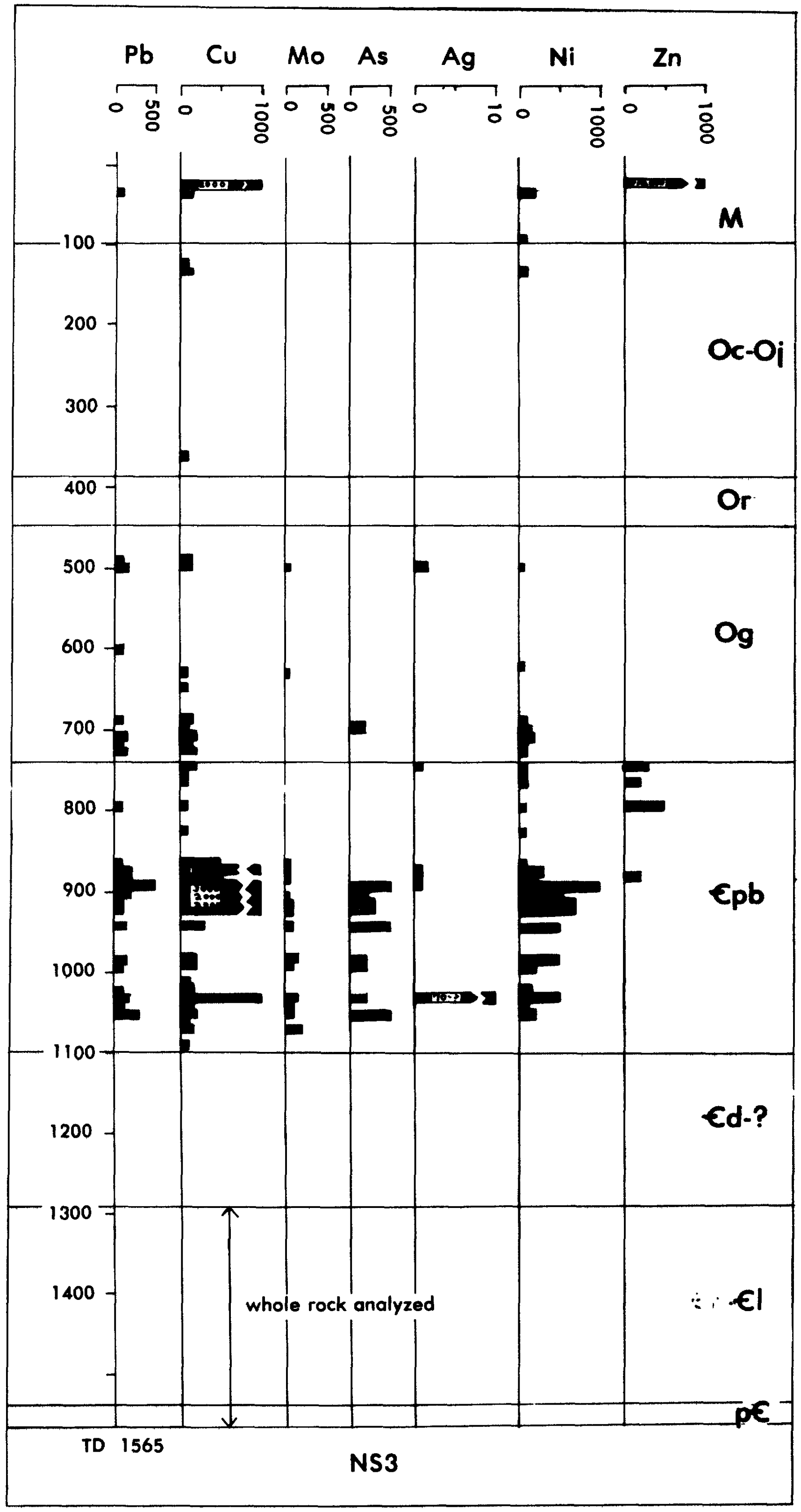


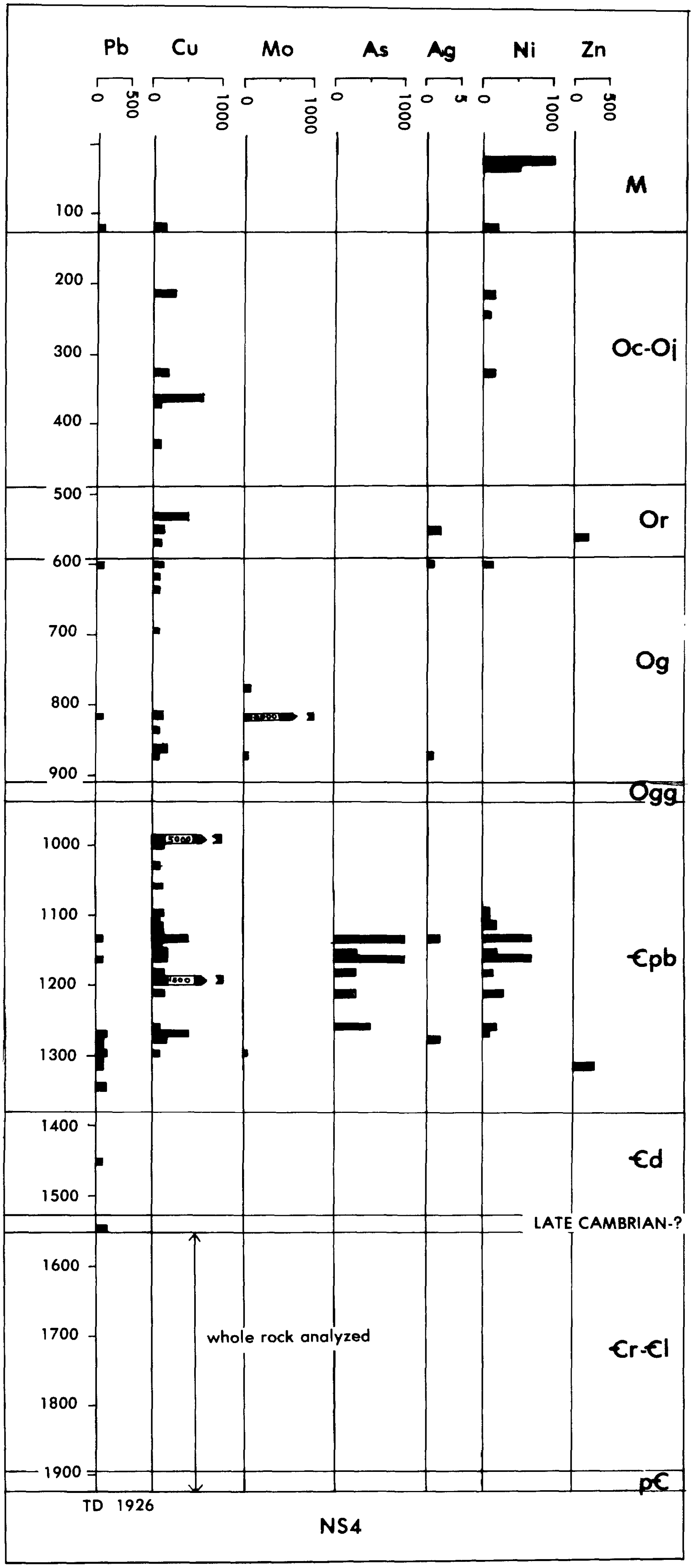
Pb
Zn
Cu
Ni & Co
Mo
Ag
As
0 1000
0 1000
0 1000
0 500
0 500
0 25
0 2500
Ogg
€e
€p
€dd
€d
€b
€l
1500
1500
5000
G10,000
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
D.H. 101

