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GEOPEKO LIMITED

KING ISLAND

REPORT NO. KI/75/2

A STATISTICAL STUDY OF GEOCHEMICAL DATA FROM SOUTH-EASTERN KING ISLAND.

by R. V. SMART

approved by M. C. ROGERS

KING ISLAND MARCH, 1975.

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INTRODUCTION

A considerable amount of geochemical data has been collected from the contact aureole of the Grassy granite (Figure 1). This data includes assays for Mo and W in about 2,000 samples of rock chips from percussion drill holes and assays for Cu, Ni, Zn, Mo and W in about 1,000 samples of soil from the base of the B-horizon obtained by auger drilling.

This geochemical data has been supplemented with assays for Mo and W of 240 rock samples from the east coast of King Island to the north of Grassy (Figure 1). The rocks in that area are outside the contact aureole of the granite but are probably stratigraphically equivalent to the sequence of rocks in the contact aureole.

The geochemical data has been processed statistically with the following as objectives:

1. The determination of how Mo and W moved during mineralisation and weathering of the rocks of the contact aureole, particularly the mine series.
2. The presentation of criteria for the delineation of areas subjected to Mo or W mineralisation and the use of those criteria in conjunction with available data for that purpose.
3. The provision of information required to make a statistical inference as to the type of basement rock at a given locality in the contact aureole given Cu, Ni, Zn, Mo and W assays for a soil sample from immediately above bedrock at that locality.

The purpose of this report is to describe the statistical treatment of the geochemical data and to present the results obtained and the conclusions reached in the fulfilling of the above three objectives.

SUMMARY

The specific rock and soil types of the contact aureole and of the east coast to which attention is directed in this report are set out in Table 1.

TABLE 1

Rock Types of the Contact Aureole	Probable Equivalent Rocks on the East Coast	Initial Weathering Product
Upper volcanics	Basaltic volcanics	Weathered volcanics
Middle volcanics	Dolerite	" "
Mine series	Shale, limestone and tilloid	Weathered mine series
Overlying siltstone	Not considered	Weathered overlying siltstone
Underlying siltstone	" "	Weathered underlying siltstone

Table 1: Rock types of the contact aureole and other related rock and soil types to which attention is directed.

A preliminary study was made of the movements of Cu, Ni, Zn, Mo and W during mineralisation of the contact aureole. No strong introduction of Cu, Ni or Zn was indicated, so the present study concentrates on the movements of Mo and W only.

It is possible to approximate the populations of logarithms of Mo and W concentrations in each rock or weathered rock type of the contact aureole and of the east coast by a single normally distributed population or by a combination in appropriate proportions of two or more normally distributed populations, but this is a subjective process. Synoptic diagrams showing graphs of the distribution functions* of all the component normally distributed populations are presented in Figures 2, 3, 4 and 5.

The probable movements of Mo and W are ascertained by interpreting the origins of the component populations of Mo and W in the various rock and weathered rock types.

* The graph of a distribution function is commonly called a "cumulative frequency curve".

Table 2 gives the threshold values* for Mo and W populations in mine series and weathered mine series. (There are four component populations of both Mo and W in the mine series and the same is true of the weathered mine series.)

TABLE 2

Rock or Soil Type	Mo Threshold Values		W Threshold Values	
	$\log_{10}$ (conc. in ppm)	conc. in ppm	$\log_{10}$ (conc. in ppm)	conc. in ppm
Mine series	1.17 FRESH 2.51 2.93	14.8 323 851	1.17 2.14 2.83	14.8 138 676
Weathered mine series	0.73 SOIL 1.73 ?	5.4 53.7 ?	1.17 2.51 2.99	14.8 324 977

Table 2: Threshold values for Mo and W populations in mine series and weathered mine series.

The probabilities of incorrectly classifying a Mo or W assay in mine series or weathered mine series as a product of strong mineralisation or otherwise because it does or does not exceed the appropriate intermediate threshold value respectively have been calculated and do not exceed 0.05 .

Figures 6a, b and c show the locations of percussion and auger drill holes which produced samples of mine series or weathered mine series with concentrations of Mo either exceeding the appropriate intermediate threshold value or falling between the appropriate low and intermediate threshold values. Figures 7a, b and c are analogous to Figures 6a, b and c but apply to W concentrations. In accordance with Conclusions 8 and 9 (q.v.) these figures suggest that there may be Mo or W ore bodies in various areas as summarized in Table 3.

