CHAPTER 4

ANALYSIS OF GEOCHEMICAL DATA

4.1 Statistical Treatment of Geochemical Data

The overall frequency distribution of concentrations of Cr, Ni, Co and Cu are treated statistically for stream sediment samples and soil samples. The concentrations of the elements which the values are higher than the mean values plus three standard deviations will be excluded primarily from the treatment. A total of 9 Cr, 5 Ni, and 11 Co in stream sediments and 38 Cr, 29 Ni, 41 Co, and 2 Cu in soil samples are eliminated from statistic computation. In stream sediment samples, 3 specimens of Cr, Ni and Co excluded are located in the same location, whereas 11 specimens of these elements in soil samples excluded are situated in the same area (Appendix C). Histogram for Cr, Ni, Co and Cu are constructed and cumulative percentile frequency curves are also plotted on the probability graphs. The lowermost class of histogram includes all values that are lower than the upper limit of the class, and the highest class includes all values that are higher than the lower limit of the class. Histogram showing concentration distributions of Cr, Ni, Co and Cu in stream sediments are presented in Fig.4.1, 4.5, 4.9, and 4.13 respectively, and in soils are in Fig. 4.3, 4.7, 4.11 and 4.15 respectively. Cr and Ni distributions indicate positively skewed. Co and Cu show lognormal distribution. The mean values, ranges, and standard deviations of stream sediment and stream bank soil samples for Cr, Ni, Co and Cu are tabulated in Table 4.1 and 4.2.

Table 4.1 Range, means, and standard deviation of stream sediment samples in ultramafic terrain, Wang Nam Yen, Prachin Buri (x After excluding highly anomalous values)

	Cr	Ni	Co	Cu
Range	6-12700	6-12000	0-1273	2-62
Mean^{x}	1368	1283	82	18
S.D.^{x}	1650	1588	65	7
N^{x}	318	322	316	327

Table 4.2 Range, means and standard deviation of soils samples in Ultramafic terrain, Wang Nam Yen, Prachin Buri (x After excluding highly anomalous values)

	Cr	Ni	Co	Cu
Range	6-22570	6-24000	0-3515	6-62
Mean^{x}	1382	1358	95	22
S.D.^{x}	1833	1902	85	9
N^{x}	616	625	613	652

4.2 Determination of Threshold Values in Geochemical Data by Probability Graphical Representation.

Threshold value or the upper limit of normal background fluctuation is the term applied to a value that distinguishes an upper or anomalous data set from a lower or background set (Sinclair, 1974). For mineral exploration, various data of geochemical nature and anomalous values are related to mineralized rocks. Consequently, the choice of a threshold value has considerable importance in directing exploration to specific anomalous sample sites where the chance of discovery of mineral deposit are greatly enhanced. The selection of the threshold values can be treated in a various ways. Probability graphical method is the one efficiency. The advantages of probability plots are worth noting here: the parameters of normal and lognormal population can be estimated rapidly and with adequate accuracy for most sets of geochemical data, several data sets can be represented on a single graph and can be compared visually for rapid recognition of similarities or differences, and important additional advantage is the ability to partition polymodal distributions into their individual populations. The general procedure for graphical method are summarized as follows: the percentages are cumulated from high to low values with the data percent cumulated at the class boundary, and cumulated frequencies are plotted against the lower class limit on the appropriate graph paper (Lepeltier, 1969). A series of points will be obtained. Assuming normally or lognormally distributed data, the cumulative plot either approximates a single line (single population) or contains significant breaks in the pattern resulting in a segmented plot (mixed population). Straight segments in the latter instance may be difficult to draw;therefore,Sinclair (1974) suggest smoothing the plots with a French curve. In the case of a single population where there may be insufficient anomalous values to cause a significant deviation to the plot, the resulting line would represent background data. Thus, the ppm values for $\bar{X}$, $\bar{X}$+S, $\bar{X}$+2S, $\bar{X}$+3S can be read from the ordinate corresponding to the 50, 15.87, 2.28 and 0.13 percentile respectively assuming a reverse cumulative had been done (Chand, 1980). If the mixed populations are indicated on the total plot, then the plot must be partitioned to exact individual population from a polymodal distribution. Inflection point or change in direction of curvature on the probability curve are used to identify these populations or estimate of their population

4.2.1 Chromium in Stream Sediments and Soils, Wang Nam Yen, Prachin Buri

The geochemical data of 318 stream sediments, and 616 B-horizon soils taken from stream banks were analysed statistically for chromium by throwing out the high erratic values which are considered to be of significant anomalous values. The chromium analyses are shown as prabability plot in Fig.4.2 and 4.4. A smooth curve drawn through the data point has the form of a bimodal density distribution. Inflection points of curve are at the 20 and 22 cumulative percentiles for stream sediments, and soils, respectively. The curve was partitioned using the method described by Sinclair (1974) to obtain population A and B whose estimated parameters are presented in Table 4.3 and 4.4. Validity of the two population models were checked by combining them at various ordinate levels. The checking procedure involves the calculation of ideal combination of the partitioned populations using the expression of :

$$Pm = FaPa + FbPb$$

Where Pm is the probability of the "mixture"; Pa and Pb are cumulative probabilities of populations A and B read from the graph at a specified ordinate level; Fa and Fb are the proportions of population A and B. The check points are shown as open triangles on the figure and are seen to coincide with the real data curve. In this case, some high values are associated with small chromite mineralizations related to ultramafic rocks, and it seems reasonable to interpret the two population as anomalous and back ground.

Two arbitrary threshold values can be determined readily from the graph at the 2.0 cumulative percentile of the B population and 98 cumulative percentile of population A. These percentiles coincide with

Table 4.3 Estimated parameters of partitioned population for Cr in stream sediments, Wang Nam Yen, Prachin Buri.

Population	Proportion %	Values in ppm Cr			
		b	b+s	b+2s	b-2s
A: anomalous	20	4100	5800	8400	2000
B: background	80	400	1100	3200	-
A + B	100				

Table 4.4 Estimated parameters of partitioned population for Cr in soils, Wang Nam Yen, Prachin Buri.

Population	Proportion %	Values in ppm Cr			
		b	b+s	b+2s	b-2s
A: anomalous	22	4200	6200	9800	1500
B: background	78	340	950	3000	-
A + B	100				

Table 4.5 Estimated threshold values for Cr in stream sediments and soils, Wang Nam Yen, Prachin Buri.

Threshold values (ppm)		Principal content of group
Stream sediment	soil	
		Almost exclusively population A
3200	3000	Combination of population A and B
2000	1500	Almost exclusively population B

3200 ppm and 2000 ppm Cr for stream sediments, 3000 ppm and 1500 ppm Cr for soil samples. Hence, the data are divided into three groups: an upper group of predominantly anomalous values, a lower group of predominantly background values, and intermediated group containing both anomalous and background values. Consequently, anomalous values occur in only two ppm intervals to which priorities can be assigned for follow up exploration. Virtually all values above 2 cumulative percentile of B population are anomalous and have top priority. Second priority is assigned to the values between 98 cumulative percentile of A population and 2 cumulative percentile of B population as they contain values of intermediate range comprising both of populations A and B. Theoretically, individual values that lie between the two thresholds can not be assigned to either A or B population. In practice, some of the anomalous values in this central range can be recognized with a fair degree of certainly. Estimate parameters of threshold values of partitioned populations for chromium are presented in Table 4.5.

4.2.2 Nickel in Stream Sediments and Soils, Wang Nam Yen, Prachin Buri

A probability plot of 322 stream sediments and 625 B-horizon soils from stream banks for nickel analyses are shown in Fig.4.6 and 4.8. High erratic values are eliminated from statistical treatment. Both figures display smooth curves drawn through their individual data points,and each has the form of biomodal density distribution and has inflection points at 22 and 23 cumulative percentiles for stream sediments and soils respectively.

Table 4.6 Estimated parameters of partitioned population for Ni in stream sediments, Wang Nam Yen, Prachin Buri

Population	Proportion %	Values in ppm Ni			
		b	b+s	b+2s	b-2s
A: anomalous	22	3800	5800	9300	1500
B: background	78	400	1000	2800	-
A + B	100				

Table 4.7 Estimated parameters of partitioned population for Ni in soils, Wang Nam Yen, Prachin Buri

Population	Proportion %	Values in ppm Ni			
		b	b+s	b+2s	b-2s
A: anomalous	23	4100	6400	9800	1750
B: background	77	300	850	2750	-
A + B	100				

Table 4.8 Estimate threshold values for Ni in stream sediments and soils, Wang Nam Yen, Prachin Buri

Threshold values (ppm)		Principal content of group
Stream sediment	Soil	
		Almost exclusively population A
2800	2750	
		Combination of population A and B
1500	1750	
		Almost exclusively population B

The population can be estimated by partitioning the curve using the method described by Sinclair (1974), hence population A and B are obtained. The estimated parameters of population A and B are given in Table 4.6 and 4.7. Check points are shown in figures as open triangles almost coincide with the original data. Two arbitrary threshold values are determined readily from the graph at 2.0 and 98.0 cumulative percentile of B and A populations, respectively. The values of 2800 ppm and 1500 ppm for stream sediments and 2750 ppm and 1750 ppm for soil samples are coincident with these percentiles. The upper group above the upper threshold at 2.0 cumulative percentile of B population is anomalous and can be considered top priority for follow up work. The lower priority can be attached to values in the intermediate group. Estimated parameters of threshold values for Ni in stream sediments and soil are given in Table 4.8

4.2.3 Cobalt in Stream Sediments and Soils, Wang Nam Yen, Prachin Buri

Cobalt values of stream sediments and B-horizon soils taken from stream banks are analysed and shown as probability plot in Fig. 4.10 and 4.12. The high erratic values are excluded from statistical treatment. In the case of cobalt distribution, the range of the values and the form of the probability graph indicate that the data represent lognormal distribution. The estimation of distribution is obtained by a straight line drawn through the plotted points. 95 % confidence limits of the population were determined graphically (Lepeltier, 1969), but it may be estimated into two populations The procedure for recognizing significant curvature in a probability graph is to assume the presence of a single population and construct its 95 % confidence belt. Significant curvature to the plot is assumed at point that plot outside the zone of 95 % confidence. None of the plotted points for cobalt from investigated are lie outside the band defined by 95 % confidence limit indicating that only a single population is present. To standardize a procedure for dealing with such data, it is convenient to pick an arbitrary threshold at an ordinate level corresponding to the mean plus two standard deviations as recommended by Hawkes and Webb (1962). This procedure assumed that approximately the upper 2.28 % of values are anomalous. Estimated parameters and selected threshold values of Co distribution are presented in Table 4.9

Table 4.9 Estimated parameters and selected threshold values of Co distribution, Wang Nam Yen, Prachin Buri

	Threshold value	Values in ppm Co		
		b	b+s	b+2s
Stream sediments	310	62	135	310
Soils	430	73	175	430

4.2.4 Copper in Stream Sediments and Soils, Wang Nam Yen, Prachin Buri

Copper analyses for 327 stream sediment samples and 652 B-horizon soil samples taken from stream banks are presented as probability plot in Fig. 4.14 and 4.16, respectively. The distribution of copper obtained from a straight line suggests a single population pattern as same as indicated from cobalt distribution. The procedure for recognizing significant curvature in a probability graph was determined by constructing the 95% confidence belt. None of the plotted points for copper data lie outside the band defined by 95 % confidence limit. Arbitrary threshold value was selected at an ordinate level corresponding to approximately 2.28 percentile from probability graph. Estimated parameters and arbitrary threshold values of Cu distribution are given in Table 4.10

Table 4.10 Estimated parameters and selected threshold values of Cu distribution, Wang Nam Yen, Prachin Buri

	Threshold value	Values in ppm Cu		
		b	b+s	b+2s
Stream sediments	37	18	26	37
Soils	46	20	30	46

4.3 Preparation of Geochemical Maps

Geochemical values can be shown on a map by numbers, symbols, symbol-number combination and contour pattern (Howarth and Martin, 1979). One of the most common method that has been used in constructing geochemical map is the contouring method which can be produced either manually or by computer techniques. But in the case of this investigation, there are some area consist of low sample densities. Therefore, the application of the contouring technique is not generally suited to smooth out geochemical data in such non uniform sampling area. The applicable method will be point-symbol technique which is used to produce geochemical map in this investigation. The symbol serves as dual role in indicating both site and element value. A convenient set of symbols can thus be used in a map, each symbol denoting a class or range of element values. The choice of classes are based on the results of statistical treatment of data and the symbols will then indicate some level of significance. This will be a useful aids for anomalies identification. The estimated parameters and selected threshold values of the elements which summarized in previous section will be used to design the ranges of value for constructing geochemical map. The ranges of Cr, Ni, Co and Cu values in stream sediments are presented in Table 4.11 and in soils in Table 4.12. The values of these elements are plotted discretely on a drainage map by using different symbols. The point-symbol geochemical maps of Cr, Ni, Co and Cu are shown in Fig.4.17 to Fig. 4.24

Table 4.11 The ranges of geochemical values (ppm) for Cr, Ni, Co and Cu in stream sediments use for the construction of geochemical maps.

Cr	Ni	Co	Cu
< 2000	< 1500	< 62	< 18
2000 - 3200	1500 - 2800	62 - 135	18 - 18
3200 - 4100	2800 - 3800	135 - 310	26 - 37
4100 - 5800	3800 - 5800	> 310	> 37
> 5800	> 5800		

Table 4.12 The ranges of geochemical values (ppm) for Cr, Ni, Co and Cu in soils use for the construction of geochemical maps.

