# NAHANNI PROJECT

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Feb. 17, 1974

It is the purpose of this project, to comprehensively study the copper lead and zinc geochemistry of the 105 I (Nahanni) map area of the Yukon and North West Territories.

The immediate application of the work will be an evaluation of the 1973 Selwyn Project field data, to form a basis of the follow-up work for the 1974 Selwyn Project. It is hoped that a major portion of the material will be applied to a Bachelor's Thesis to be submitted in the spring of 1975.

The data consists of the copper,lead and zinc proportions in parts per million, of the -80 mesh fraction of approximately 2500 stream sediment samples collected during the summer of 1973. Associated with each sample is a stream water pH determined with BDH universal pH indicator solution. This liquid type indicator has a range of pH4.0 to pH 10.0 and is probably accuarate to within 0.5 pH units.

The majority of the work performed by the writer to date, has been a computer based determination of standard deviation and mean as well as distribution of the four parameters namely copper, lead, zinc and pH. These determinations have been performed on several subsets of the data as outlined in table 1.

The data subsets have been partitioned, according to the method outlined by Sinclair (1973),on the basis of sub-populations which become descrete when plotted on probability paper.

The results of the probability analysis, examples of which are shown in figures 1 to 10, are summarized in tables 2-1 to 2-3.

In order to be of use in a regional evaluation, the metal values,as divided into sub-groups according to geology, must be separated into anomalous and non-anomalous sets. For most units this is achieved by establishing an arbitrary first priority threshold above which only 2.3% of the samples occur, and a second priority threshold above which 16% of the samples occur. In some cases where a population division occurs near the 2 percentile level a non arbitrary division is made. (For example, the upper population for copper in unit 18, according to Sinclair's method, includes the highest 2% of the samples, and these are thus assigned to the first priority set.)

TABLE 1 Histogram Programs

| | |
|---|---|
| 1) Total population | n=2334 |
| 2) Samples from G.S.C. unit number: | |
| 1-quartzite, conglomerate, shale, phyllite | n=109 |
| 2-slate, phyllite | n=88 |
| 3-siltstone, quartzite, slate, dolomite | n=17 |
| 4-dolomitic siltstone, limestone | n=21 |
| 5-quartzite, siltstone dolomite, shale | n=21 |
| 6-siltstone, limestone | n=17 |
| 7-limestone, dolomite | n=158 |
| 8-undifferentiated units 4,5,6,7 | n=9 |
| 9-dolomite, limestone | n=99 |
| 10-shale, argillaceous limestone | n=13 |
| 15-limestone, dolomite | n=20 |
| 16-limestone | n=25 |
| 18-shale, chert, pebble conglomerate | n=639 |
| 19-monzonite, granodiorite, granite | n=31 |
| 3) Samples from unit 20 (recent alluvium) affected by unit 18 | n=687 |
| 4) Samples from unit 18 affected by unit 19 | n=97 |

5) Samples with pH ranging from:

0 - 4.0
4.0 - 4.5
4.6 - 5.5
5.6 - 6.5
6.6 - 7.5
7.6 - 8.5
8.6 - 14

6) As in group 5, but from unit 18 only.