* A threshold value is one at which a local minimum occurs in the probability density function - the function which defines the "form" of the distribution.

TABLE 3

Area	Nature of Suggested Ore Body
Investigator 2	Mo and W, at depth.
Investigator 3	Mo and W, near surface; W, at depth.
Investigator 6	Mo and W, near surface.
Investigator 21	Mo and W, at depth.
Investigator 22	W, near surface.
Investigator 23	W, at depth.
Investigator 24	W, at depth.

Table 3: The suggested positions and types of possible Mo and W ore bodies.

Further testing for the possible ore bodies in the various areas listed in Table 3 has been completed by means of diamond drilling. None of the areas proved to contain economic Mo or W ore bodies. All, however, were found to contain at least minor molybdenite or scheelite or both, in accordance with the suggested type of ore body, with the exceptions of Investigator 3, which did not contain significant molybdenite, and Investigator 23, which did not contain significant scheelite. Table 5 gives details of the relevant diamond drill hole intersections in the various areas concerned.

Figures 8, 9, 10, 11 and 12 show some values of the distribution functions, as percentages, for the populations of Cu, Ni, Zn, Mo and W concentrations in samples of soil derived from four rock types of the contact aureole, namely mine series, volcanics, overlying siltstone and underlying siltstone. The mine series is distinguished by high Cu, Zn and W content and the volcanics by high Ni content. The underlying siltstone is distinguished from the overlying siltstone by the low Ni and high Mo contents of the former.

CONCLUSIONS

1. No strong introduction of Cu, Ni or Zn occurred during mineralisation of the rocks of the contact aureole.

2. The east coast rocks contain single low-valued populations of Mo and W which are interpreted as background or original populations.

3. The upper volcanics of the contact aureole contain a background population and a higher-valued mineralised population of Mo and similarly for W. In accord with this is the common occurrence of molybdenite in joints and fractures through the upper volcanics, visible in the Bold Head Decline.

4. The middle volcanics of the contact aureole contain a single low-valued population of Mo which has too great a variance to be a background population. So it is suggested that no significant amount of Mo has entered the middle volcanics though Mo has been redistributed within the rock type as a whole.

   The middle volcanics contain a background population and a higher-valued mineralised population of W.

5. The mine series contains a background and three higher-valued mineralised populations of Mo and the same is true of its content of W. Mo and W have been introduced into the mine series of the contact aureole by three different mechanisms. The least efficient of these mechanisms is probably the same mechanism responsible for mineralisation in the upper and middle volcanics and may be a process of solid state diffusion, aided by the presence of joints and faults. The other two mechanisms are probably compositionally controlled and only take place when certain rock types or combinations of rock types are present in the mine series.

6. Mo is depleted and W slightly depleted from the volcanics of the contact aureole during weathering. Original distinct populations in the upper and middle volcanics lose their identity.

7. Mo is almost certainly depleted from and W slightly enriched in the mine series of the contact aureole by weathering. It appears that original distinct populations in the mine series remain distinguishable in weathered mine series.

8. Further to Conclusion 5, the intermediate Mo and W threshold values for fresh mine series rocks (323 and 138 ppm respectively) are the most useful for distinguishing strata which may contain ore bodies. Strata in which Mo and W assays exceed the low threshold values (14.8 ppm for both Mo and W) have been weakly mineralised and may contain ore bodies at some distance from the sample locality.

9. Because original mine series populations of Mo and W appear to be preserved during weathering, the intermediate Mo and W threshold values for soil derived from mine series rocks (53.7 and 324 ppm respectively) are the most useful for delineating areas which may contain ore bodies in contact with the zone of soil formation. Areas in which Mo and W assays exceed the low threshold values for soil overlying mine series rocks (5.4 and 14.8 ppm respectively) may contain ore bodies at depth.

10. The technique of geochemical prospecting is effective in the search for Mo and W ore bodies in the mine series of the contact aureole using the threshold values suggested in Conclusions 8 and 9 even though the data considered in this study did not reveal any ore bodies which were economic.