Cr	Ni	Co	Cu
< 1500	< 1750	< 73	< 20
1500 - 3000	1750 - 2750	73 - 175	21 - 30
3000 - 4200	2750 - 4100	175 - 430	31 - 46
4200 - 6200	4100 - 6400	> 430	> 46
> 6200	> 6400		

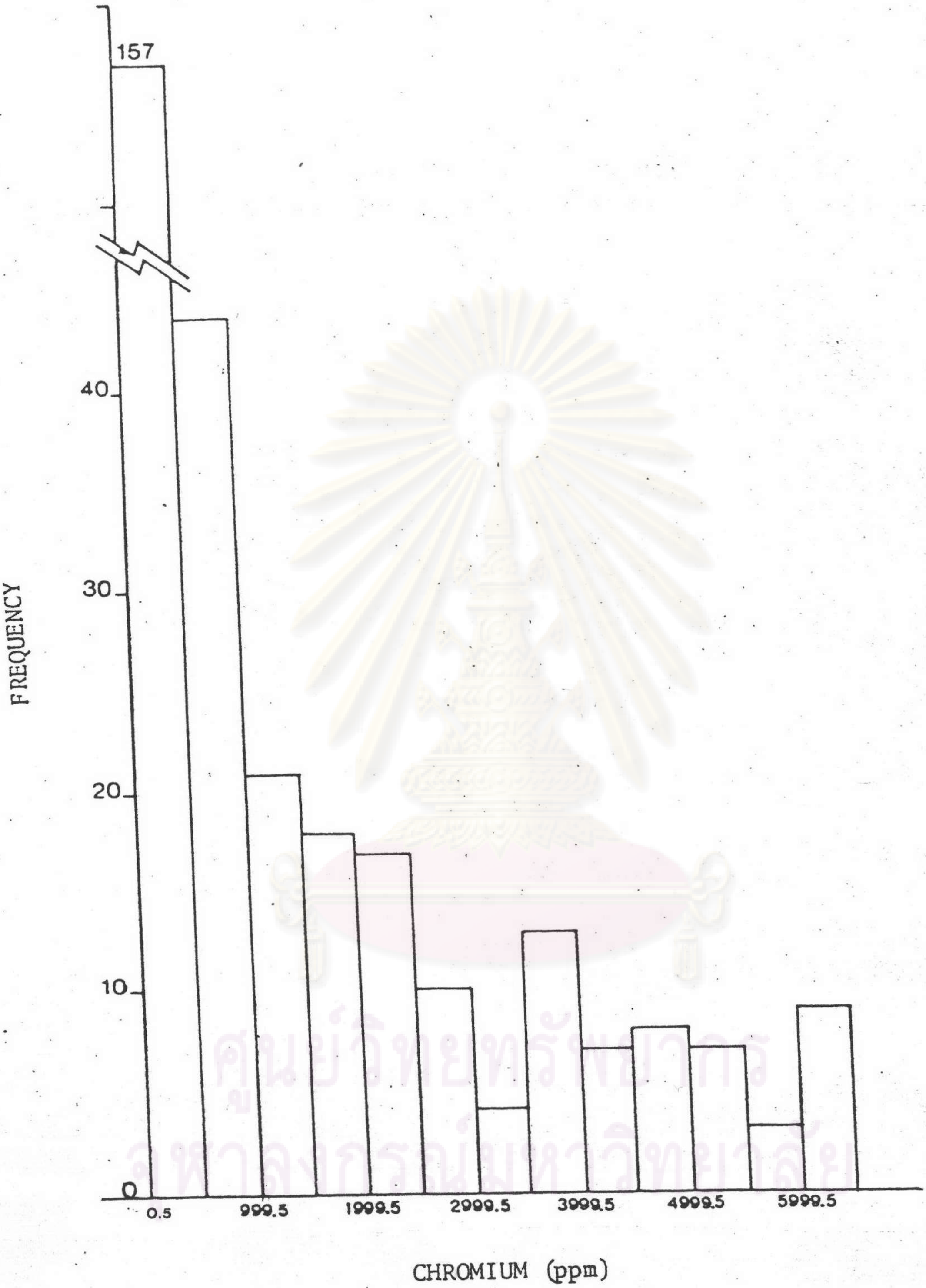

Fig. 4.1 Histogram showing the distribution for chromium in stream sediments, Wang Nam Yen, Prachin Buri.

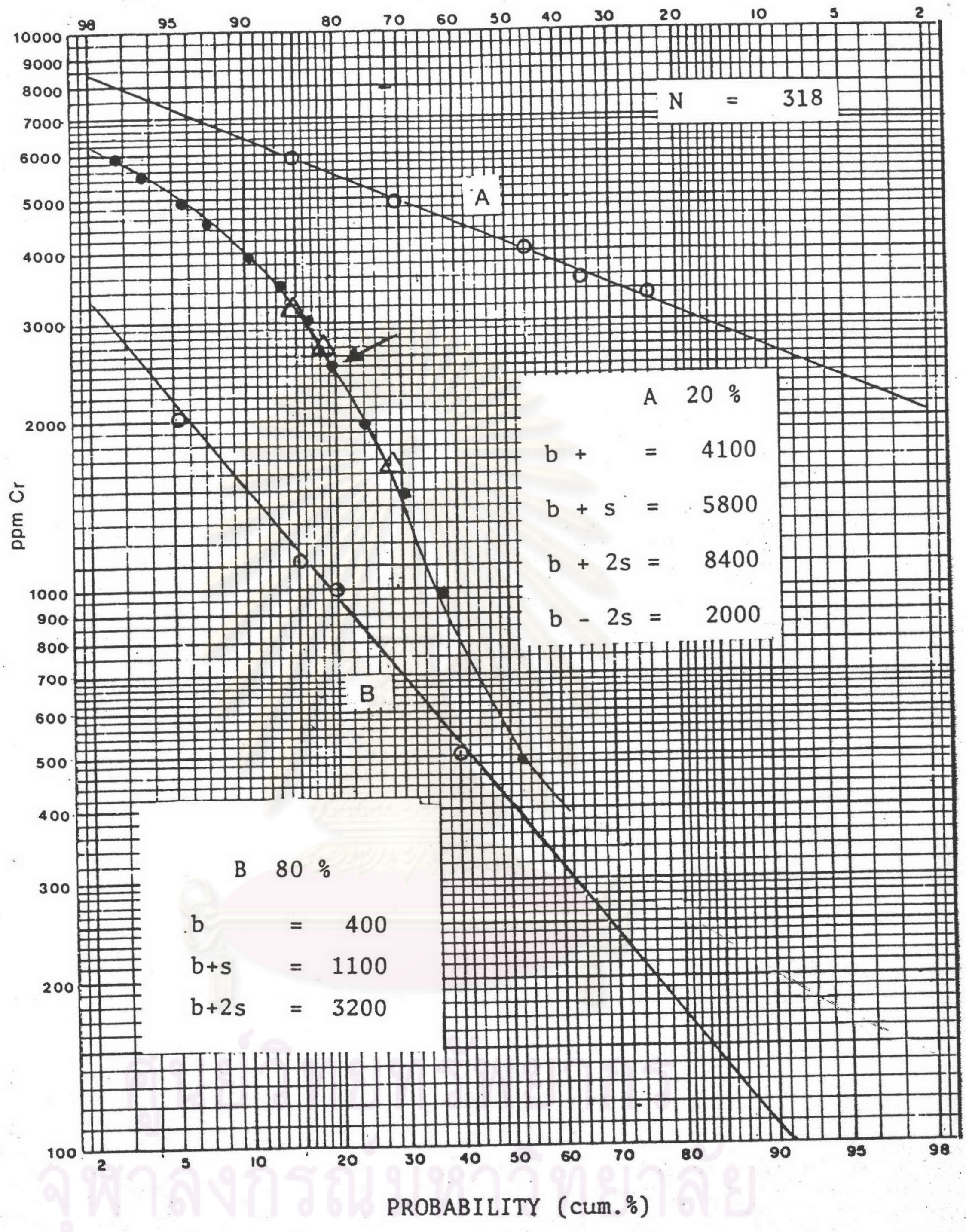

Fig. 4.2 Bimodal probability plot of Cr content in stream sediments, Wang Nam Yen, Prachin Buri. The intermediate curved distribution shown as black dots. An inflection point is shown by the arrowhead. Open circles are partitioning points used to establish population A and B. Open triangle are check points obtained by combining A and B in the ratio 20/80.

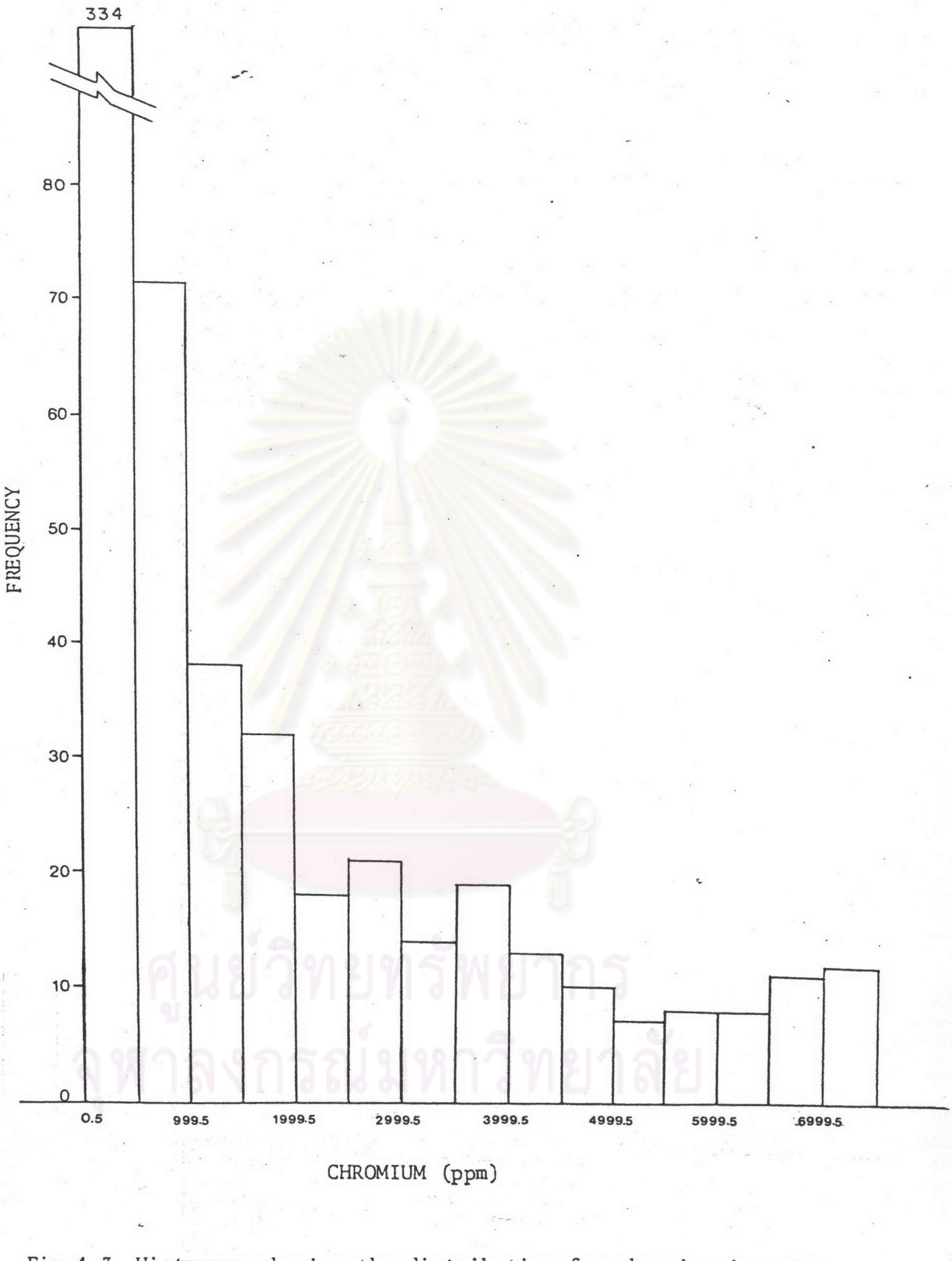

Fig. 4.3 Histogram showing the distribution for chromium in soils, Wang Nam Yen, Prachin Buri.