FIG. 1 pH UNIT 1

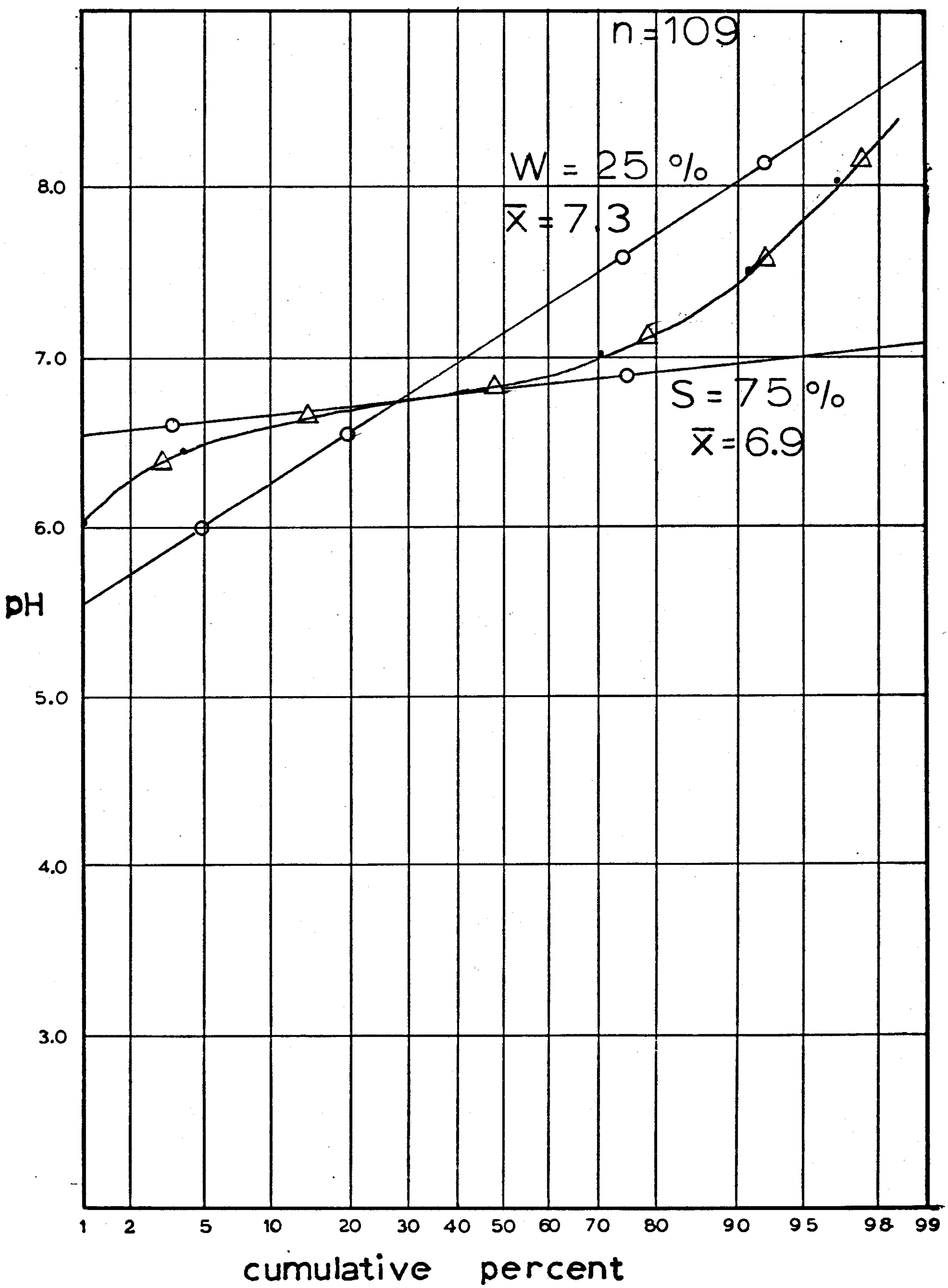


FIG. 2 pH UNIT 7

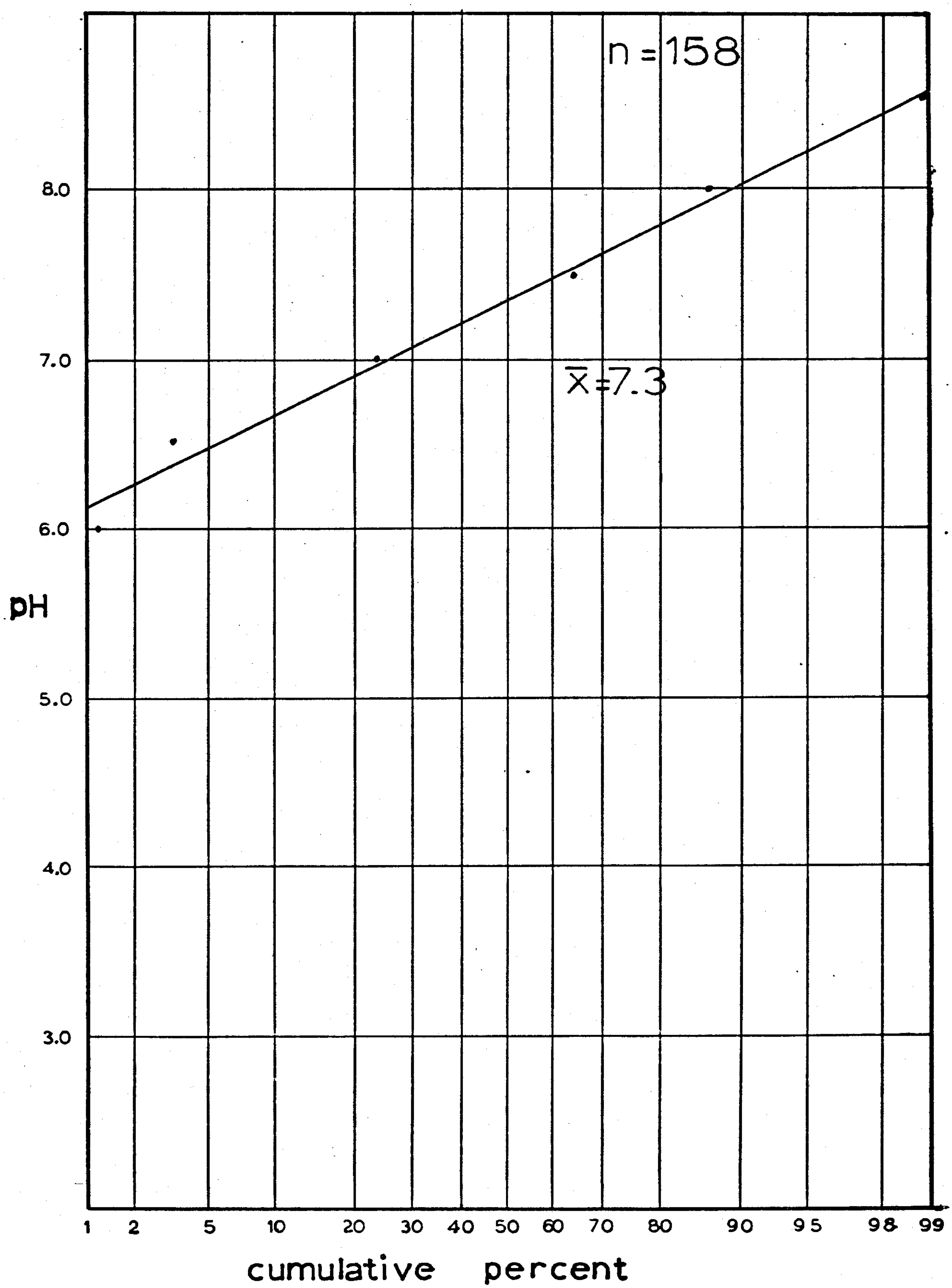


FIG. 3 pH UNIT 18

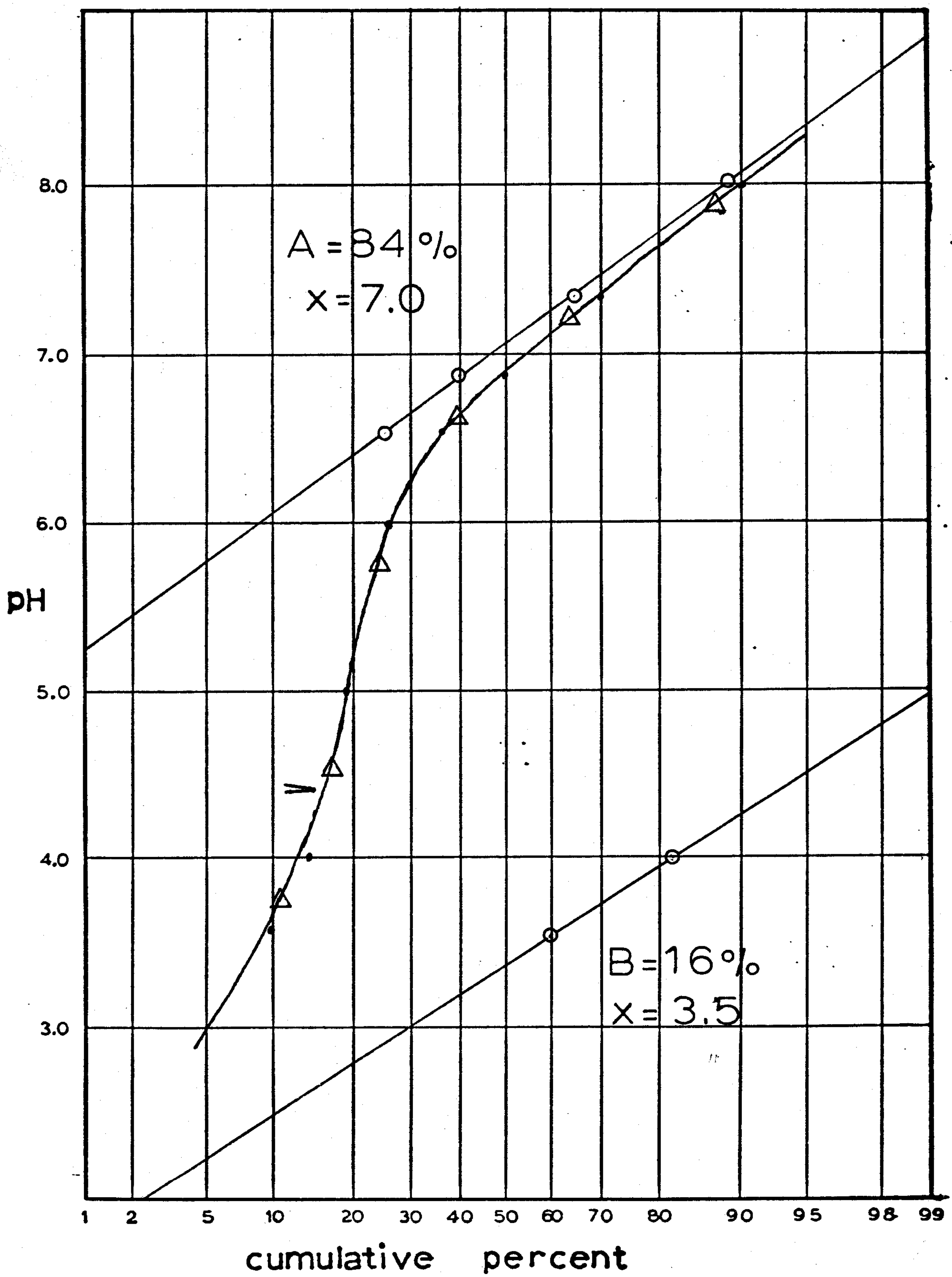


FIG. 4 pH UNIT 18 NEAR UNIT 19

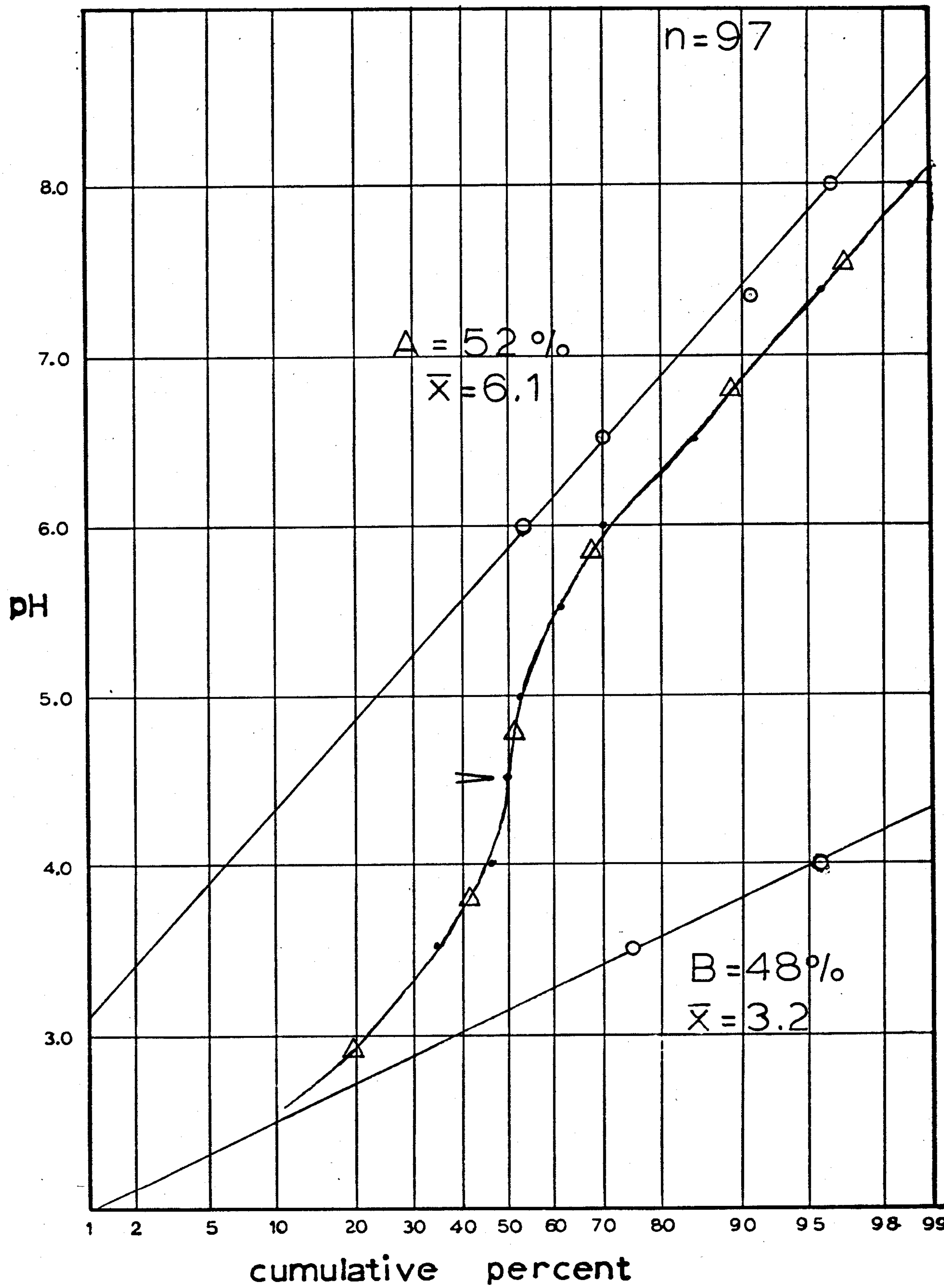


FIG. 5 COPPER UNIT 7

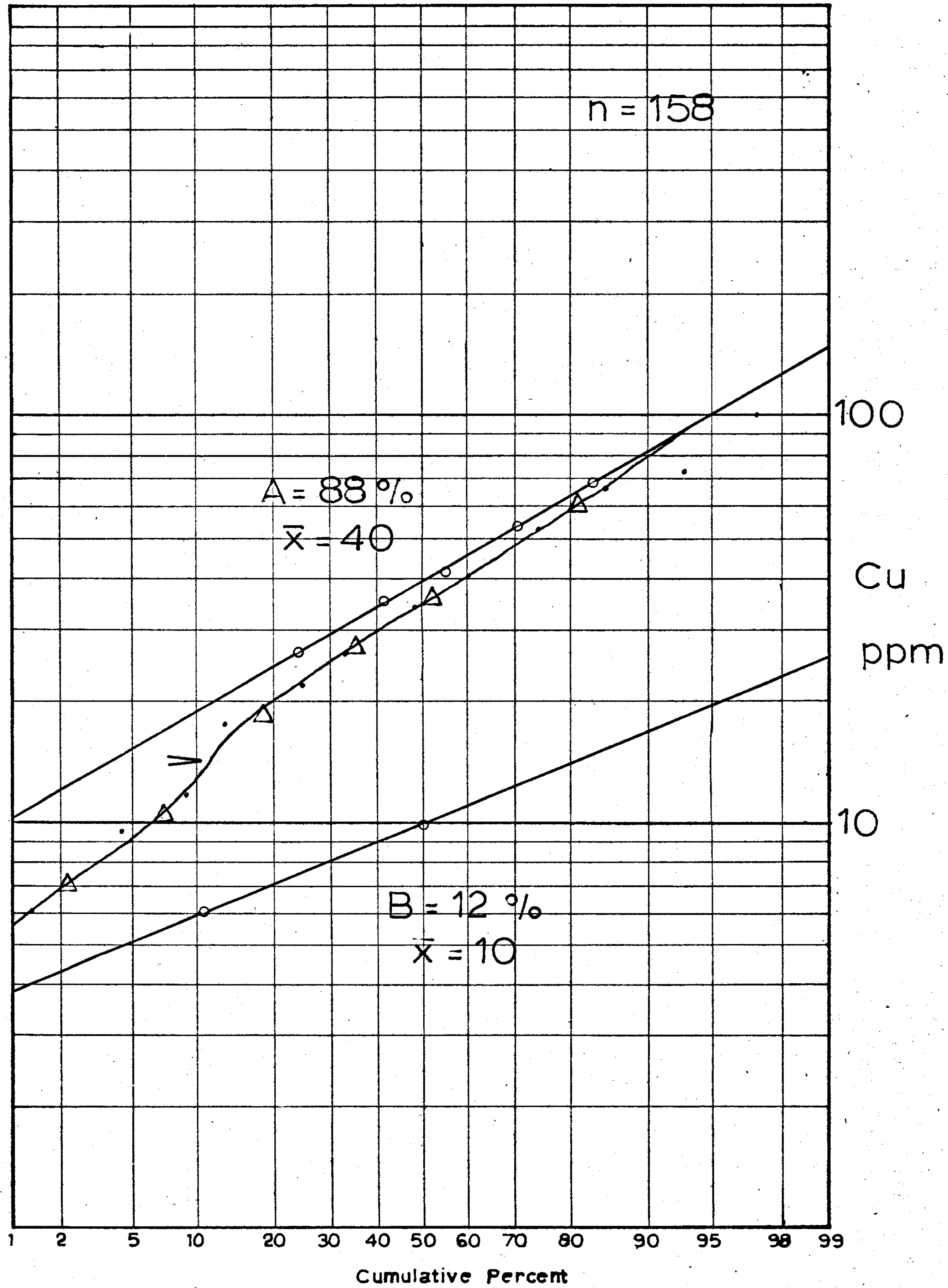


FIG. 6 LEAD UNIT 7

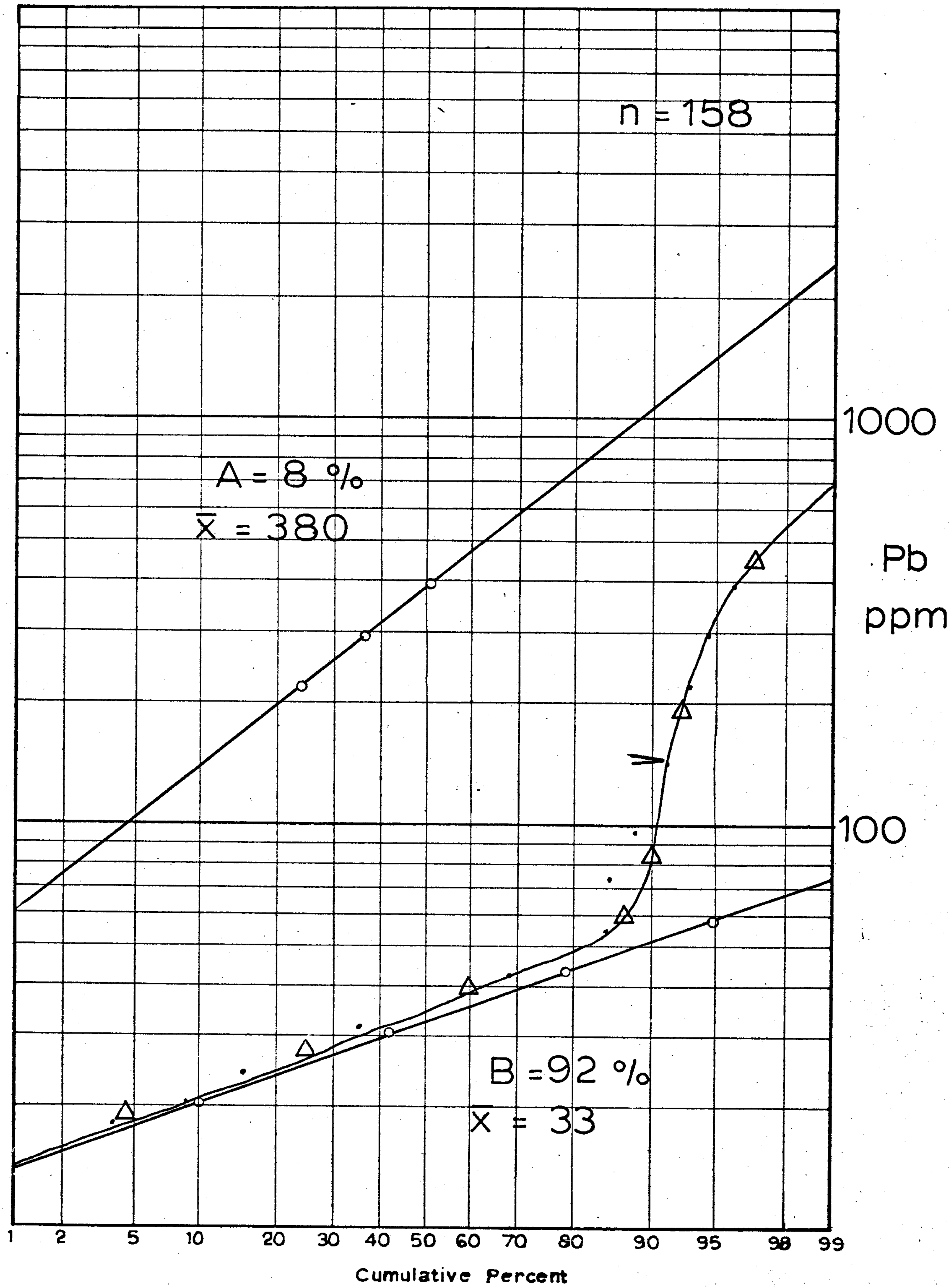


FIG. 7 ZINC UNIT 7

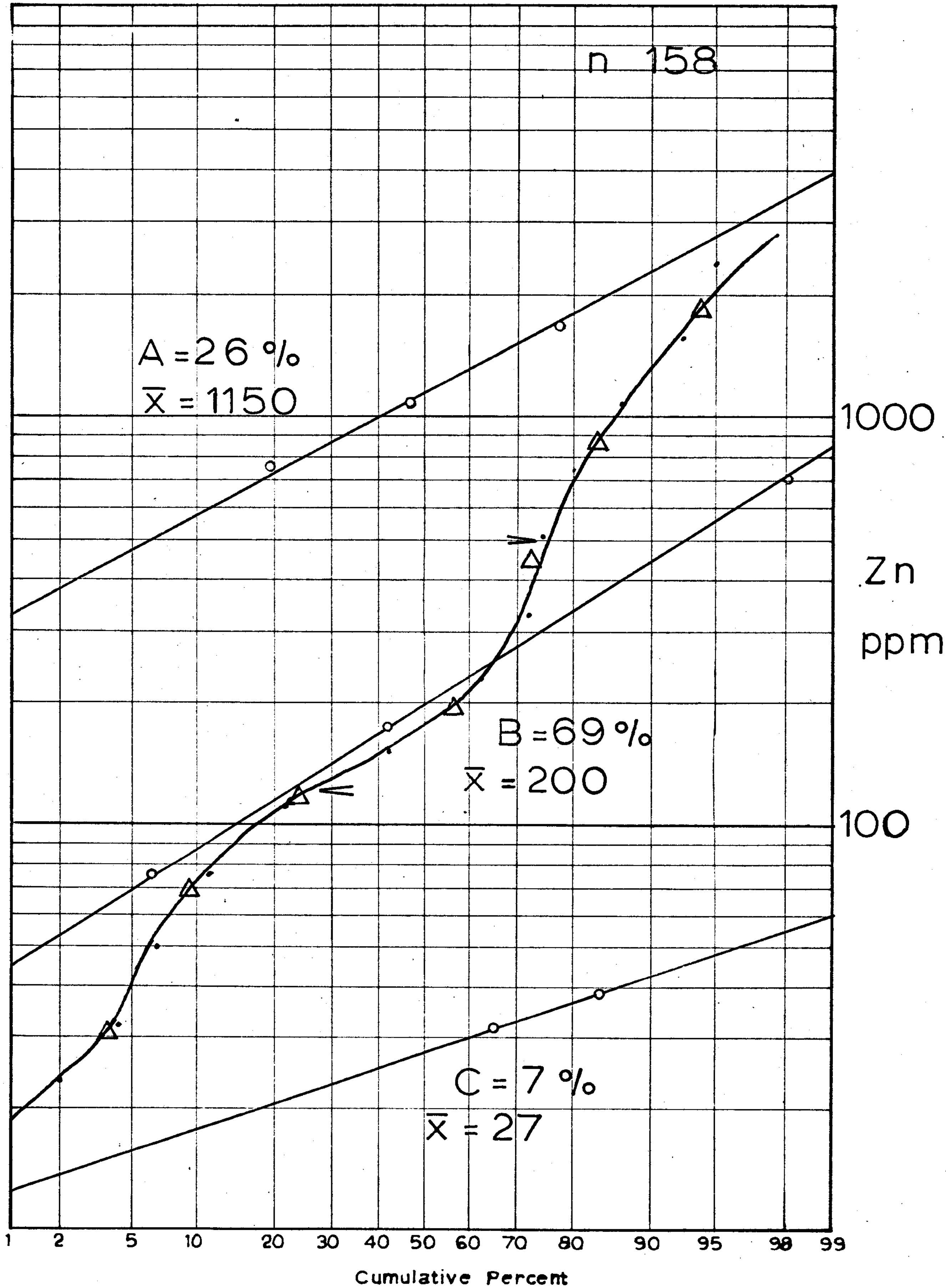


FIG. 8 COPPER UNIT 18

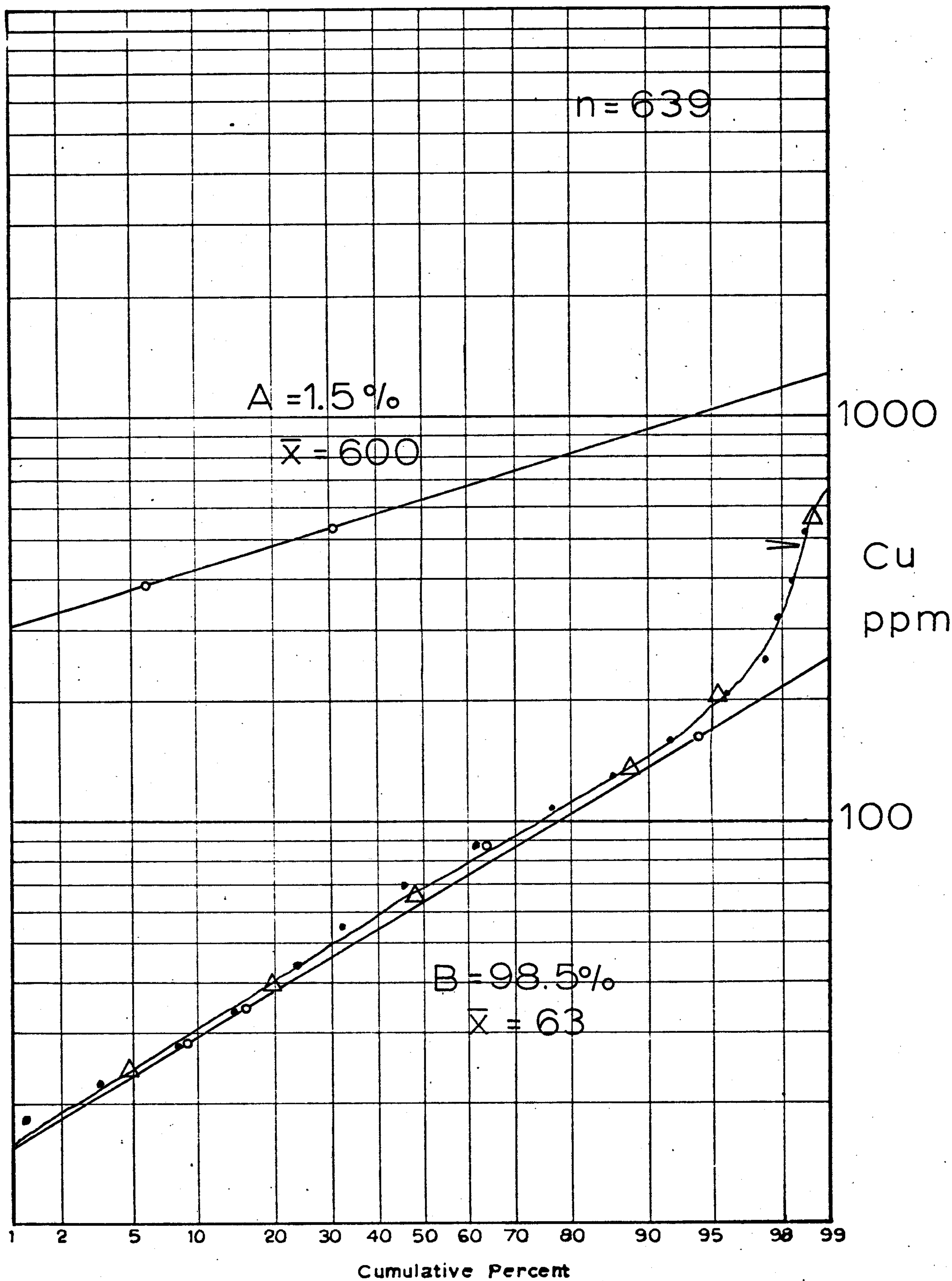


FIG. 9 LEAD UNIT 18

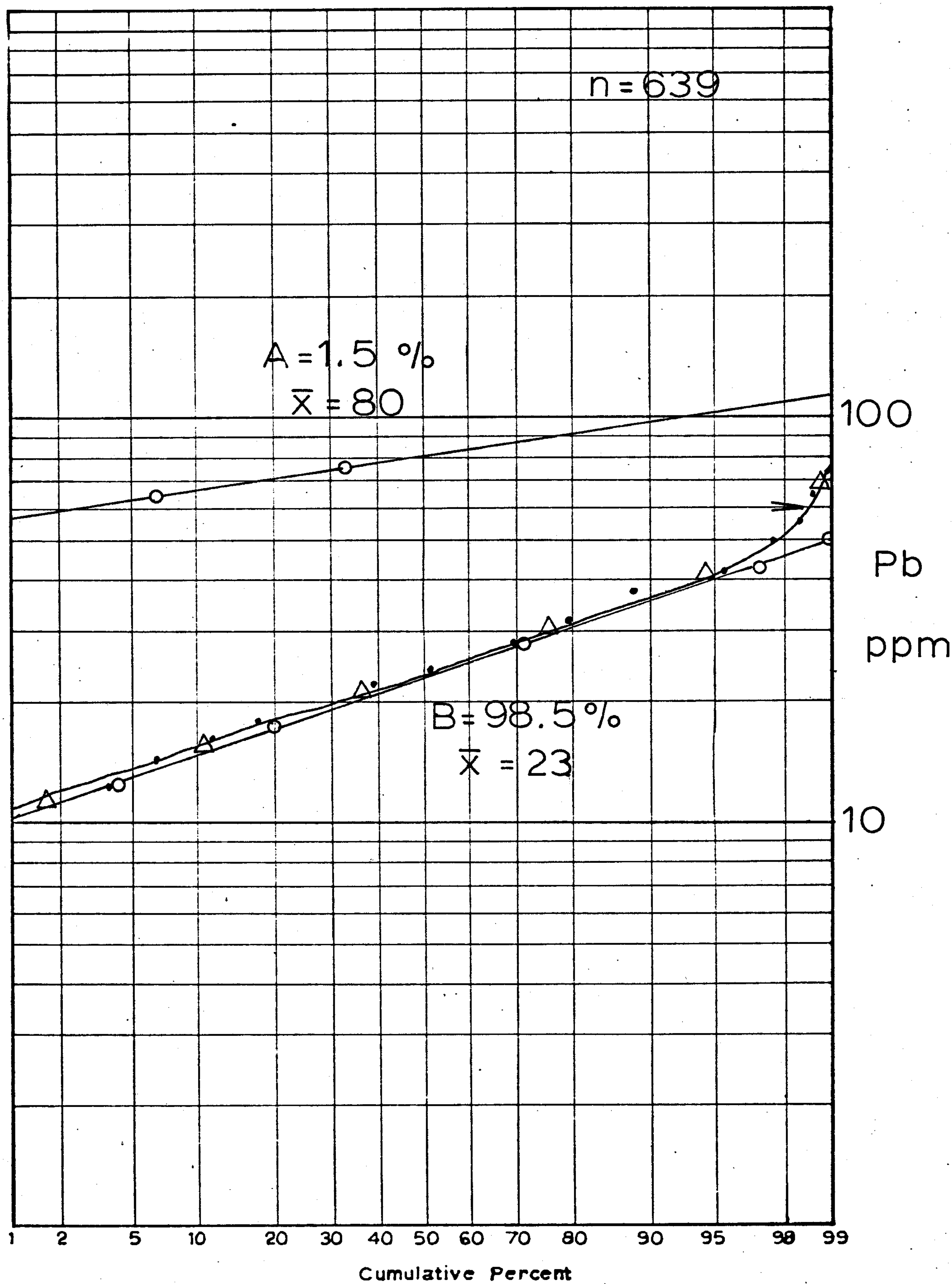
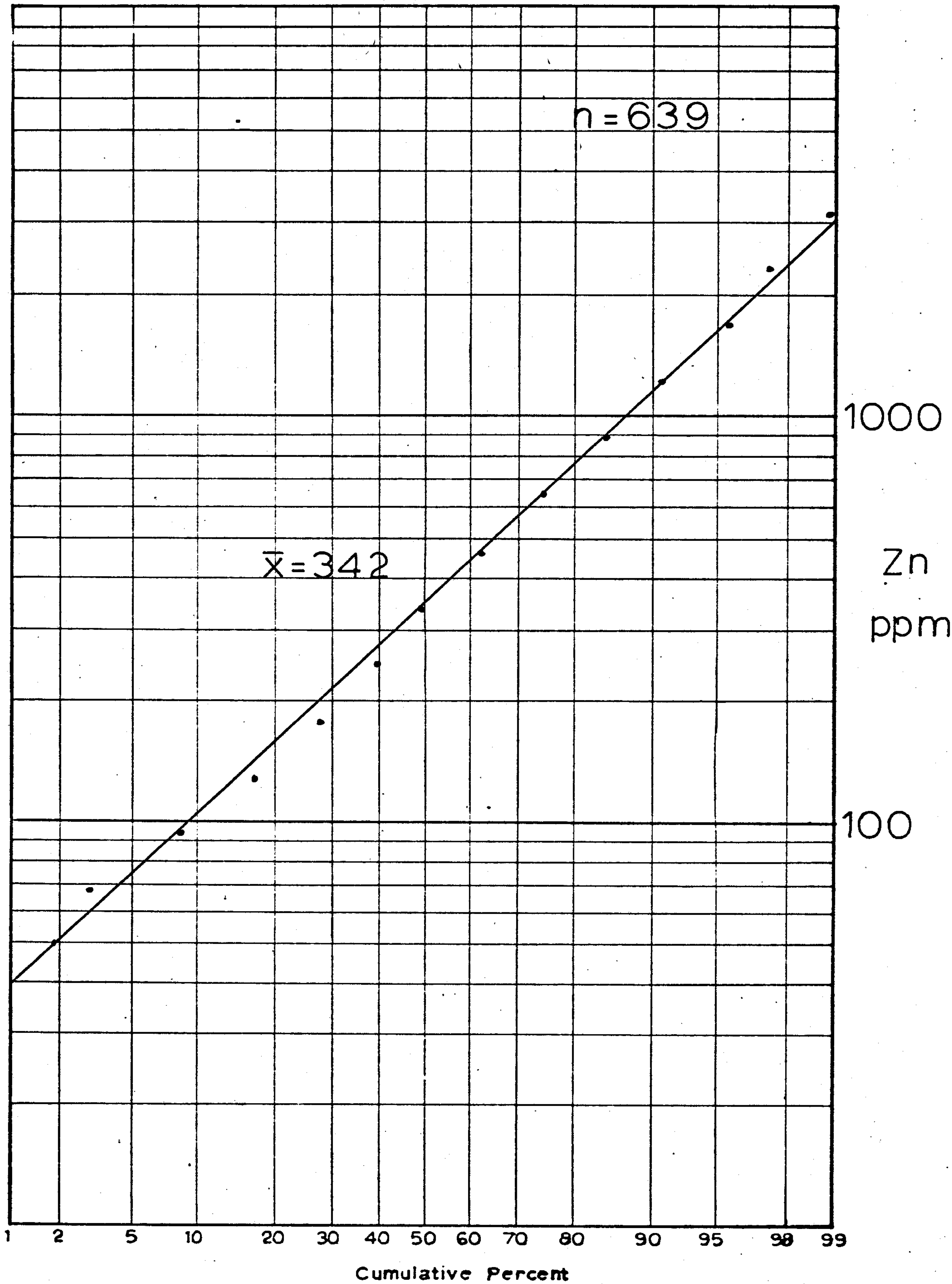