11. Figures 8, 9, 10, 11 and 12 can be used to determine whether the basement rock type at any locality in the contact aureole is mine series, volcanics, overlying siltstone or underlying siltstone, given Cu, Ni, Zn, Mo and W assays for a soil sample from immediately above the basement at that locality. In those cases where the basement rock type is known to be one of two types, the probability of an incorrect identification can also be determined from the figures.

12. The truth of the preceding conclusions depends upon the following assumptions.

    (a) The east coast rocks are stratigraphically equivalent to the rocks of the contact aureole.

    (b) The population of concentrations of an element in a given rock or soil type is infinite.

    (c) The accuracy of assaying is as good as the reported figures imply.

    (d) The sample of each population of concentrations of an element in a given rock or soil type is truly representative of the population.

    (e) The populations of Cu, Ni and Zn concentrations in the four major rock types of the contact aureole are log-normal.*

* The logarithms of the concentrations are normally distributed.

RECOMMENDATIONS

1. It is unlikely that economic concentrations of Cu, Ni or Zn will be found in the contact aureole of the Grassy granite; moreover it is unlikely that economic concentrations of Mo or W will be found in any rock type of the contact aureole other than the mine series. Further prospecting should be directed accordingly.

2. The technique of geochemical prospecting should be retained in the search for Mo and W in the mine series of the contact aureole (unless another technique proves to be equally effective yet cheaper).

3. In geochemical prospecting for Mo and W using assays for these elements in fresh mine series rocks, threshold values of 323 and 138 ppm should be used for Mo and W assays respectively in order to define strata which may contain ore bodies. A threshold value of 14.8 ppm should be used for both Mo and W assays in order to distinguish strata which have been mineralised and may contain ore bodies elsewhere.

4. In geochemical prospecting for Mo and W using assays for these elements in samples of soil derived from mine series rocks, threshold values of 53.7 and 324 ppm should be used for Mo and W assays respectively in order to define areas which may contain ore bodies in contact with the zone of soil formation. Threshold values of 5.4 and 14.8 ppm should be used for Mo and W assays respectively in order to define areas which may contain Mo and W ore bodies at depth.

5. When a soil sample from an auger drill hole in the contact aureole is not accompanied by chips of basement rock or when chips of basement rock are recovered but are too weathered to be identified, Cu, Ni, Zn, Mo and W assays for the sample should be used in conjunction with Figures 8, 9, 10, 11 and 12 to identify the basement rock type. If the basement is known with certainty to be one of two rock types, then the probability of an incorrect identification should be stated.

ACTION SHEET

STATISTICAL TREATMENT OF THE GEOCHEMICAL DATA

1. Rock and soil types to which attention is directed.

In the statistical treatment of the geochemical data, attention was directed towards certain rock types of the contact aureole, their probable equivalents on the east coast and their initial weathering products. These rock and soil types are set out in Table 1 (refer to Summary - page 4).

The strata of the east coast are thought to be equivalent to the contact metamorphosed strata surrounding the Grassy granite for three reasons. Firstly, the relative positions and orientations of the two sets of strata, though not suggestive of obvious stratigraphic continuity between them, do not preclude their stratigraphic equivalence. Secondly, there are possible parent rocks among the east coast rocks for most of the metamorphosed rocks surrounding the granite. Thirdly, it has been shown (Rogers and Smart, 1974) that a very distinctive lithological unit of the east coast (a tilloid) has, in great detail, the characteristics which would be expected in the parent of an equally distinctive lithological unit of the metamorphosed strata (a marble podded pyroxene-garnet hornfels).

The initial weathering products of rocks of the contact aureole were sampled by auger drilling. From each hole, the last few layers of soil penetrated before reaching bedrock were collected together with any chips of bedrock which may have been brought to the surface. The soil only was sent away for assaying; the chips of bedrock were used to determine the type of rock from which the soil formed.

2. Movement of Mo and W during mineralisation and weathering of the contact aureole of the Grassy granite

Preamble

In a preliminary study in which Cu, Ni and Zn were considered in addition to Mo and W, it was not possible to demonstrate that any strong Cu, Ni or Zn mineralisation had occurred in rocks of the contact aureole. Hence only Mo and W are considered here.