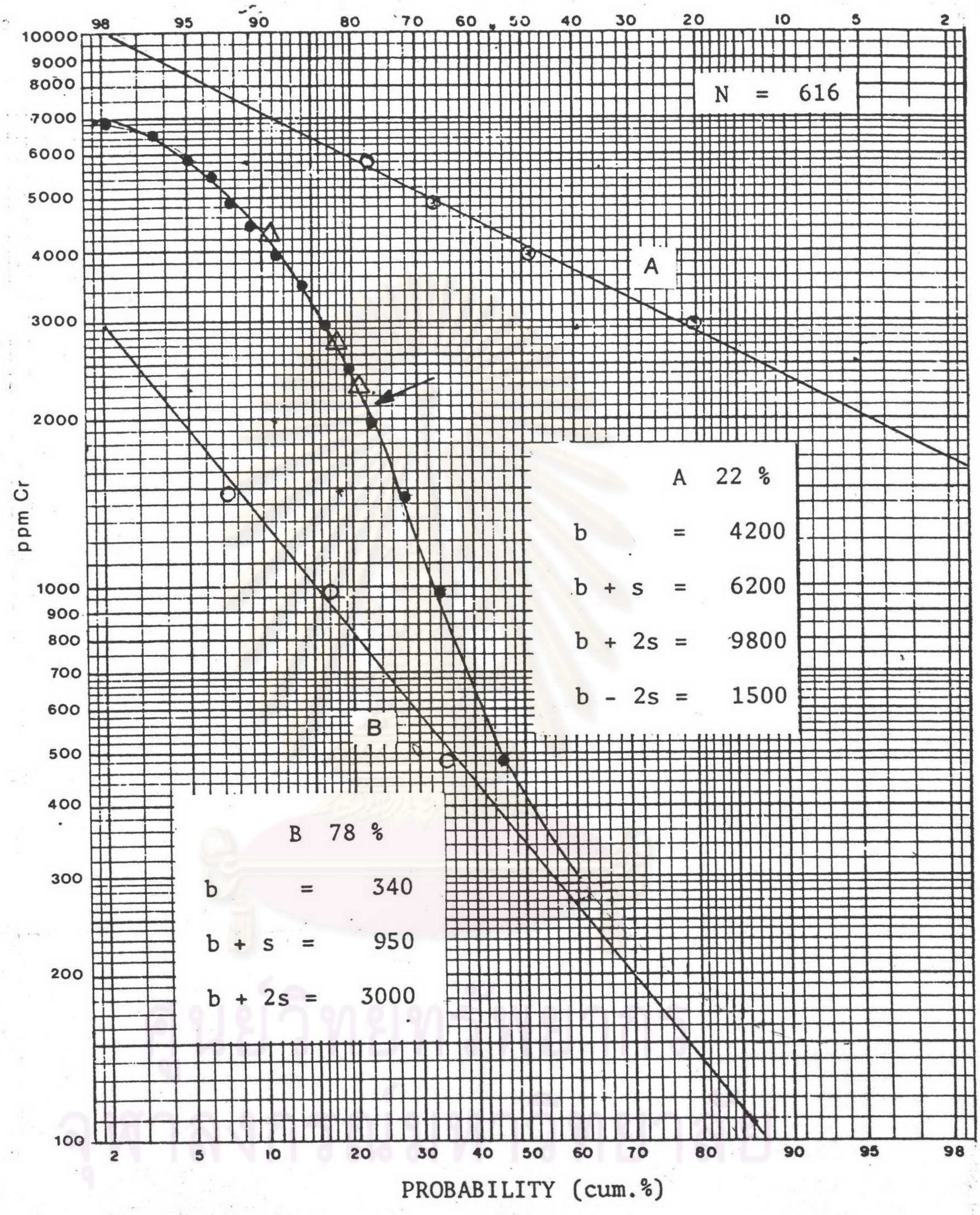

Fig. 4.4 Bimodal probability plot of Cr content in B-horizon soils, Wang Nam Yen, Prachin Buri. The intermediate curved distribution shown as black dots. An inflection point is shown by the arrowhead. Open circles are partitioning points used to establish population A and B. Open triangles are check points obtained by combining A and B in the ratio 22/78.

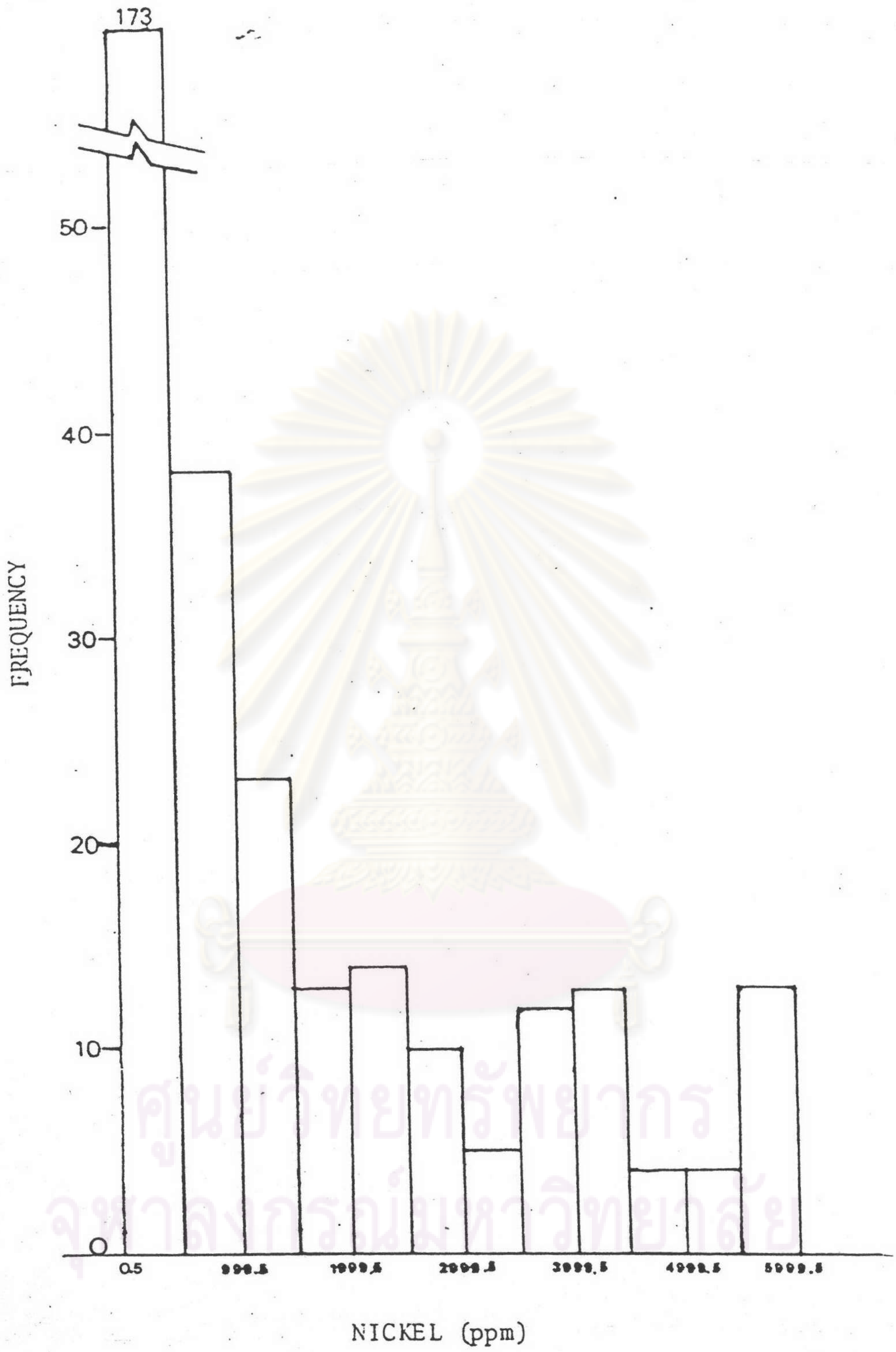

Fig. 4.5 Histogram showing the distribution for nickel in stream sediments, Wang Nam Yen, Prachin Buri.

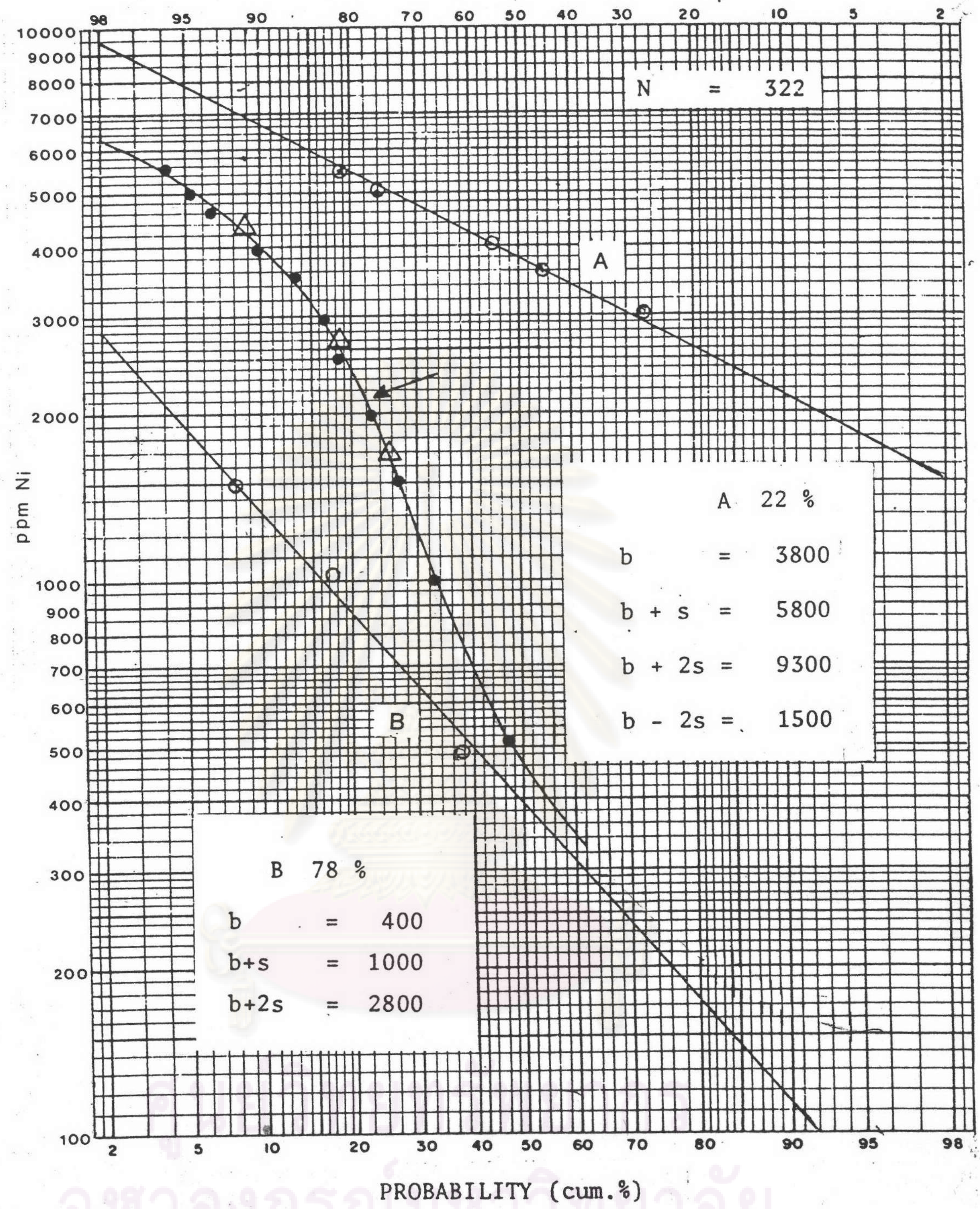

Fig. 4.6 Bimodal probability plot of Ni content in stream sediments, Wang Nam yen, Prachin Buri. An inflection point indicated by arrowhead suggesting its result from combination of two populations in the ratio of 22/78. A and B are the two partitioned populations estimated by the lines drawn through the calculated points (open circles). Open triangles are check points that agree with original data (black dots).

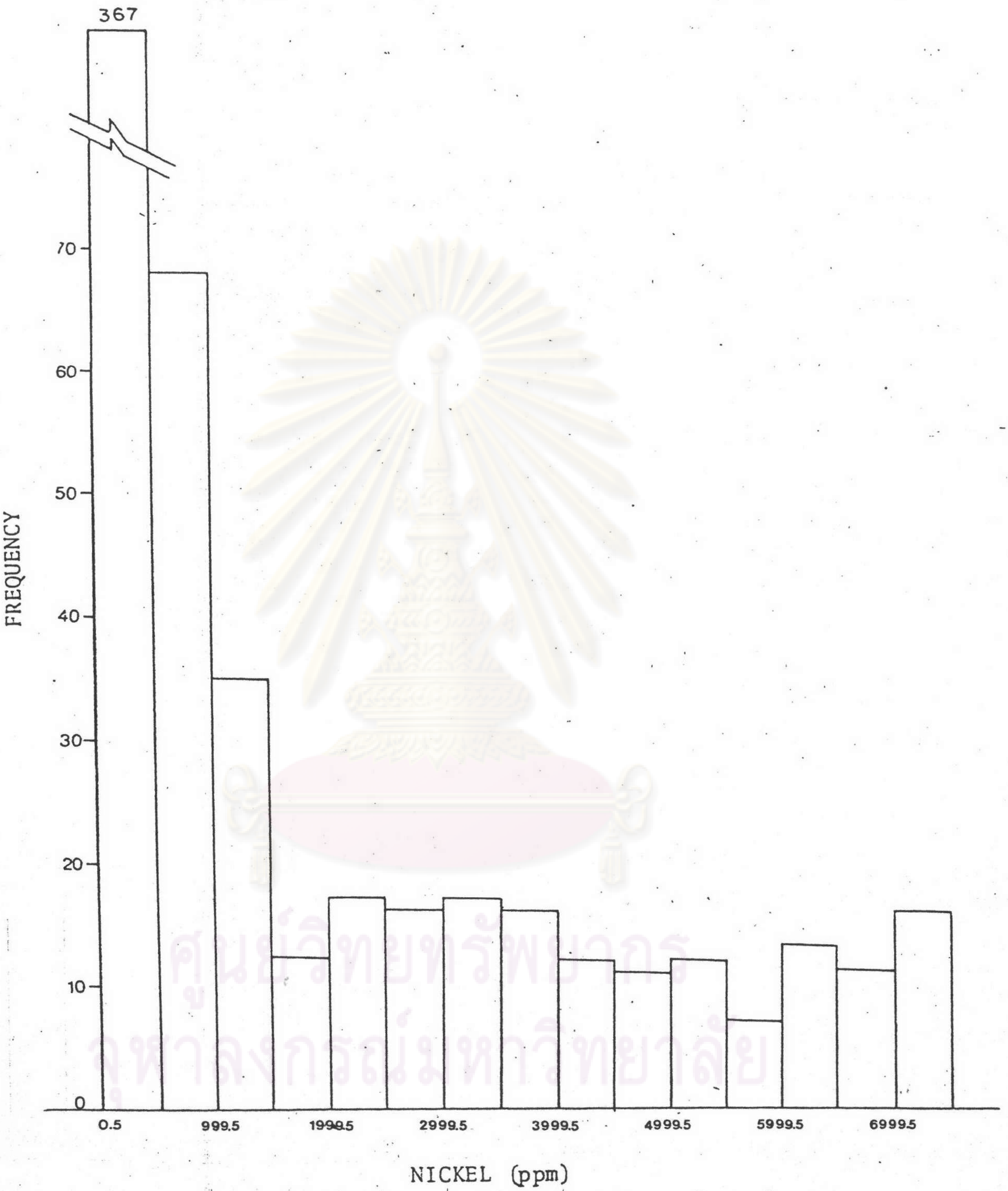

Fig. 4.7 Histogram showing the distribution for nickel in soils, Wang Nam Yen, Prachin Buri.