FIG. 10 ZINC UNIT 18



## Explanation for tables 2-1 to 2-3

unit=geology of subgroup according to table 1

n=number of samples per subgroup

x=geometric mean

s=log of standard deviation

type=population type

A=higheest of two populations
B=lowest of two populations, or intermediate of three populations
C=lowest of three populations
W=widest of two populations whose cumulatives curves cross
S=shortest of two populations whose cumulative curves cross

%=percent of population within the designated subpopulation

99+ =the value below which 99% of the subpopuation lies

99- =the value above which 99% of the population lies

range= log(99+) - log(99-)

# TABLE 2-1 COPPER POPULATIONS

| TITLE (UNIT) | n | $\bar{X}$ | S | NO. POP. | TYPE | % | $\bar{X}$ | 99 + | 99 - | RANGE |
|---|---|---|---|---|---|---|---|---|---|---|
| CU 1 | 109 | 30.1 | .190 | 2 | W | 50 | 31 | 140 | 7 | 1.301 |
| | | | | | S | 50 | 28 | 40 | 19 | .262 |
| CU 2 | 88 | 44.7 | .269 | 2 | A | 4 | 190 | 360 | 103 | .543 |
| | | | | | B | 96 | 43 | 125 | 15 | 2.130 |
| CU 3 | 17 | 23.3 | .134 | 1 | | | | | | |
| CU 4 | 11 | 17.7 | .171 | 1 | | | | | | |
| CU 5 | 21 | [illegible] | .226 | 1 | | | | | | |
| CU 6 | 17 | 14.3 | .290 | 1 | | | | | | |
| CU 7 | 159 | 34.3 | .282 | 2 | A | 93 | 38 | 155 | 9 | |
| | | | | | B | 7 | 8 | 18 | 4 | |
| CU 8 | 9 | 14.2 | .307 | 1 | | | | | | |
| CU 9 | 99 | 10.7 | .301 | 2 | A | 28 | 25 | 66 | 10 | .819 |
| | | | | | B | 72 | 8 | 19 | 3 | .802 |
| CU 10 | 13 | 19.7 | .199 | 1 | | | | | | |
| CU 15 | 20 | 14.6 | .128 | 1 | | | | | | |
| CU 16 | 25 | 37.4 | .412 | 1 | | | | | | |
| CU 18 | 639 | 68.7 | .293 | 2 | A | 1.5 | 600 | 1200 | 300 | .602 |
| | | | | | B | 98.5 | 63 | 290 | 1 | 2.447 |
| CU 19 | 31 | 25.2 | .335 | 1 | | | | | | |
| CU 18-19 | 97 | 56.0 | .353 | 1 | | | | | | |