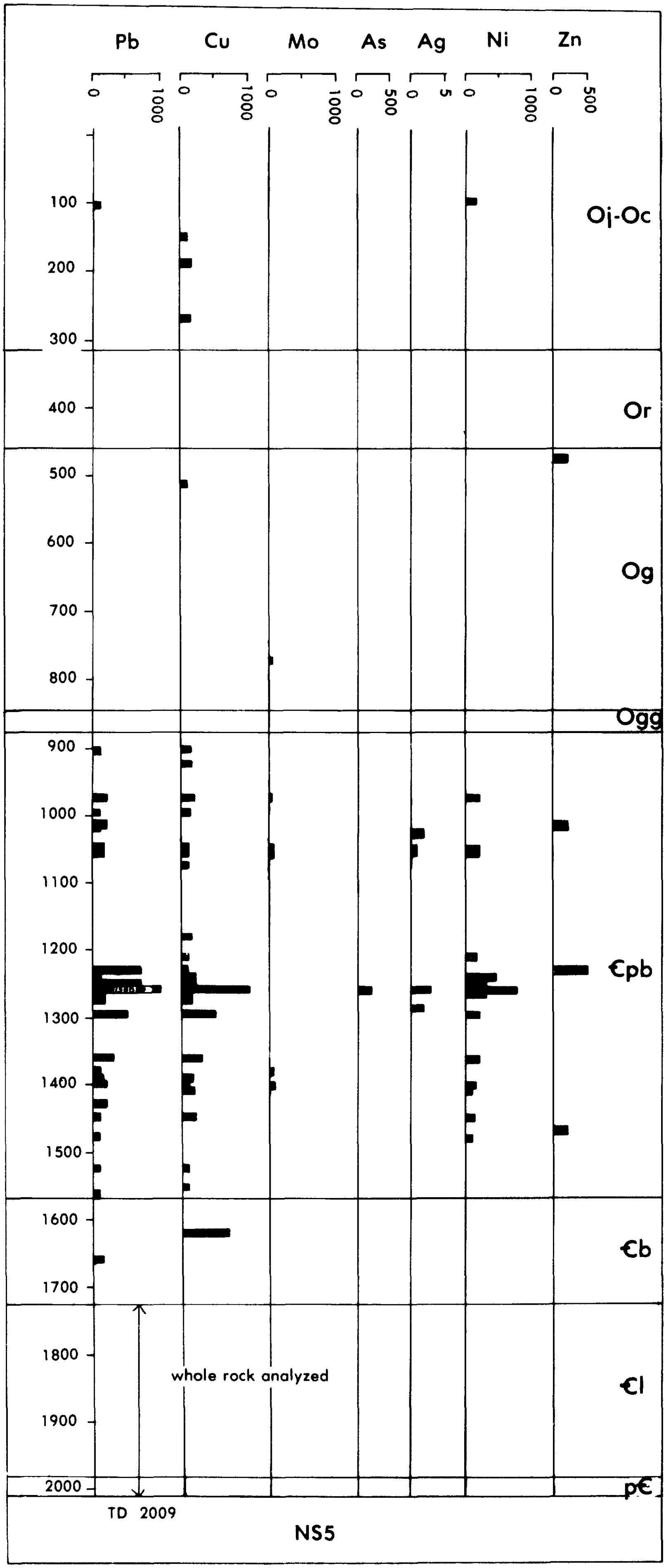

Pb
Zn
Cu
Ni
Mo
Ag
As
0
500
1000
25
2500
700
800
900
1000
1100
1200
1300
1400
1500
1600
Ogg
€e
€p
€dd
10,000
2000
D.H. 103


Pb
Cu
Mo
As
Ag
Ni
0
1000
0
1000
0
500
0
500
0
5
0
500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
M
Oc-Oj
Or
Og
Ogg
€pb
€b
€r-€l
p€
whole rock analyzed
TD 1664
NS1