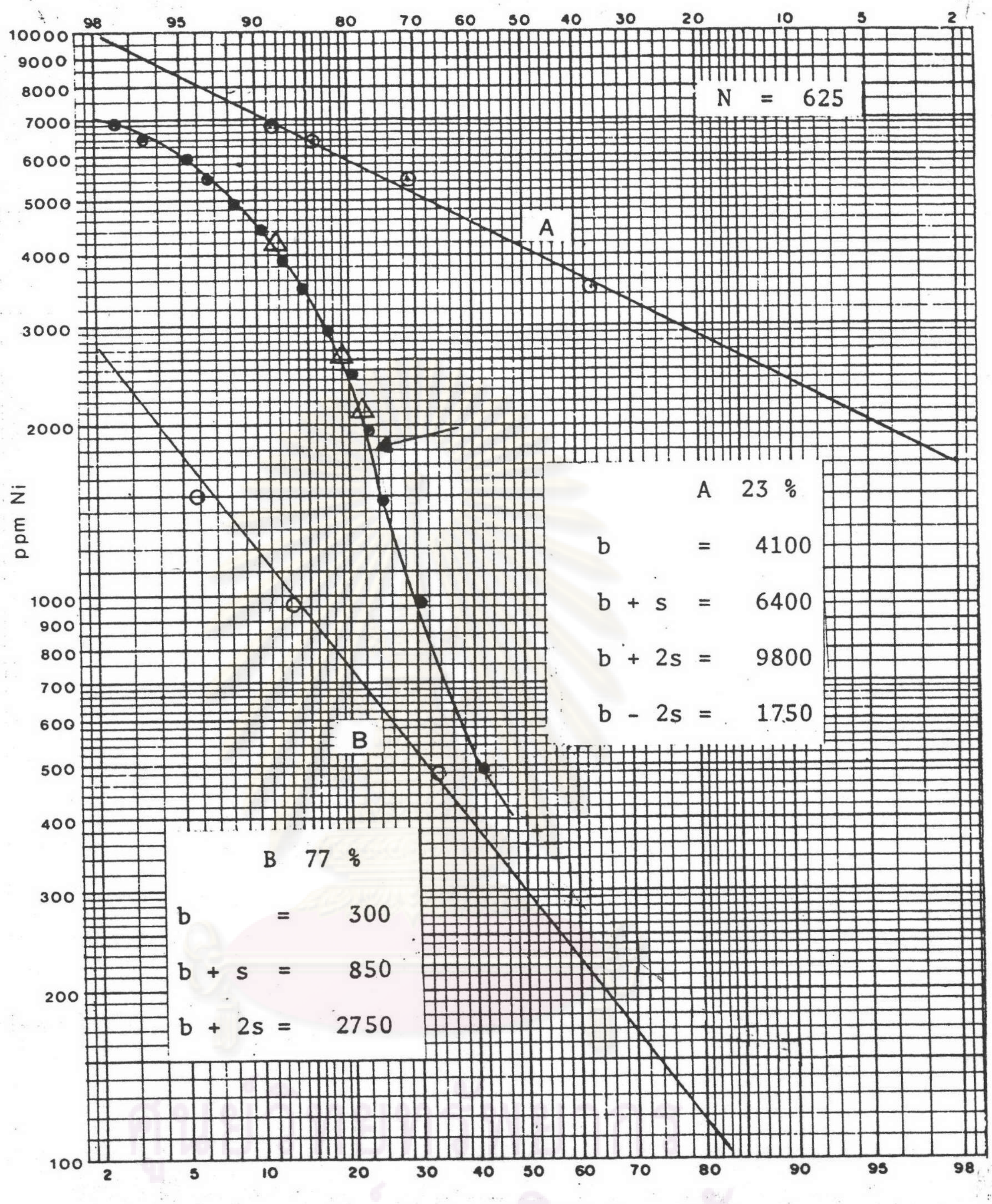

Fig.4.8 Bimodal probability plot of Ni content in B-horizon soils, Wang Nam Yen, Prachin Buri. An inflection point indicated by arrowhead suggesting its result from combination of two populations in the ratio of 23 : 77. A and B are the two partitioned populations estimated by the lines drawn through the calculated points (open circles). Open triangles are check points that agree with original data (black dots).

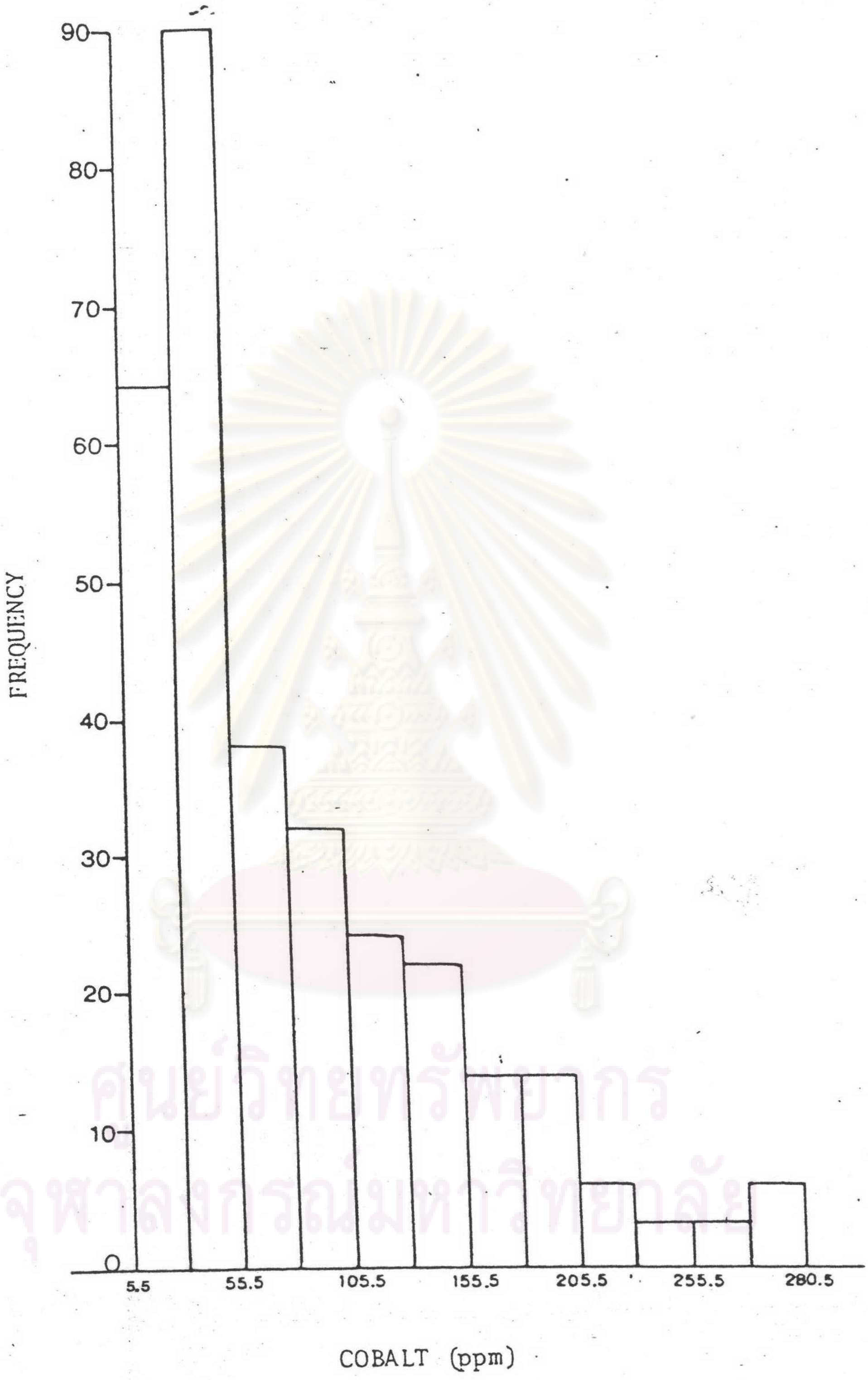

Fig. 4.9 Histogram showing the distribution for cobalt in stream sediments, Wang Nam Yen, Prachin Buri.

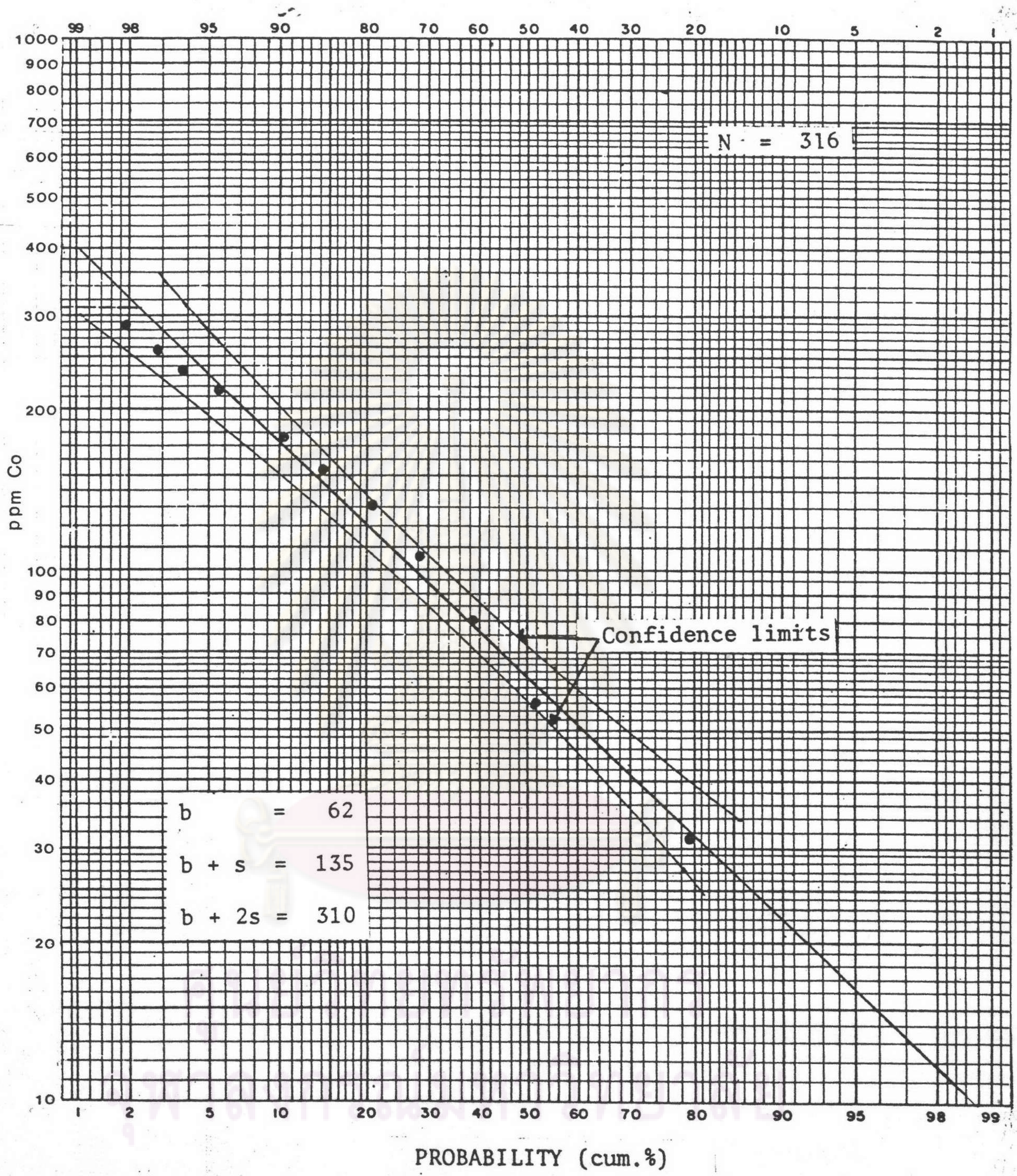

Fig. 4.10 Probability plot of Co content in stream sediments, Wang Nam Yen, Prachin Buri. Listed parameters of the distribution were obtained from the straight line drawn through original data points (black dots). 95 % confidence limits are shown after Lepeltier (1969).