The Mo and W concentrations in the rock and soil types of Table 1 have been regarded as continuous random variables and the populations of these concentrations have been assumed to be infinite in size. The geochemical data available provide finite samples of these populations. In accordance with the assumption made here, inferred distribution functions were derived for the populations from observations of the samples. Graphs of the inferred distribution functions are contained in Appendix 1. Note that a more convenient random variable than concentration in p.p.m. was found to be $\log_{10}$ (concentration in p.p.m.). The method used to infer the population distribution functions from observations of the samples is discussed in Appendices 2 and 3.

The distribution functions indicate that it is possible to approximate each population by a single normally distributed population or by a combination in appropriate proportions of two or more normally distributed populations. It is important to note that these approximations are subjective. Graphs of the distribution functions of component normally distributed populations are superimposed on the graphs of the distribution functions of their parent populations in Appendix 1. Figures 2, 3, 4 and 5 are synoptic diagrams showing graphs of the distribution functions of all the component normally distributed populations.

Interpretation of Mo Populations

Figure 2 shows the component normally distributed populations of logarithms of Mo concentrations in rocks of the east coast and of the granite contact aureole.

The east coast rock types contain single low valued populations. These are interpreted as background or original populations.

The upper volcanics contain two populations, the dominant one of which has a mean and variance similar to those of the basaltic volcanics population; the other has a markedly higher mean. These two populations are therefore interpreted as background and mineralised populations respectively.

The threshold value is 1.18 (15.1 ppm).

Mo has been introduced into the upper volcanics.

The middle volcanics contain one population only. This population has a mean which is only very slightly higher than that of the dolerite population, but its variance is much higher than that of the dolerite population.

It is proposed that virtually no Mo has entered the middle volcanics but the Mo originally contained by the middle volcanics has been redistributed.

The mine series contains four populations of Mo. The population with the lowest mean is similar to the shale, limestone and tilloid population and is taken to be a background population. It constitutes the greatest proportion of the total population. The population with the next smallest mean has similar mean and variance to the mineralised population in the upper volcanics and may be due to the same mechanism of mineralisation which acted in the upper volcanics. This mechanism is suggested to be solid state diffusion, assisted by the presence of joints and faults. The two populations with the greatest means have no analogue in any other rock type. The mechanisms of mineralisation responsible for them are probably compositionally controlled and only occur in suitable rock types or combinations of rock types found in the mine series.

The threshold values for the four populations are 1.17, 2.51 and 2.93 (14.8, 323 and 851 ppm).

Mo has been introduced into the mine series.

Figure 3 shows the component normally distributed population of logarithms of Mo concentrations in soil samples from the contact aureole.

The weathered volcanics contain a single Mo population whose mean is less than that of the population in fresh middle volcanics and that of the background population in fresh upper volcanics.

Mo is depleted from the volcanics during weathering and distinct populations merge together.

The weathered mine series contains at least three populations, probably four. Too few values of the distribution function are known to be sure that the population with the greatest mean exists or to determine the mean and variance of the population with the least mean. It is possible that there is a Mo population in weathered mine series corresponding to each population in fresh mine series. The Mo populations in weathered mine series have lower means than the Mo populations in fresh mine series to which they would correspond.

The threshold values for the three populations known to exist are 0.73 and 1.73 (5.4 and 53.7 ppm); a third threshold greater than 1.73 probably exists.

Overall, Mo is almost certainly depleted from the mine series by weathering.

Interpretation of W Populations

Figure 4 shows the component normally distributed populations of logarithms of W concentrations in rocks of the east coast and of the granite contact aureole.

The east coast rocks contain single populations of W with low means and these are interpreted as background populations.

The upper and middle volcanics both contain two populations, and in both cases the dominant population has the smaller mean and coincides approximately with the appropriate background population on the east coast. Hence in both cases there is a background population and a mineralised population.

The threshold values are 1.10 (12.6 ppm) and 1.24 (17.4 ppm) for the upper and middle volcanics respectively.

W has been introduced into both the upper and middle volcanics.

There are four W populations in the mine series. The dominant population has the least mean and has approximately the mean and variance of the east coast shale, limestone and tilloid population and hence may be regarded as a background distribution. The other three populations are due to mineralisation and remarks analogous to those concerning the mineralised Mo populations of the mine series rocks apply to them.