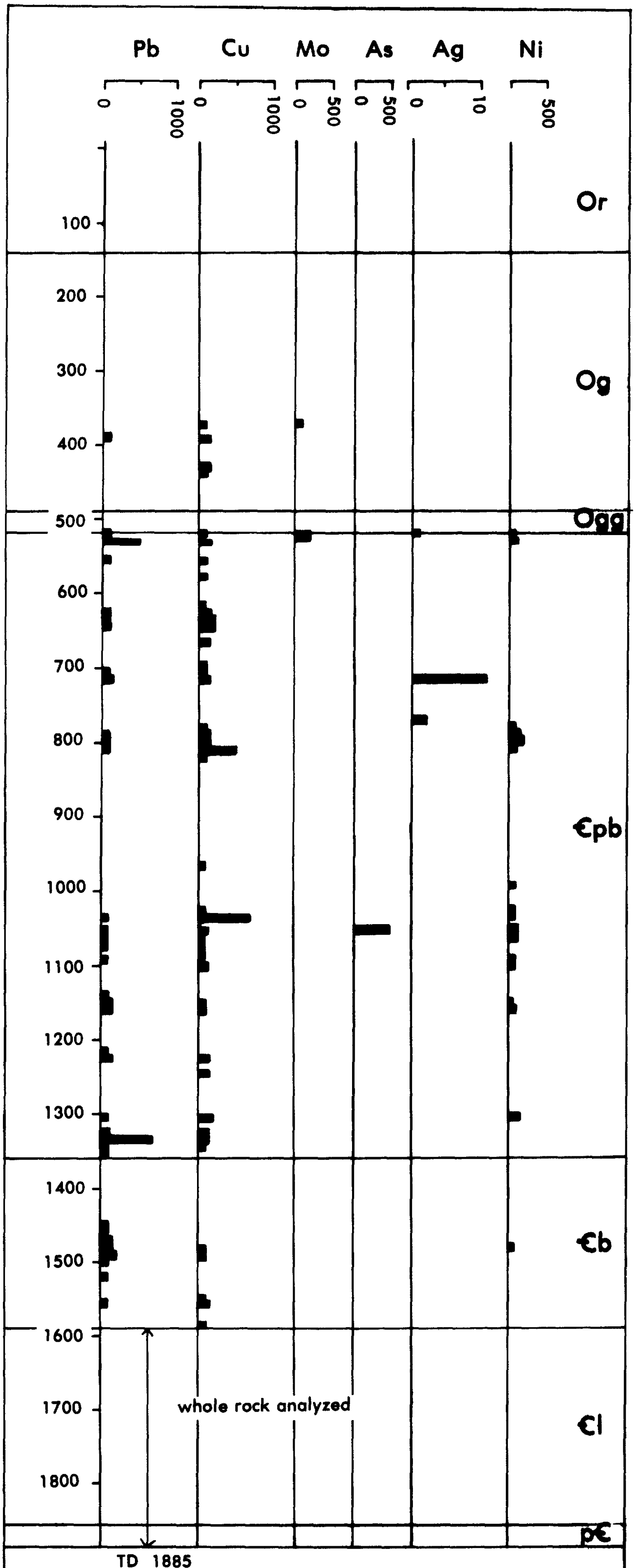

Pb
Cu
Mo
As
Ag
Ni
Zn
0
500
0
500
0
1000
0
1000
0
10
0
1000
0
1000
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
M
Oc-Oj
Or
Og
Ogg
€pb
€d-?
€r-€l
p€
whole rock analyzed
TD 1640
NS2


Pb
Cu
Mo
As
Ag
Ni
Zn
0 500
0 1000
0 500
0 500
0 10
0 1000
0 1000
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
M
Oc-Oj
Or
Og
€pb
€d-?
€l
p€
whole rock analyzed
TD 1565
NS3


Pb
Cu
Mo
As
Ag
Ni
Zn
0 500
0 1000
0 1000
0 1000
0 5
0 1000
0 500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
M
Oc-Oj
Or
Og
Ogg
€pb
€d
LATE CAMBRIAN-?
whole rock analyzed
€r-€l
p€
TD 1926
NS4



Pb
Cu
Mo
As
Ag
Ni
Zn
0 1000
0 1000
0 1000
0 500
0 5
0 1000
0 500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Oj-Oc
Or
Og
Ogg
€pb
€b
€l
p€
whole rock analyzed
TD 2009
NS5


Pb
Cu
Mo
As
Ag
Ni
0
1000
0
1000
0
500
0
500
0
10
500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Or
Og
Ogg
€pb
€b
€l
p€
whole rock analyzed
TD 1885

NS6