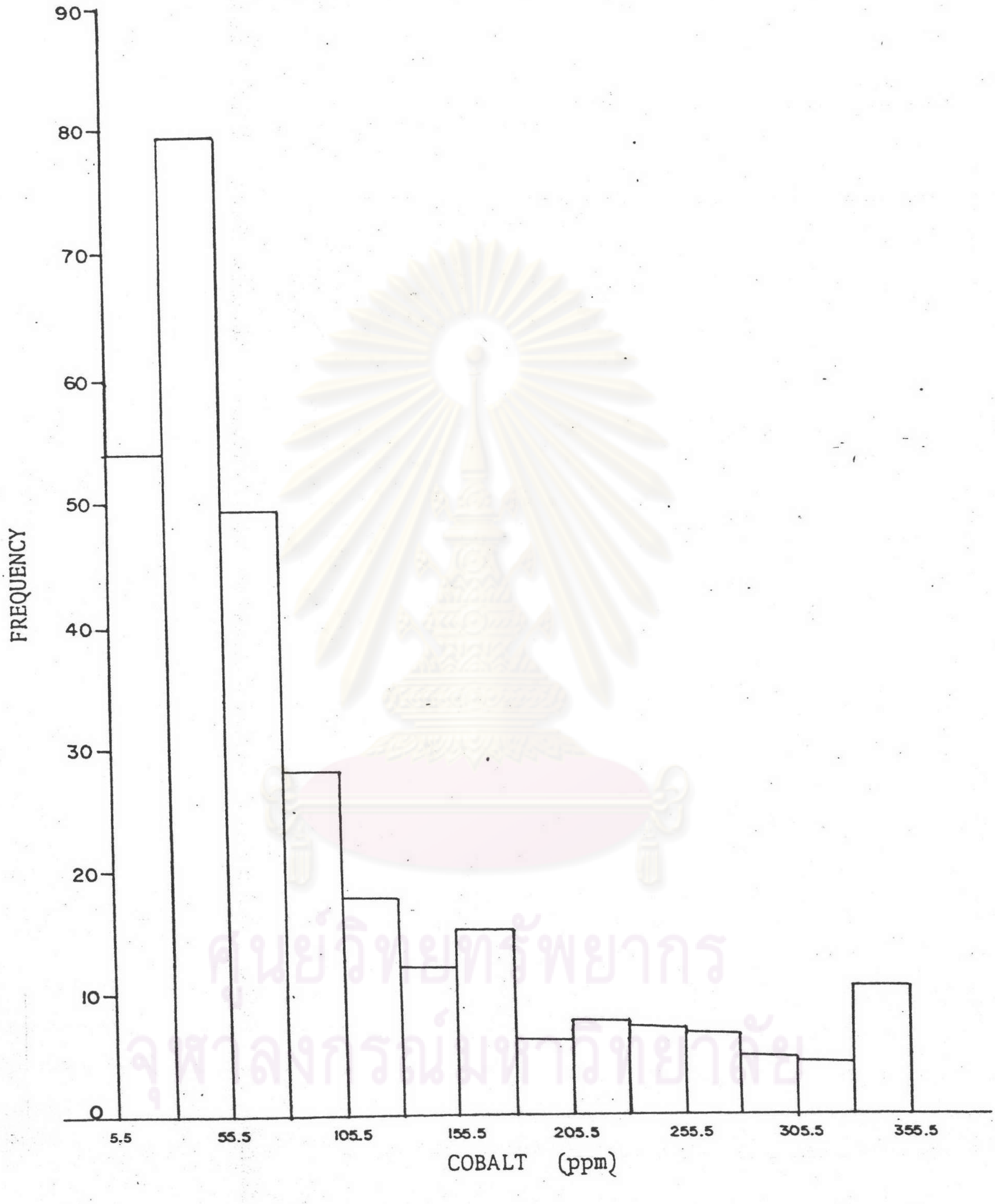

Fig. 4.11 Histogram showing the distribution for cobalt in soils, Wang Nam Yen, Prachin Buri.

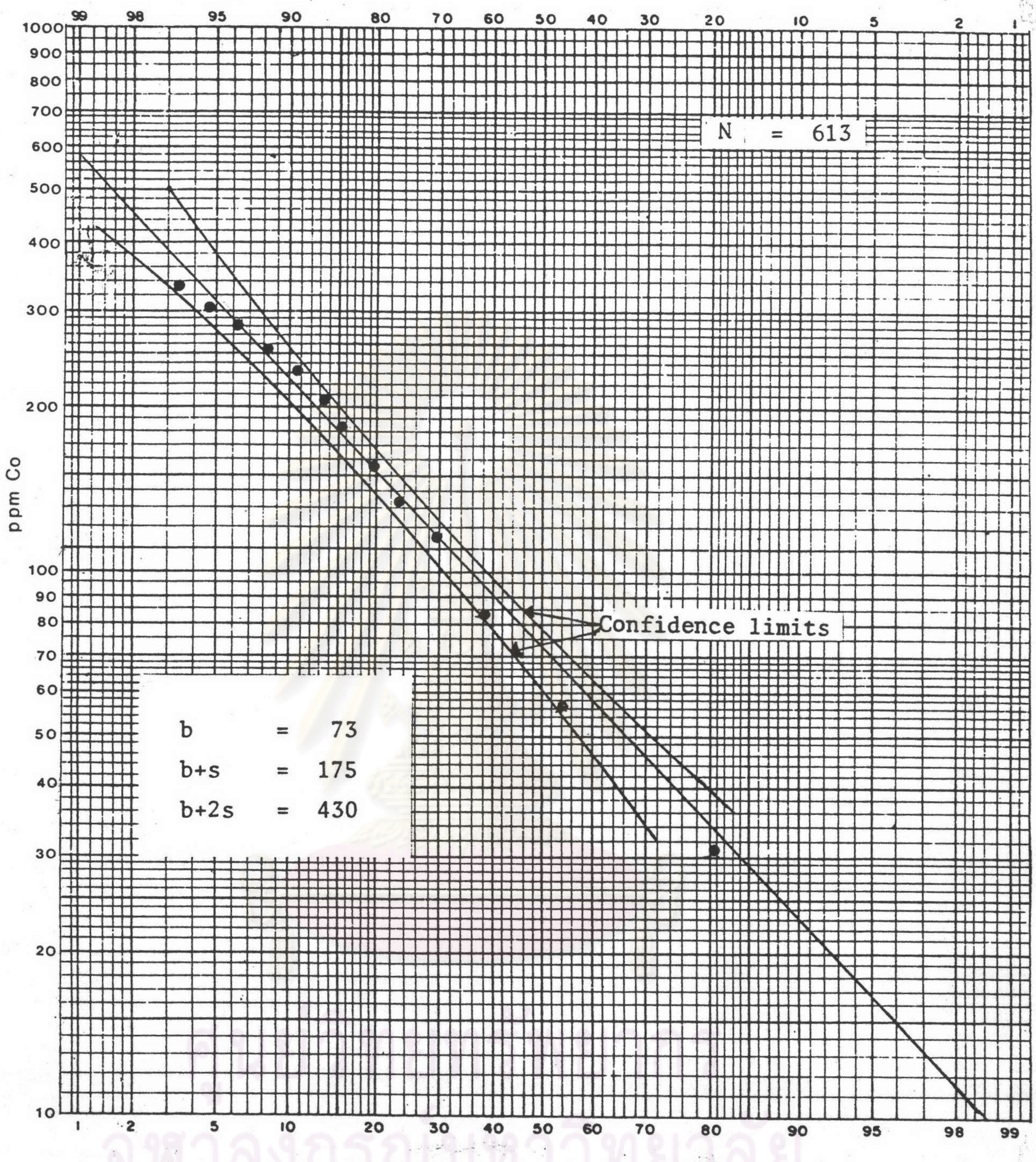

Fig. 4.12 Probability plot of Co content in B-horizon soils, Wang Nam Yen, Prachin Buri. Listed parameters of the distribution were obtained from the straight line drawn through original data points (black dots). 95 % confidence limits are shown after Lepeltier (1969).

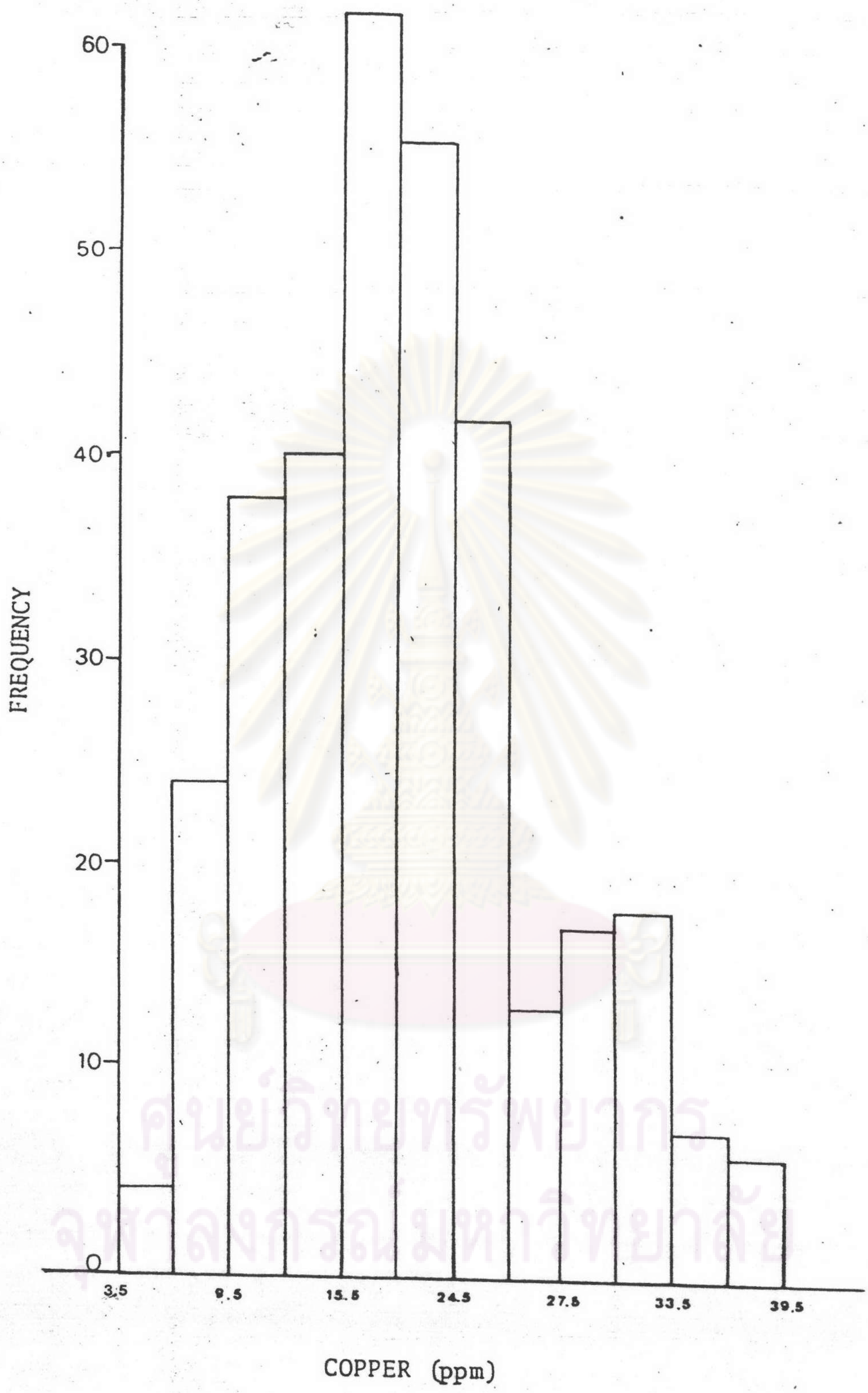

Fig. 4.13 Histogram showing the distribution for copper in stream sediments, Wang Nam Yen, Prachin Buri.

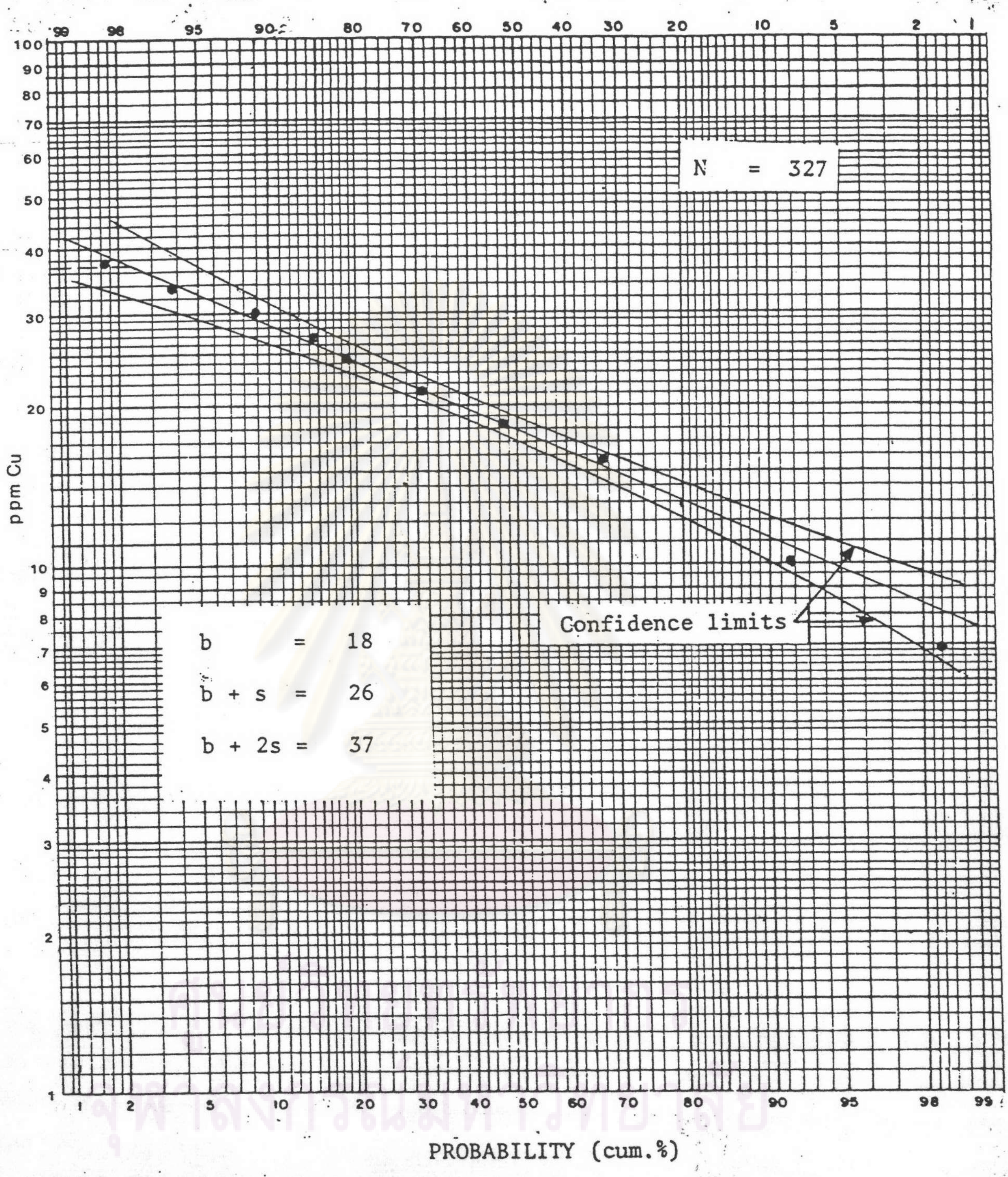

Fig. 4.14 Probability plot of Cu content in stream sediments, Wang Nam Yen, Prachin Buri. Estimated parameters of the distribution were obtained by a straight line drawn through the plotted points (black dots). 95 % confidence limits of the population were determined graphically after Lepeltier (1969).