# TABLE 2-2 LEAD POPULATIONS

| TITLE (UNIT) | n | $\bar{x}$ | s | NO. POP. | TYPE | % | $\bar{x}$ | 99 + | 99 - | RANGE |
|---|---|---|---|---|---|---|---|---|---|---|
| Pb 1 | 109 | 27.5 | [illegible] | 1 | | | | | | |
| Pb 2 | 89 | 32.0 | .123 | 2 | A | 5 | 66 | 85 | 52 | .213 |
| | | | | | B | 95 | 31 | 55 | 16 | .537 |
| Pb 3 | 17 | 33.7 | .103 | 1 | | | | | | |
| Pb 4 | 11 | [illegible] | .080 | 1 | | | | | | |
| Pb 5 | 21 | [illegible] | .274 | 1 | | | | | | |
| Pb 6 | 17 | 41.3 | .055 | 1 | | | | | | |
| Pb 7 | 159 | 41.1 | .363 | 2 | A | 8 | 380 | 2250 | 48 | |
| | | | | | B | 92 | 33 | 73 | 15 | |
| Pb 8 | | | | | | | | | | |
| Pb 9 | 99 | 41.1 | .125 | 2 | A | 85 | 49 | 86 | 27 | .502 |
| | | | | | B | 15 | 24 | 36 | 16 | .355 |
| Pb 10 | 13 | 37.7 | .126 | 1 | | | | | | |
| Pb 15 | 20 | 39.5 | .050 | 1 | | | | | | |
| Pb 16 | 25 | 38.8 | .153 | 1 | | | | | | |
| Pb 18 | 639 | 25.4 | .178 | 2 | A | 1.5 | 80 | 112 | 56 | .301 |
| | | | | | B | 98.5 | 24 | 54 | 10 | .732 |
| Pb 19 | 31 | 31.1 | .212 | 1 | | | | | | |
| Pb 18-19 | 97 | 36.5 | .167 | 1 | | | | | | |

# TABLE 2-3 ZINC POPULATIONS

| TITLE (UNIT) | n | $\bar{X}$ | S | NO. POP. | TYPE | % | $\bar{X}$ | 99 + | 99 - | RANGE |
|---|---|---|---|---|---|---|---|---|---|---|
| ZN 1 | 109 | 109 | .193 | 2 | A | 10 | 305 | 480 | 210 | .359 |
| | | | | | B | 90 | 92 | 200 | 46 | .639 |
| ZN 2 | 85 | 154 | .200 | 1 | | | | | | |
| ZN 3 | 17 | 92.1 | .295 | 1 | | | | | | |
| ZN 4 | 11 | 44.4 | .256 | 1 | | | | | | |
| ZN 5 | 21 | 127.1 | .307 | 1 | | | | | | |
| ZN 6 | 17 | 51.5 | .323 | 1 | | | | | | |
| ZN 7 | 158 | 235 | .502 | 3 | A | 26 | 1150 | 3850 | 340 | |
| | | | | | B | 69 | 200 | 815 | 46 | |
| | | | | | C | 7 | 27 | 60 | 13 | |
| ZN 8 | 9 | 95.8 | .301 | 1 | | | | | | |
| ZN 9 | 99 | 61.3 | .351 | 2 | A | 15 | 215 | 700 | 65 | 1.032 |
| | | | | | B | 85 | 46 | 165 | 13 | 1.104 |
| ZN 10 | 13 | 156.5 | .537 | 1 | | | | | | |
| ZN 15 | 20 | 124.2 | .140 | 1 | | | | | | |
| ZN 16 | 25 | 369.1 | .453 | 1 | | | | | | |
| ZN 18 | [illegible] | 342 | .416 | 1 | | | | | | |
| ZN 19 | 31 | 45.7 | .427 | 1 | | | | | | |
| ZN 18-19 | 97 | 149.1 | .414 | 1 | | | | | | |

A summary of the threshold values to be used in regional evaluation, appears in tables 3-1 to 3-3. It should be noted that the threshold values differ significantly between different rocks types, as it can hardly be assumed that the backgound should be the same for each geological unit.

O f great importance in this kind of geochemical evaluation, is the pH of stream water. As yet there has been no serious attempt to determine a way of estimating the effect of pH in a system with as many variables as that of ground water. Moreover if any meaningful relationship was to be derived it would probably pertain only to a few specific geochemical and geographical environments. Thus it would be necessary to calculate a series of pH-metal correlations in order to fully evaluate the geochemical profile of a typical environment.

Table 4 is a very crude estimation of a few pH-metal correlations. It should be kept in mind, however, that in deriving these pH factors no account has been taken of the variation of rock type within a geological unit. For example in unit 7, it is possible that rocks which are associated with a high pH are generally quite barren and that mineralized areas necessarily generate stream water of lower pH.

Table 3 - Threshold Values for Regional Evaluation

3-1 COPPER

| UNIT | PRIO. 1 | % | REMARKS | PRIO. 2 | % | REMARKS |
|---|---|---|---|---|---|---|
| 1 | ≥ 95 | 2.3 | 4.6 % OF A | ≥ 45 | 16 | 32 % OF W |
| 2 | ≥ 180 | 2.3 | 58 % OF A | ≥ 73 | 16 | 100 % OF A, 13 % OF B |
| 3 | ≥ 40 | 2.3 | ≥ 2 STDX | ≥ 30 | 16 | ≥ 1 STDX |
| 4 | ≥ 40 | 2.3 | ≥ 2 STDX | ≥ 26 | 16 | ≥ 1 STDX |
| 5 | ≥ 90 | 2.3 | ≥ 2 STDX | ≥ 54 | 16 | ≥ 1 STDX |
| 6 | ≥ 50 | 2.3 | ≥ 2 STDX | ≥ 26 | 16 | ≥ 1 STDX |
| 7 | ≥ 120 | 2.3 | 2.6 % OF A | ≥ 85 | 16 | 18 % OF A |
| 8 | ≥ 55 | 2.3 | ≥ 2 STDX | ≥ 28 | 16 | ≥ 1 STDX |
| 9 | ≥ 45 | 2.3 | 8 % OF A | ≥ 24 | 16 | 55 % OF A |
| 10 | ≥ 45 | 2.3 | ≥ 2 STDX | ≥ 30 | 16 | ≥ 1 STDX |
| 15 | ≥ 24 | 2.3 | ≥ 2 STDX | ≥ 18 | 16 | ≥ 1 STDX |
| 16 | ≥ 245 | 2.3 | ≥ 2 STDX | ≥ 96 | 16 | ≥ 1 STDX |
| 18 | ≥ 300 | 1.5 | 100 % OF A | ≥ 140 | 16 | 100 % OF A, 12 % OF B |
| 19 | ≥ 115 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |
| 18-19 | ≥ 280 | 2.3 | ≥ 2 STDX | ≥ 125 | 16 | ≥ 1 STDX |
| UNIT | PRIOR. 3 | % | REMARKS | | | |
| 9 | ≥ 10 | 45 | 100 % OF A, 25 % OF B | | | |

Table 3 - Threshold Values for Regional Evaluation

3-2 LEAD

| UNIT | PRIO. 1 | % | REMARKS | PRIO. 2 | % | REMARKS |
|---|---|---|---|---|---|---|
| 1 | ≥ 42 | 2.3 | ≥ 2 STDX | ≥ 32 | 16 | ≥ 1 STDX |
| 2 | ≥ 65 | 2.3 | 58 % OF A | ≥ 45 | 10 | 100 % OF A, 7 % OF B |
| 3 | ≥ 50 | 2.3 | ≥ 2 STDX | ≥ 40 | 16 | ≥ 1 STDX |
| 4 | ≥ 50 | 2.3 | ≥ 2 STDX | ≥ 44 | 16 | ≥ 1 STDX |
| 5 | ≥ 170 | 2.3 | ≥ 2 STDX | ≥ 90 | 16 | ≥ 1 STDX |
| 6 | ≥ 60 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |
| 7 | ≥ 570 | 2.3 | 29 % OF A | ≥ 60 | 12 | 100 % OF A, 5 % OF B |
| 8 | ≥ 70 | 2.3 | ≥ 2 STDX | ≥ 40 | 16 | ≥ 1 STDX |
| 9 | ≥ 78 | 2.3 | 2.7 % OF A | ≥ 60 | 16 | 19 % OF A |
| 10 | ≥ 65 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |
| 15 | ≥ 50 | 2.3 | ≥ 2 STDX | ≥ 44 | 16 | ≥ 1 STDX |
| 16 | ≥ 70 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |
| 18 | ≥ 55 | 1.5 | 100 % OF A | ≥ 32 | 16 | 100 % OF A, 14.5 % OF B |
| 19 | ≥ 80 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |
| 18-19 | ≥ 80 | 2.3 | ≥ 2 STDX | ≥ 50 | 16 | ≥ 1 STDX |

Table 3 - Threshold Values for Regional Evaluation

3-3 ZINC

| UNIT | PRIO. 1 | % | REMARKS | PRIO. 2 | % | REMARKS |
|---|---|---|---|---|---|---|
| 1 | ≥ 380 | 2.3 | 23% OF A | ≥ 200 | 10 | 100% OF A |
| 2 | ≥ 585 | 2.3 | ≥ 2 STDX | ≥ 300 | 16 | ≥ 1 STDX |
| 3 | ≥ 355 | 2.3 | ≥ 2 STDX | ≥ 180 | 16 | ≥ 1 STDX |
| 4 | ≥ 140 | 2.3 | ≥ 2 STDX | ≥ 80 | 16 | ≥ 1 STDX |
| 5 | ≥ 520 | 2.3 | ≥ 2 STDX | ≥ 255 | 16 | ≥ 1 STDX |
| 6 | ≥ 360 | 2.3 | ≥ 2 STDX | ≥ 170 | 16 | ≥ 1 STDX |
| 7 | ≥ 2230 | 2,3 | 9% OF A | ≥ 850 | 16 | 70% OF A |
| 8 | ≥ 380 | 2.3 | ≥ 2 STDX | ≥ 190 | 16 | ≥ 1 STDX |
| 9 | ≥ 360 | 2.3 | 15% OF A | ≥ 140 | 16 | 15% OF A, 4% OF [illegible] |
| 10 | ≥ 1850 | 2.3 | ≥ 2 STDX | ≥ 540 | 16 | ≥ 1 STDX |
| 15 | ≥ 230 | 2.3 | ≥ 2 STDX | ≥ 170 | 16 | ≥ 1 STDX |
| 16 | ≥ 2960 | 2.3 | ≥ 2 STDX | ≥ 1040 | 16 | ≥ 1 STDX |
| 18 | ≥ 2320 | 2.3 | ≥ 2 STDX | ≥ 900 | 16 | ≥ 1 STDX |
| 19 | ≥ 320 | 2.3 | ≥ 2 STDX | ≥ 120 | 16 | ≥ 1 STDX |
| 18-19 | ≥ 1000 | 2.3 | ≥ 2 STDX | ≥ 385 | 16 | ≥ 1 STDX |

| UNIT | PRIOR. 3 | % | REMARKS |
|---|---|---|---|
| 7 | ≥ 340 | 30 | 100% OF A, 20% OF B |
| 9 | ≥ 65 | 40 | 100% OF A, 27% OF B |

The information in table 4 was calculated from figures 11 to 15, in which metal values are plotted against a series of pH ranges. The validity of this method can hopefully be tested with regression analysis, however the writer does not believe that these relationships can be reduced to a simple regression equation. Much work remains to be done in this area.

For the purposes of aregional evaluation the data from tables 3-1 to 3-3 has been plotted on 1:250,000 scale maps. Maps 1-3 are useful in gaining an overall picture of the metal distribution in the Nahanni area. The 1:62,000 scale maps from which these were compiled are necessary to accurately establish areas for follow-up work.

Map 4 shows the distribution of streams (according to their pH) as divided into four ranges. A simple knowlege of the effect of lithology on stream pH , can make a map of this type a useful aid in prospecting. Assuming that an accurate pH-metal correlation does not exist, a map of pH becomes indespensible if a meaningful evaluation of geochemical data is to be attempted.

Perhaps more useful for population analysis is map 5, which shows for unit 18 only, the distribution of anomalously high and low pH values. When examined with reference to metal distribution, map 5 should give some indication of

the

the origin of pH populations and might help to solve the problem of pH-metal correlation.