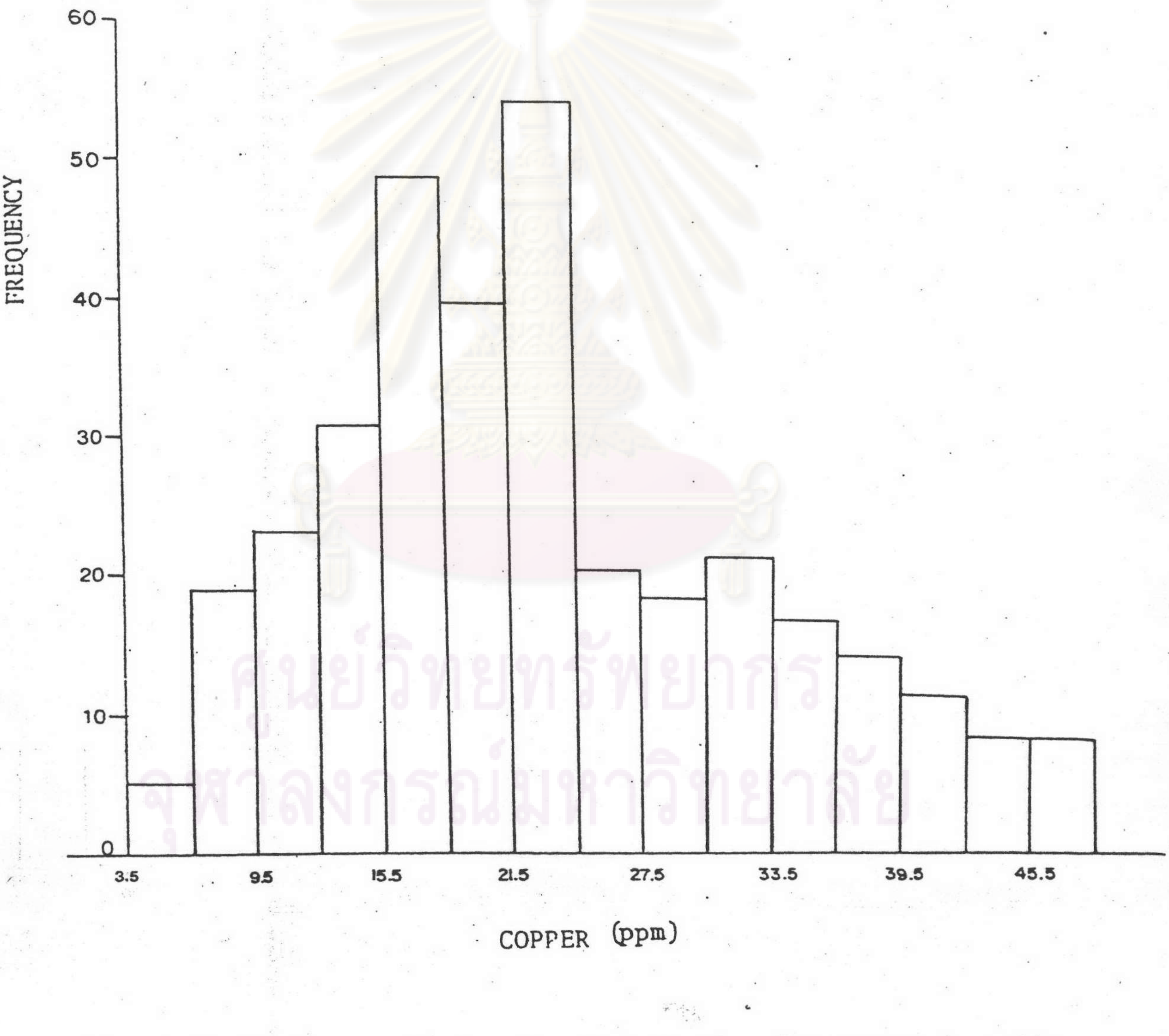

Fig. 4.15 Histogram showing the distribution for copper in soils, Wang Nam Yen, Prachin Buri.

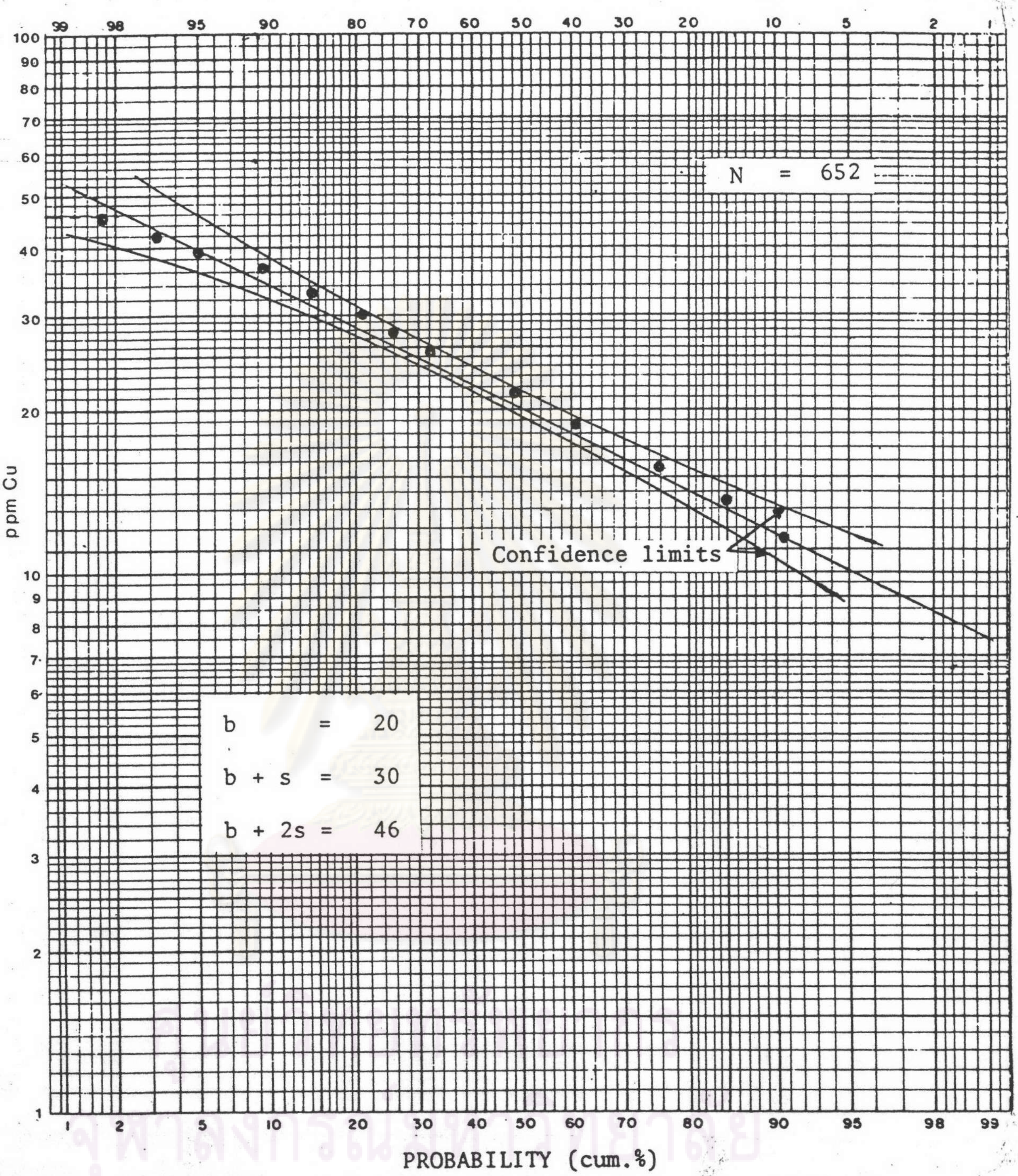

Fig. 4.16 Probability plot of Cu content in B-horizon soils, Wang Nam Yen, Prachin Buri. Estimated parameters of the distribution were obtained by straight line drawn through the plotted points (black dots). 95 % confidence limits of the population were determined graphically after Lepeltier (1969).

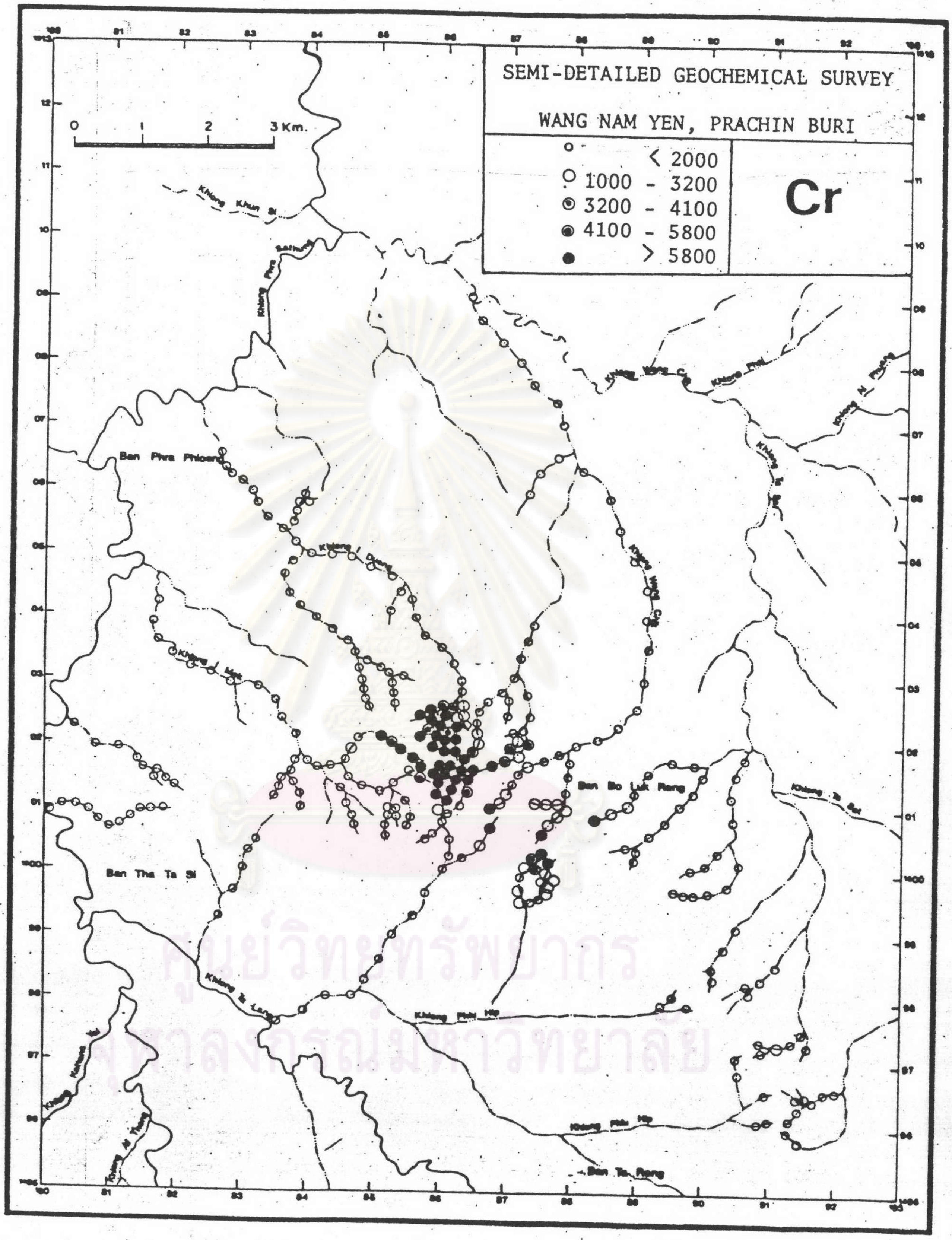

Fig.4.17 Geochemical map for Cr in stream sediments, Amphoe Wang Nam Yen, Changwat Prachin Buri.

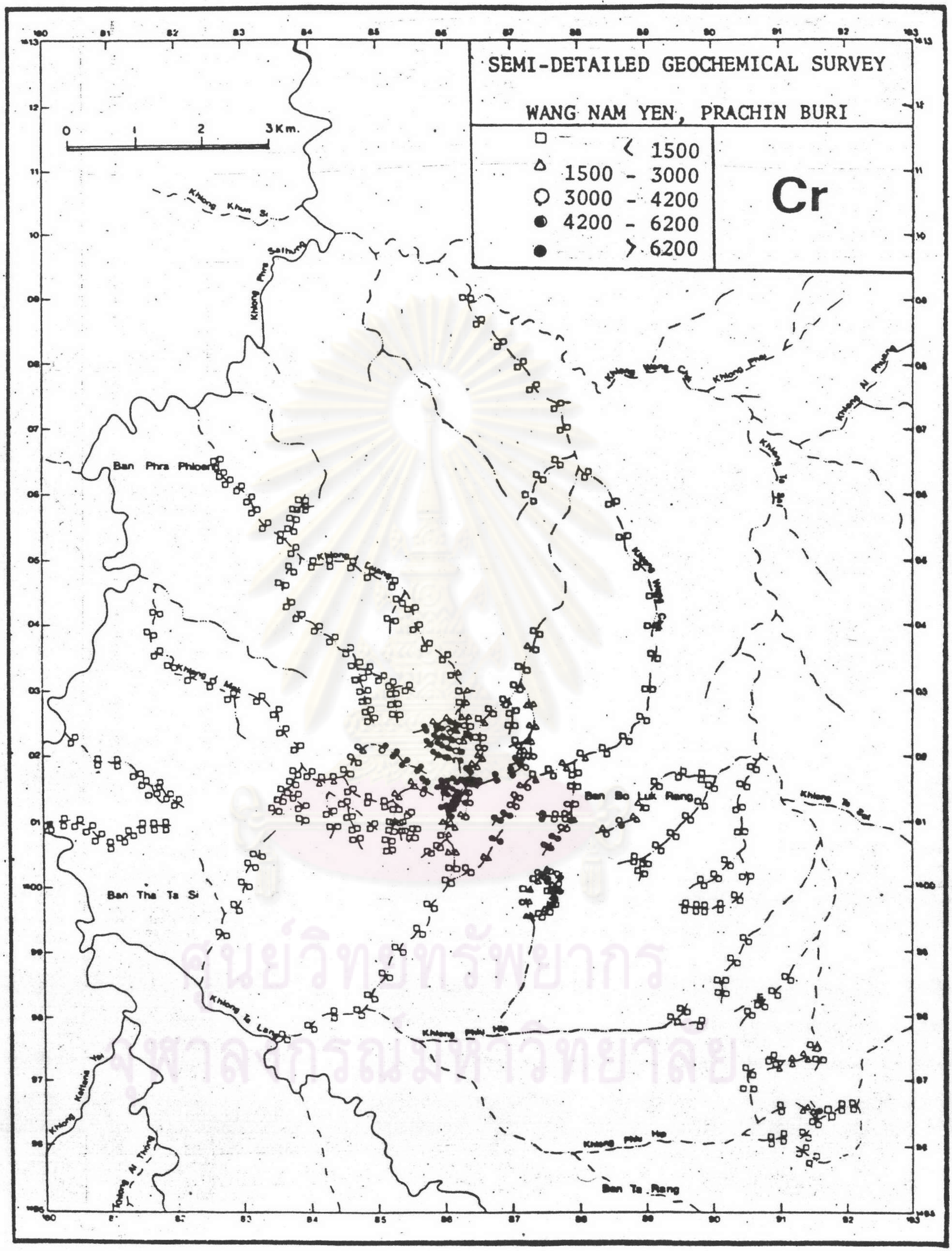

Fig. 4.18 Geochemical map for Cr in soils, Amphoe Wang Nam Yen, Changwat Prachin Buri.

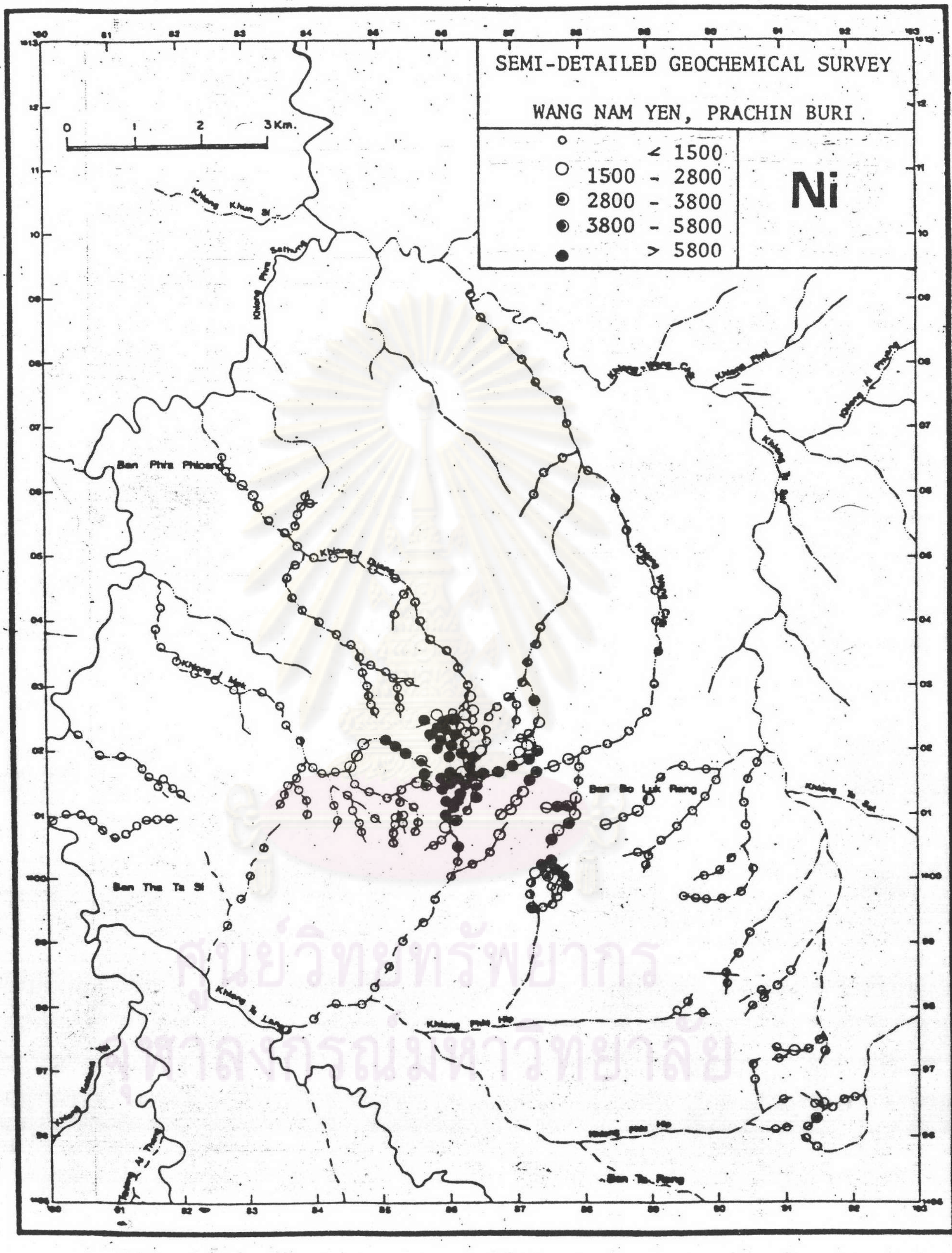

Fig.4.19 Geochemical map for Ni in stream sediments, Amphoe Wang Nam Yen, Changwat Prachin Buri.

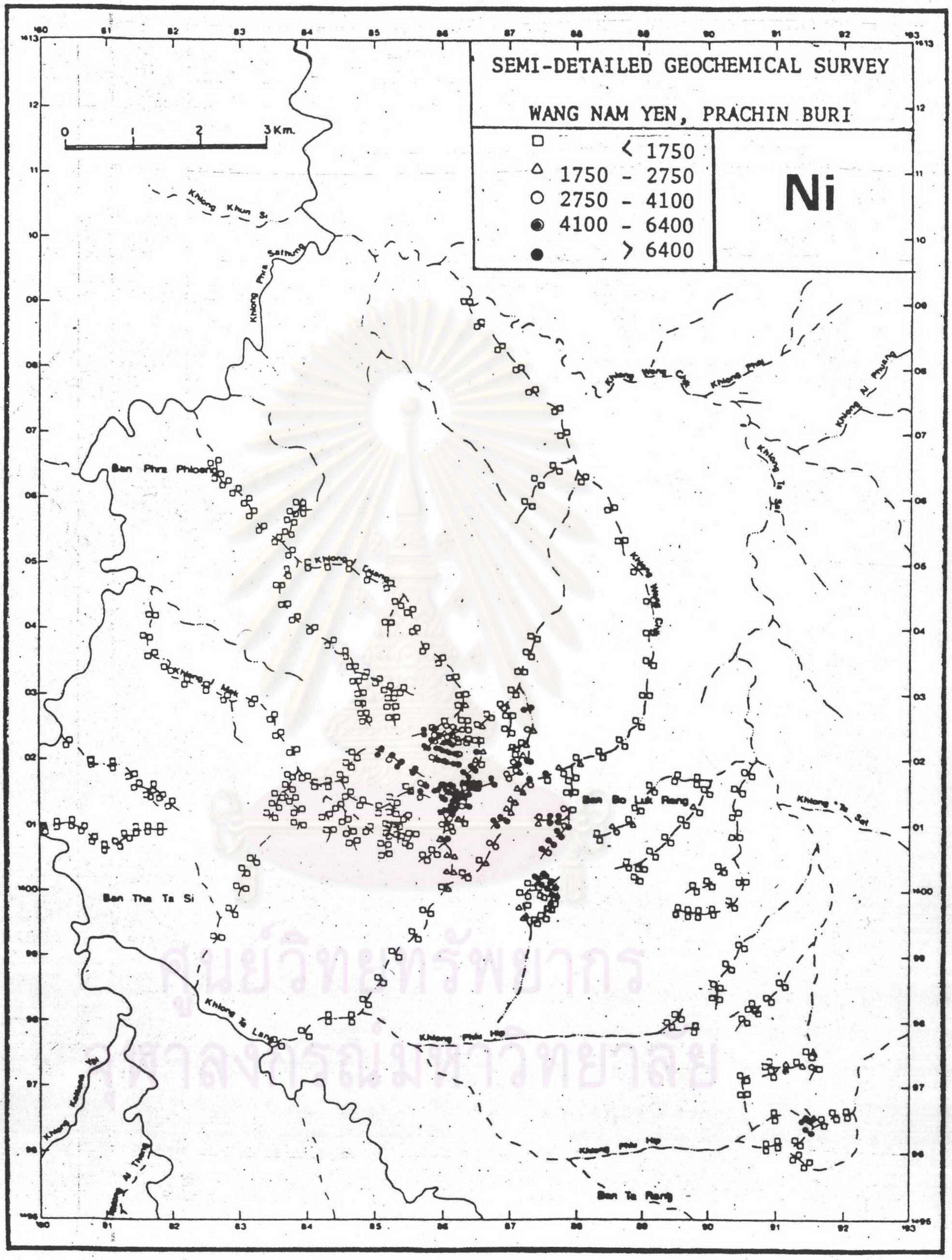

Fig. 4.20 Geochemical map for Ni in soils, Amphoe Wang Nam Yen, Changwat Prachin Buri.