# FIG.11 ALL UNITS METAL vs pH

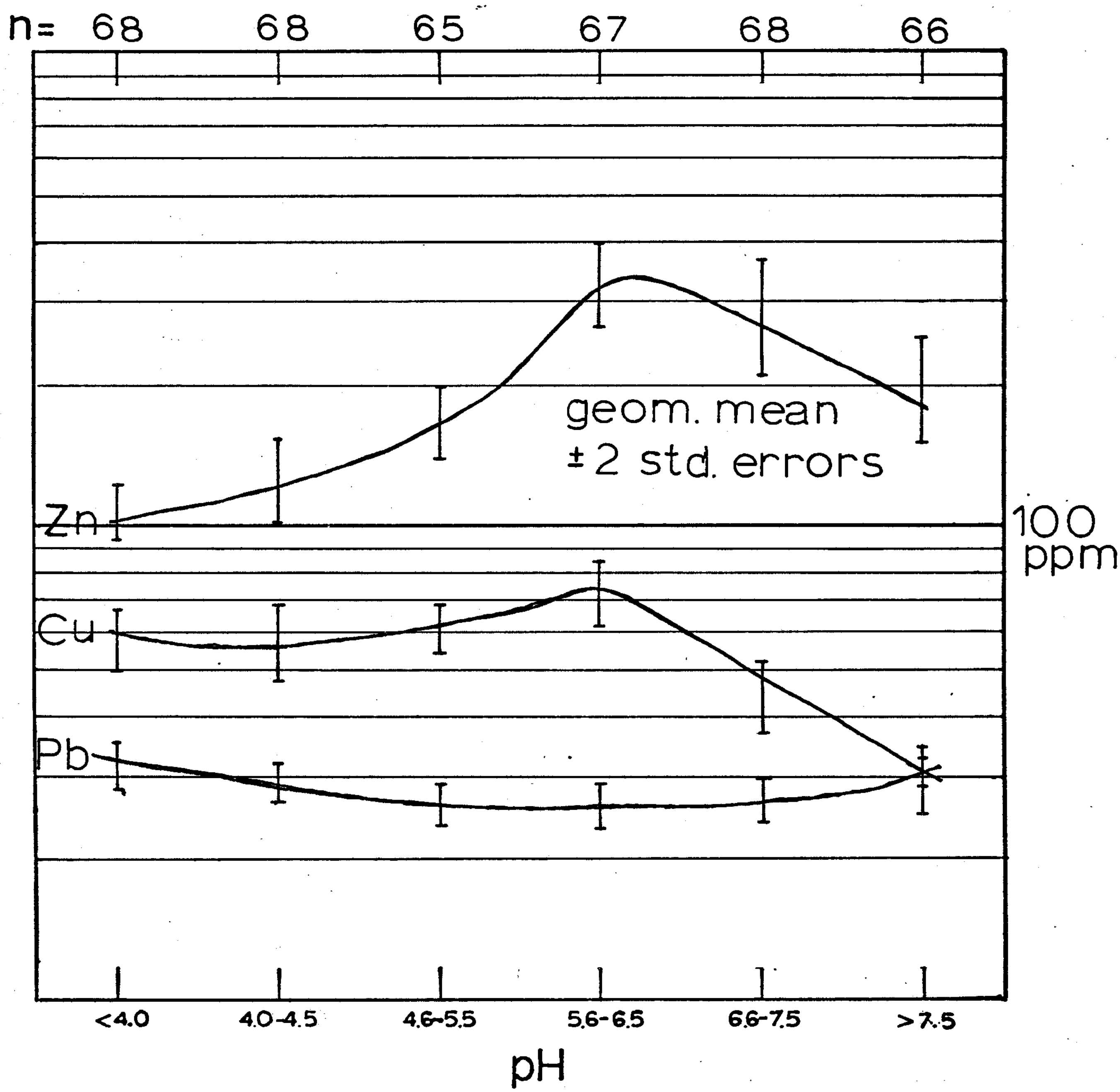


FIG. 12 UNIT 1 METAL vs pH

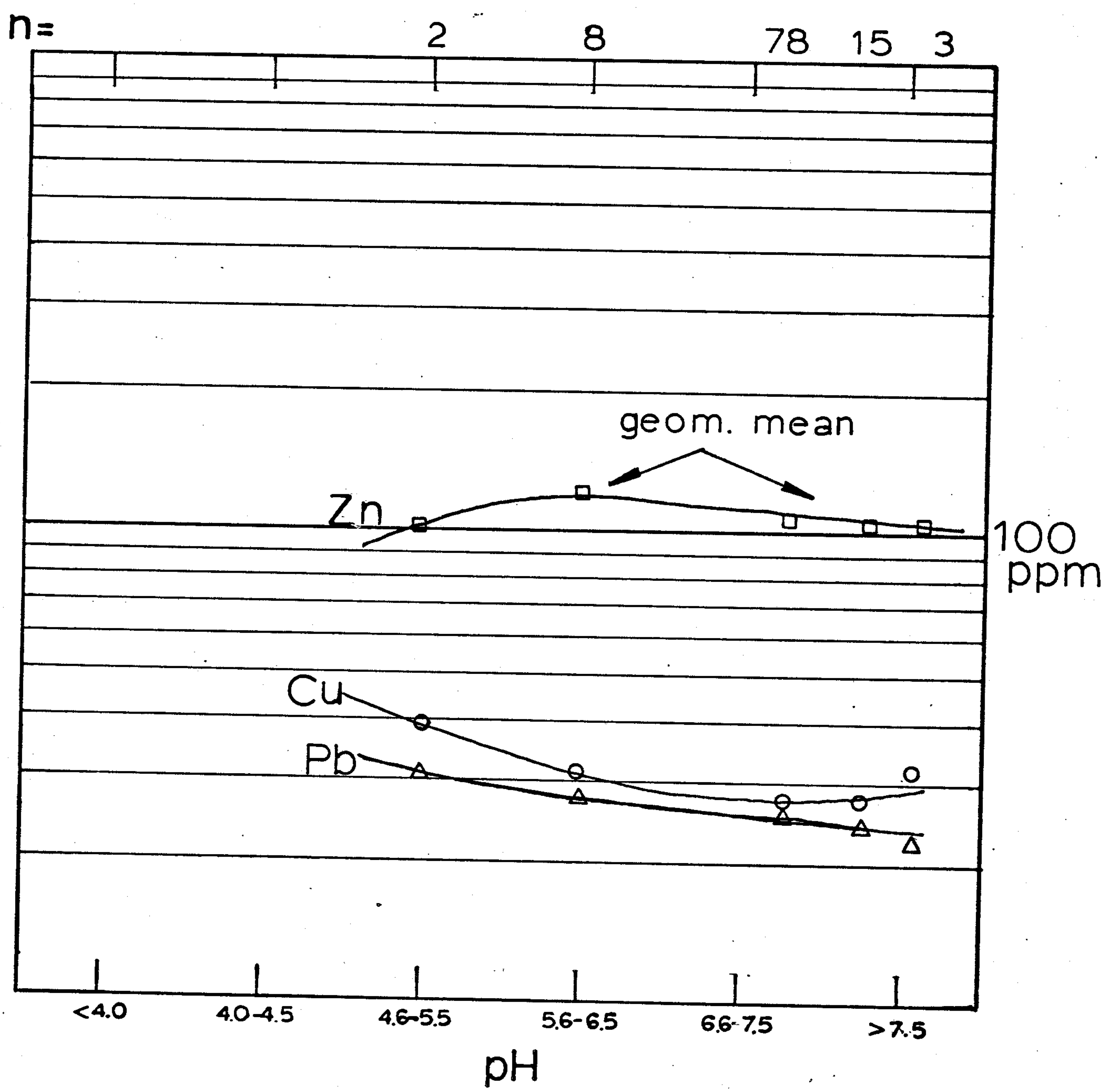


FIG. 13 UNIT 7 METAL vs pH

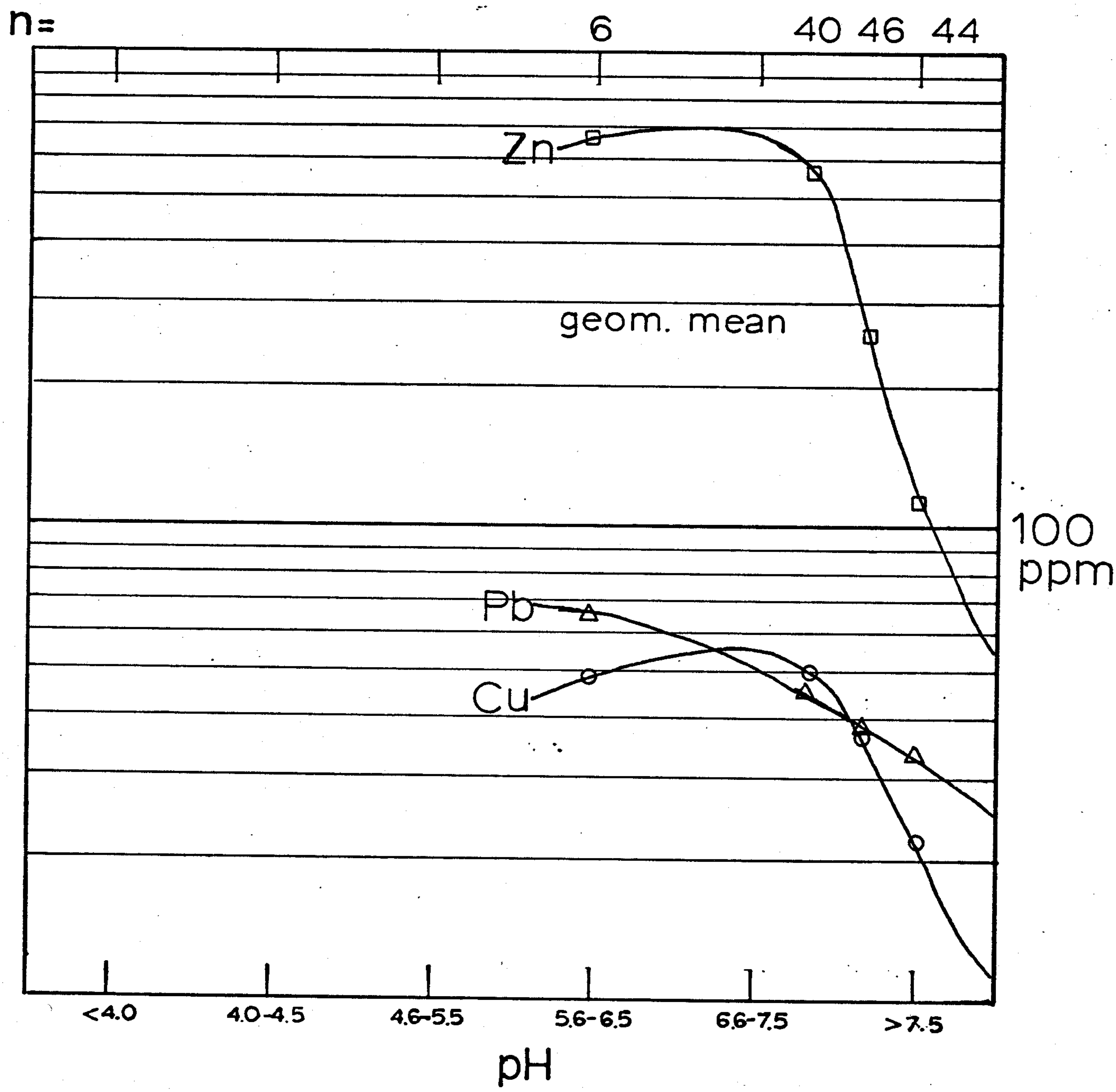
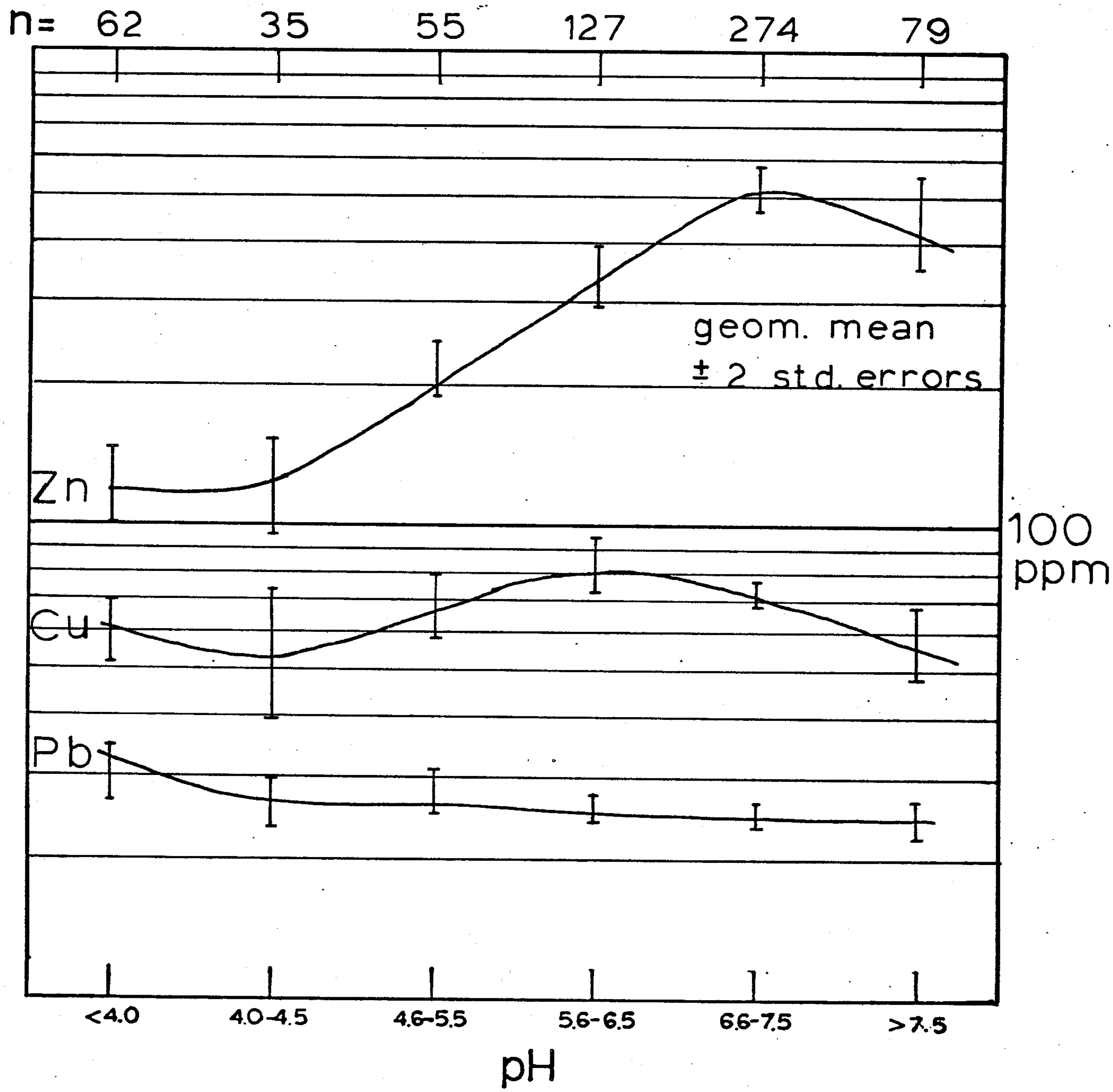


FIG. 14 UNIT 18 METAL vs pH



## TABLE 4 pH CORRECTIONS FOR REGIONAL EVALUATION

1 Total population

| pH range | Cu factor | Zn factor | Pb factor |
|---|---|---|---|
| > 7.5 | 2.50 | 1.79 | N/A |
| 6.6 to 7.5 | 1.67 | 1.26 | |
| 5.6 to 6.5 | 1.00 | 1.00 | |
| 4.6 to 5.5 | 1.21 | 1.94 | |
| 4.0 to 4.5 | 1.32 | 2.62 | |
| < 4.0 | 1.25 | 3.09 | |

2 Unit seven (limestone)

| pH range | Cu factor | Zn factor | Pb factor |
|---|---|---|---|
| > 7.5 | 6.0 | 7.0 | 2.0 |
| 7.5 to 7.9 | 1.5 | 2.8 | 2.0 |
| 7.0 to 7.4 | 1.0 | 1.2 | 1.4 |
| < 7.0 | 1.2 | 1.0 | 1.0 |

3 Unit eighteen (shale)

| pH range | Cu factor | Zn factor | Pb factor |
|---|---|---|---|
| > 7.5 | 1.45 | 1.25 | N/A |
| 6.6 to 7.5 | 1.14 | 1.00 | |
| 5.6 to 6.5 | 1.00 | 1.43 | |
| 4.6 to 5.5 | 1.20 | 2.50 | |
| 4.0 to 4.5 | 1.54 | 4.00 | |
| < 4.0 | 1.34 | 4.00 | |

# LEGEND FOR 105 I GEOLOGY MAP

**Cret.**

19 (G.S.C. code) — monzonite, granodiorite, granite

**Sil. & Dev.**

18 — shale, chert, pebble conglomerate (limestone bands west of line)