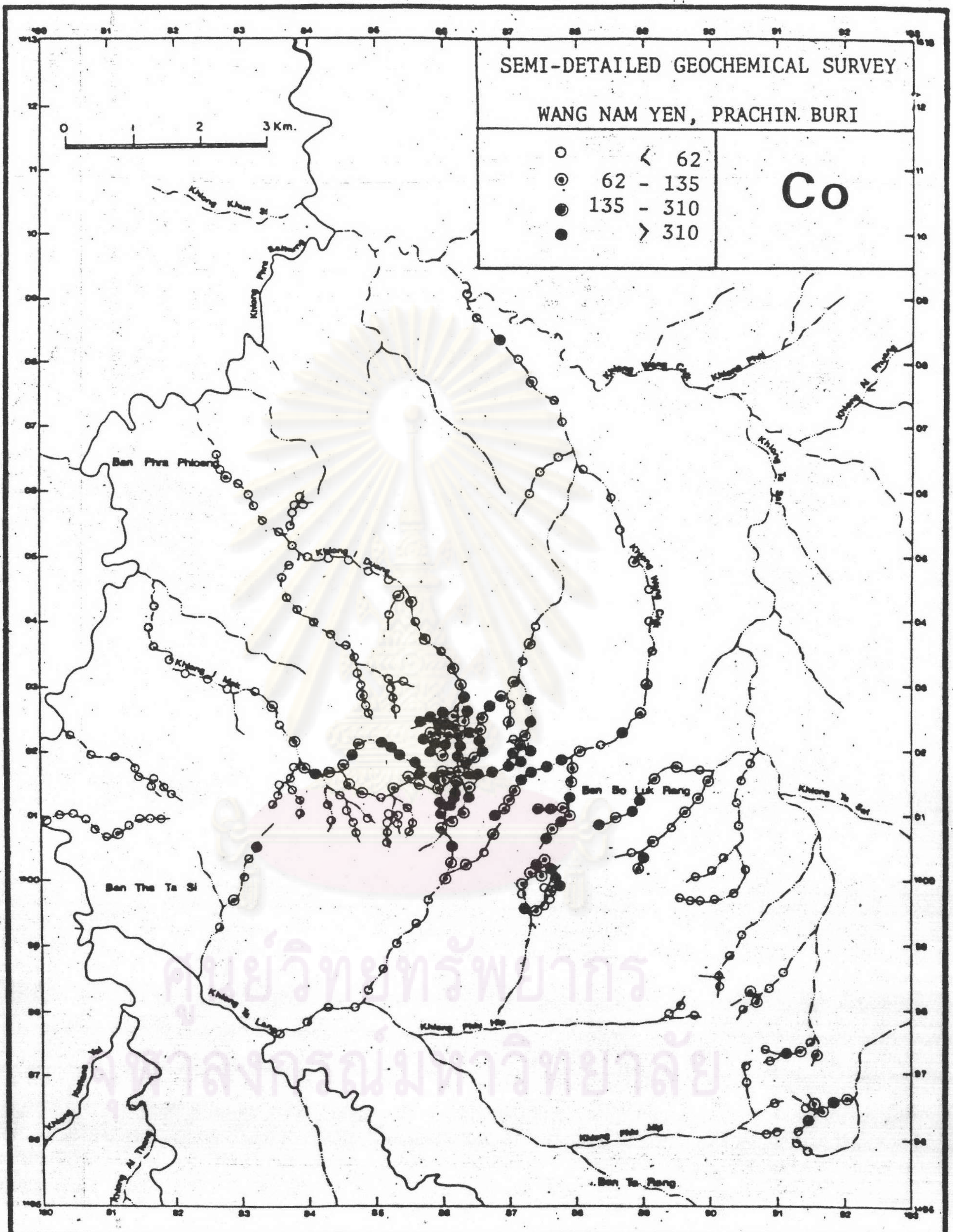

Fig. 4.21 Geochemical map for Co in stream sediments, Amphoe Wang Nam Yen, Changwat Prachin Buri.

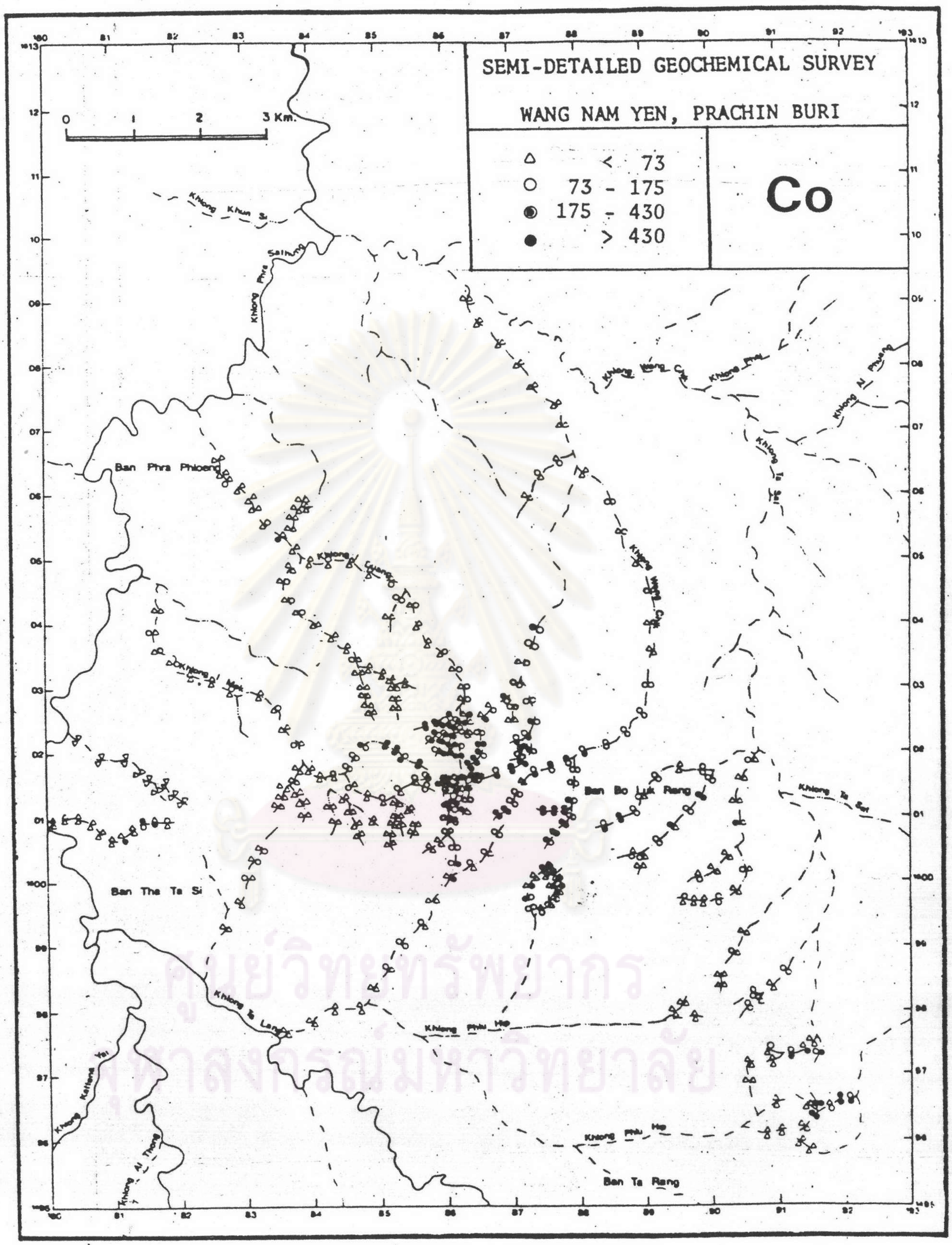

Fig. 4.22 Geochemical map for Co in soils, Amphoe Wang Nam Yen, Changwat Prachin Buri.

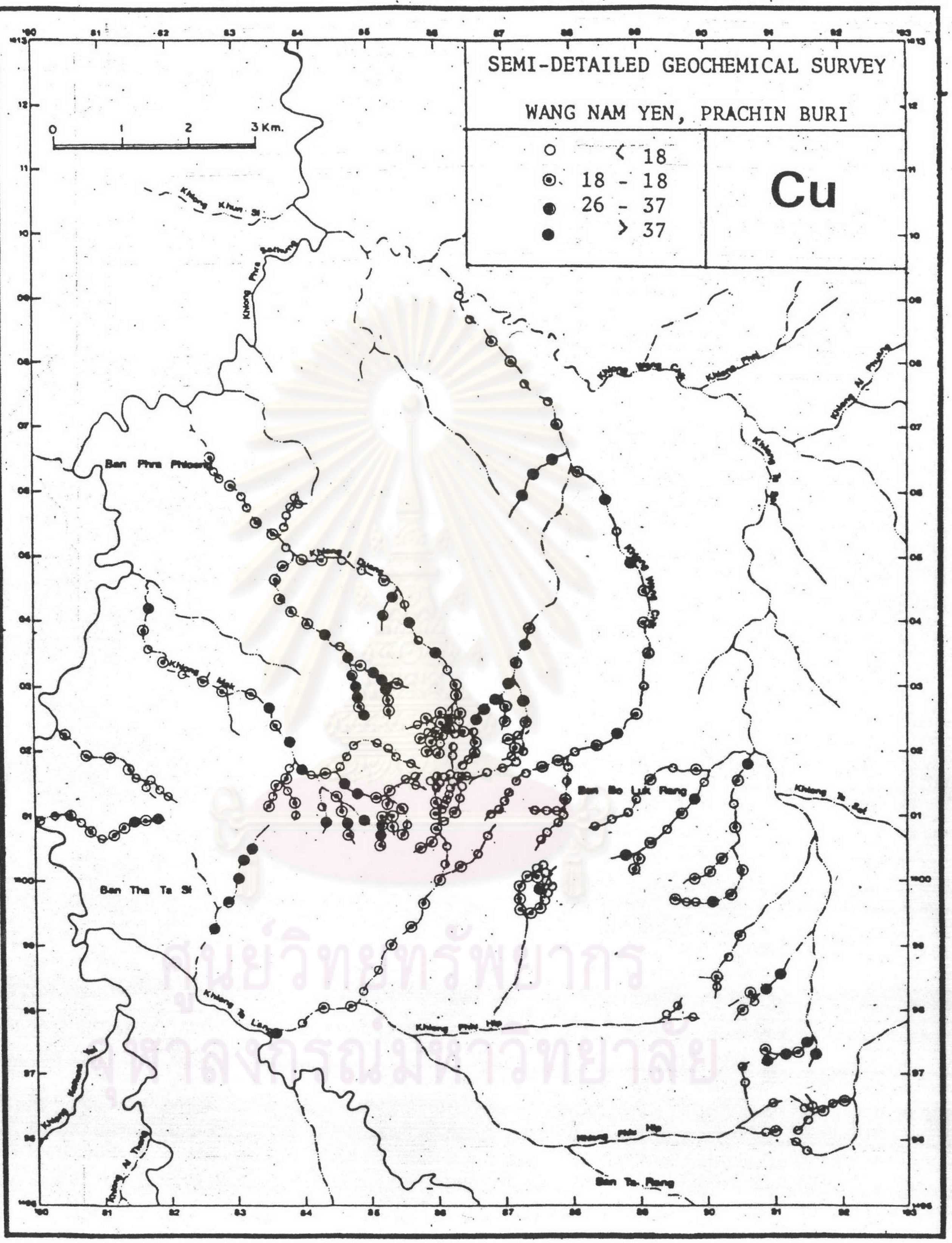

Fig.4.23 Geochemical map for Cu in stream sediments, Amphoe Wang Nam Yen, Changwat Prachin Buri.

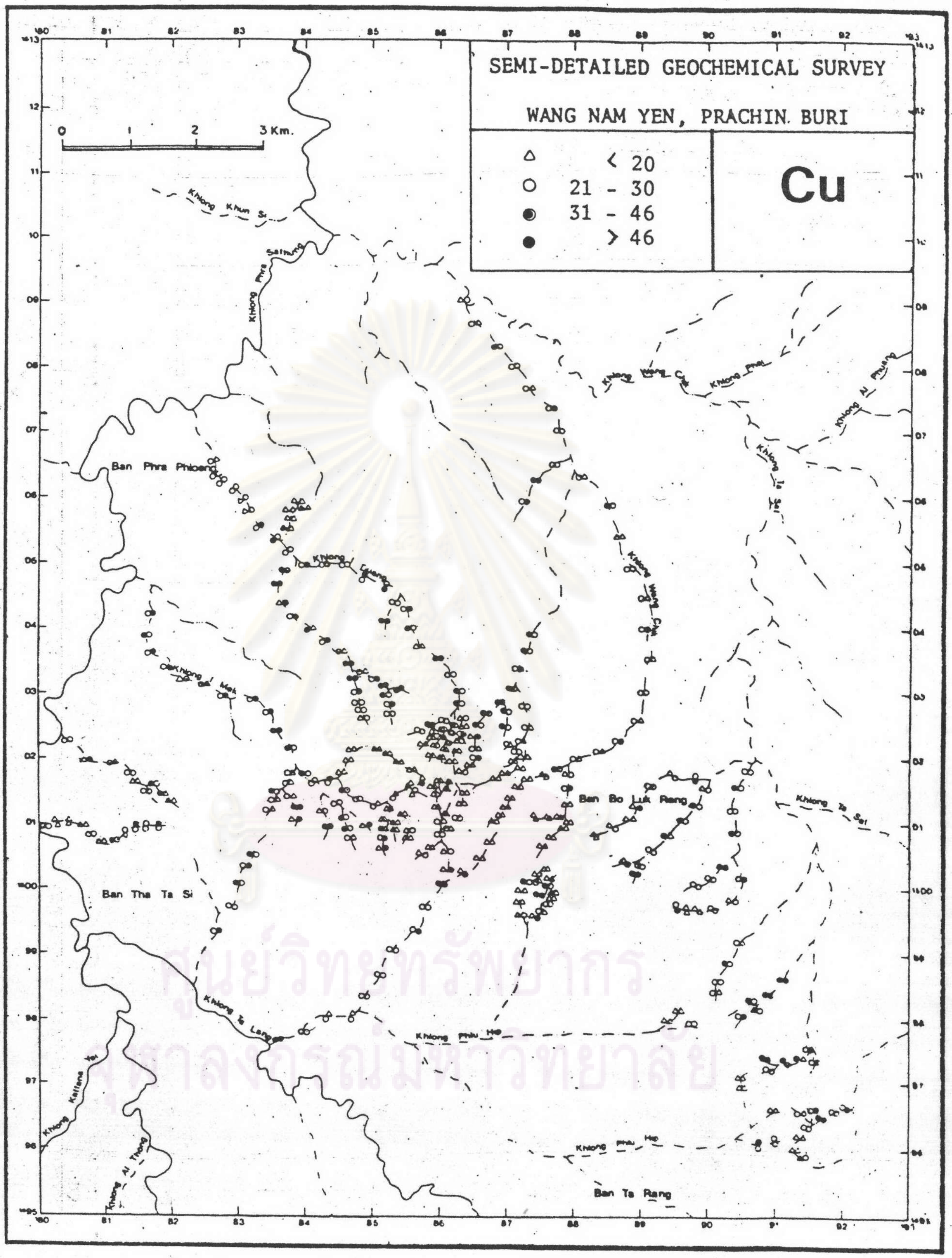

Fig. 4.24 Geochemical map for Cu in soils, Amphoe Wang Nam Yen, Changwat Prachin Buri.