16 — limestone

15 — limestone, dolomite

11-14 — dolomite, limestone

**Ord. & Sil.**

10 — black shale, argillaceous limestone

9 — dolomite, limestone

**U. Camb. & Ord.**

7 — limestone, dolomite

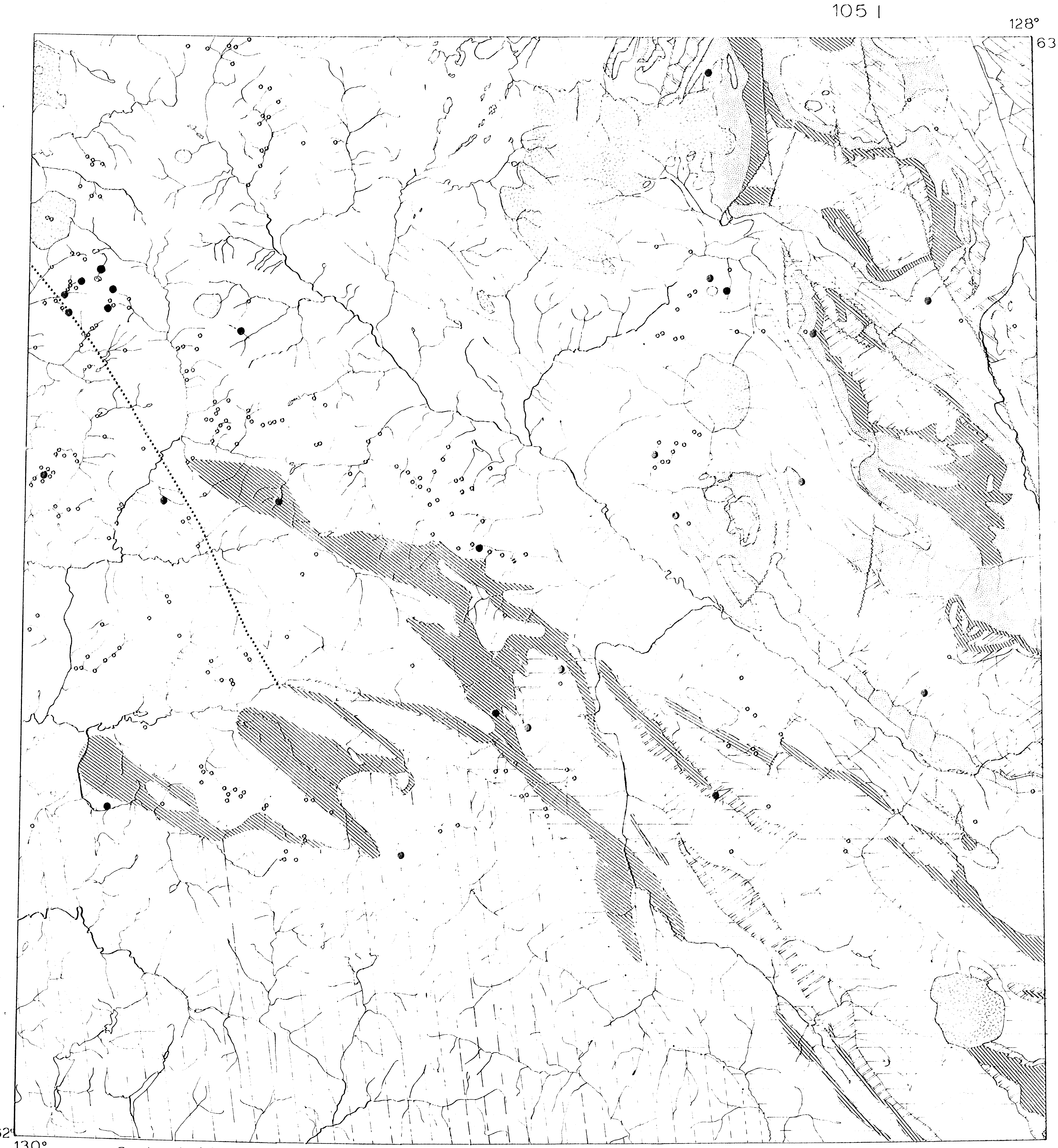
**Camb.**

3-6 — dolomite, siltstone, quartzite, limestone

**Camb. & earlier**

2 — slate, phyllite

1 — quartzite, conglomerate, shale, phyllite



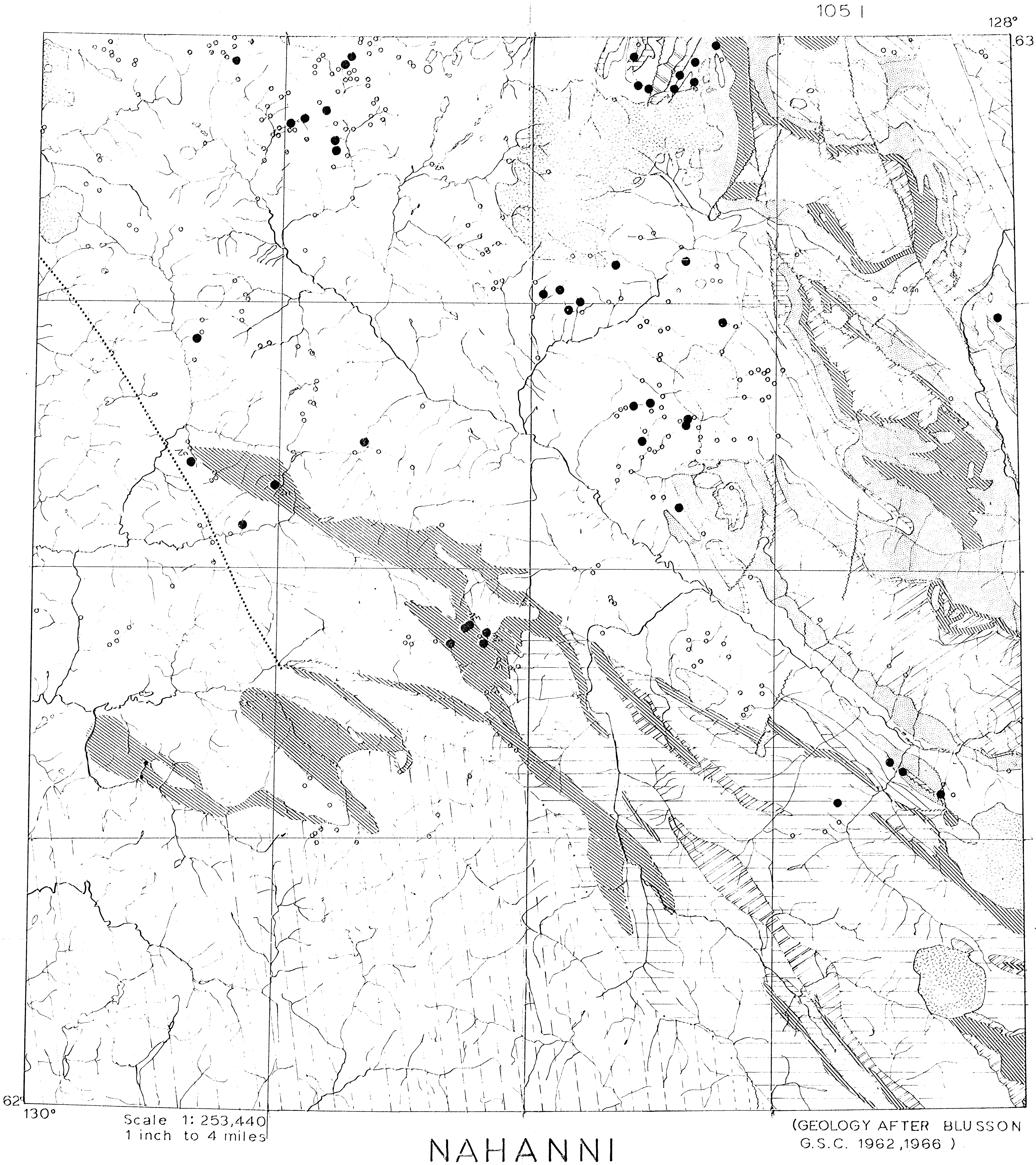

Scale 1: 253,440
1 inch to 4 miles

# NAHANNI

(GEOLOGY AFTER BLUSSON
G.S.C. 1962 ,1966 )

## 1 - COPPER DISTRIBUTION

- ● 1st priority
- ∘ 2nd priority

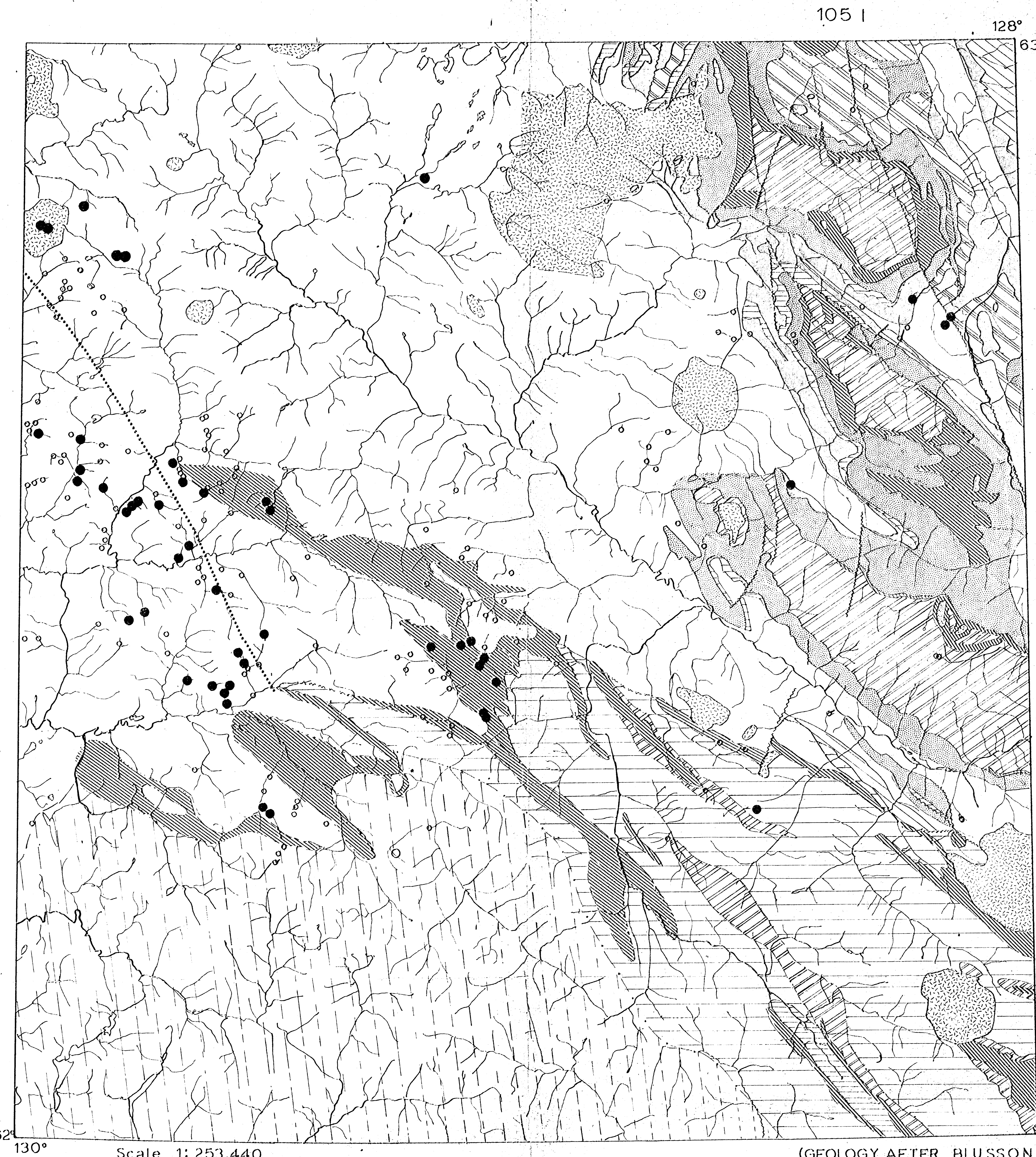



# NAHANNI

## 2 - LEAD DISTRIBUTION

● 1st priority

○ 2nd priority




Scale 1: 253,440
1 inch to 4 miles

(GEOLOGY AFTER BLUSSON
G.S.C. 1962, 1966 )

# NAHANNI

## ZINC DISTRIBUTION

● 1st priority
○ 2nd priority


Scale 1: 253,440
1 inch to 4 miles

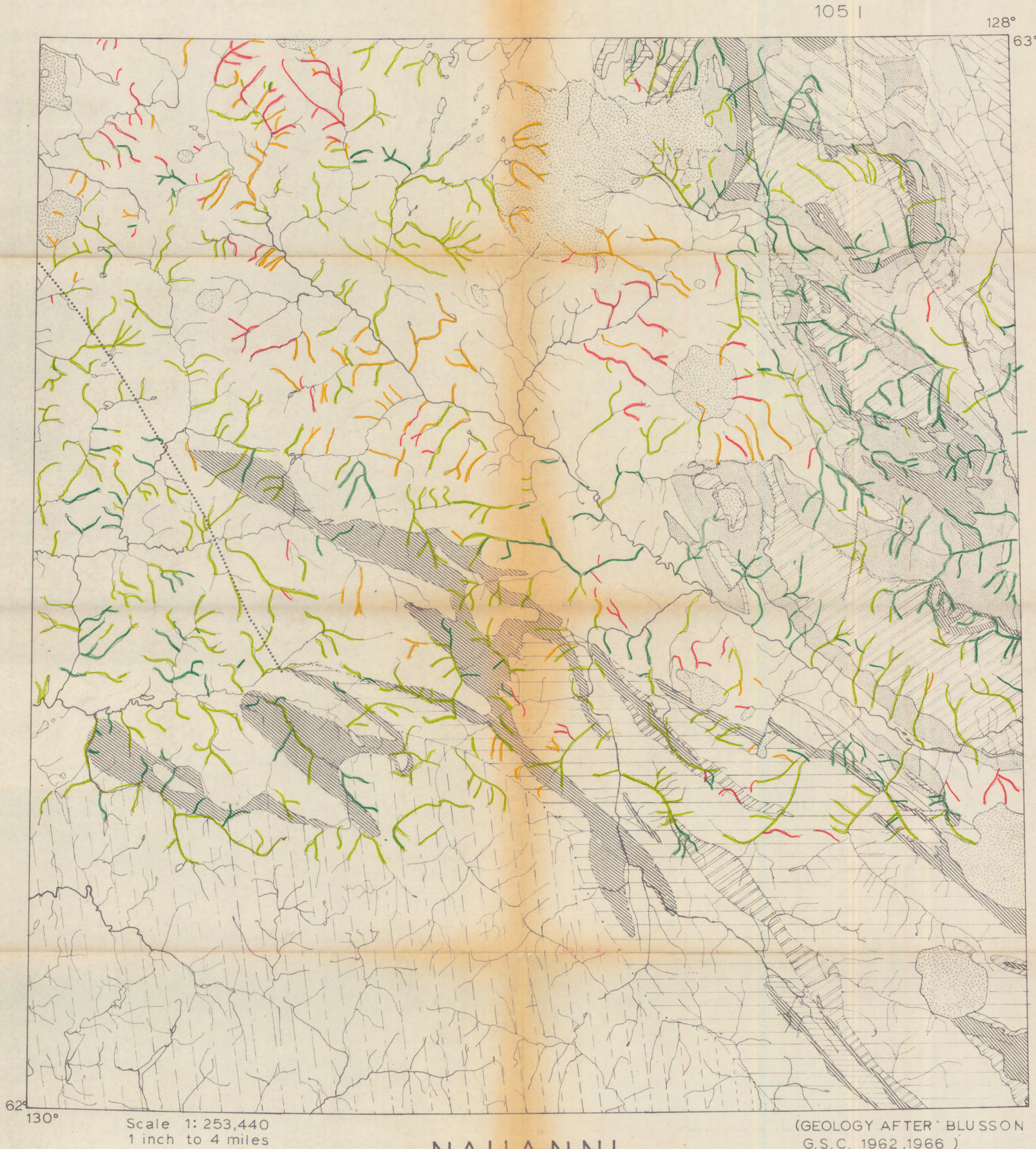
(GEOLOGY AFTER BLUSSON
G.S.C. 1962, 1966 )

# NAHANNI

## 5- pH anomalies

— basic
— acid

(unit 18 only)




# NAHANNI

## 4 - pH worms

- 0-5.5
- 5.6-6.5
- 6.6-7.5
- 7.6-14