The threshold values for the four populations are 1.17, 2.14 and 2.83 (14.8, 138 and 676 ppm).

Overall, W has been introduced into the mine series.

Figure 5 shows the component normally distributed populations of logarithms of W concentrations in soil samples from the granite contact aureole.

The weathered volcanics contain a single W population whose mean is slightly less than that of the background populations in fresh upper and middle volcanics but whose variance is markedly greater than those of the background populations in fresh upper and middle volcanics.

W has been slightly depleted in the volcanics by weathering and the identity of distinct populations has been lost.

The weathered mine series contains four populations. As for Mo, it is possible that each of the four W populations in weathered mine series corresponds with a W population in fresh mine series.

The threshold values for the four populations are 1.17, 2.51 and 2.99 (14.8, 324 and 977 ppm).

Overall, W is very slightly enriched in the mine series by weathering. (The overall mean for weathered mine series is 1.09 while that for fresh mine series is 1.03.)

3. Delineation of areas subjected to Mo and W mineralisation

Table 2 (refer to Summary - page 5) gives the threshold values for Mo and W populations in mine series and weathered mine series.

Because the intermediate Mo and W threshold values for mine series rocks (323 and 138 ppm respectively) separate the background and probable solid state diffusion populations from the more strongly mineralised populations which are unique to the mine series, these values are the most useful for distinguishing strata which may contain ore bodies. Strata in which Mo and W assays exceed the low threshold values for mine series rocks (14.8 ppm for both Mo and W) and have been weakly mineralised may contain ore bodies at some distance from the sample locality.

As Mo and W populations in the mine series appear to be preserved during weathering, the intermediate Mo and W threshold values for soil overlying mine series rocks (53.7 and 324 ppm respectively) are the most useful for delineating areas which may contain ore bodies in contact with the zone of soil formation. Areas in which Mo and W assays exceed the low threshold values for weathered mine series (5.4 and 14.8 ppm respectively) may contain ore bodies at depth.

For the populations of Mo and W in mine series and weathered mine series, Table 4 gives the probabilities, α, of incorrectly classifying a Mo or W assay in mine series or weathered mine series as a background concentration or a product of weak mineralisation because it does not exceed the appropriate intermediate threshold value (even though it is really a product of strong mineralisation); also given are the probabilities, β, of incorrectly classifying a Mo or W assay in mine series or weathered mine series as a product of strong mineralisation because it exceeds the appropriate intermediate threshold value (even though it is really a background concentration, or a product of weak mineralisation only). The possibility of error in the assay is ignored here.

TABLE 4

Population	Intermediate Threshold Value (ppm)	α	β
Mo in mine series	323	0.05	0.0006
Mo in weathered mine series	53.7	0.03	0.001
W in mine series	138	0.04	0.001
W in weathered mine series	324	0.02	0.0002

Table 4: Probabilities, α and β, of incorrectly classifying Mo and W assays in mine series and weathered mine series, see text for explanation.

Figures 6a, b and c show the locations of those percussion drill holes for which some Mo assays in mine series rocks exceed 323 ppm, those for which some Mo assays fall between 14.8 and 323 ppm, and those for which no Mo assays exceed 14.8 ppm. Also shown are the locations of those auger drill holes over a mine series basement for which Mo assays exceed 53.7 ppm, those for which Mo assays fall between 5.4 and 53.7 ppm, and those for which Mo assays are less than 5.4 ppm.

Percussion drill holes indicate that the mine series contains horizons with between 14.8 and 323 ppm Mo throughout the contact aureole though horizons with more than 323 ppm Mo were only intersected in Investigators 2 and 21. Soil samples contain between 5.4 and 53.7 ppm Mo principally in Investigators 3 and 6. Soil samples with more than 53.7 ppm Mo were taken only in Investigators 3 and 6.

Thus Figures 6a, b and c suggest that there may be Mo ore bodies in contact with the zone of soil formation in Investigators 3 and 6 and that there may be Mo ore bodies at depth in Investigators 2 and 21.

Figures 7a, b and c show the locations of those percussion drill holes for which W assays exceed 138 ppm, those for which W assays fall between 14.8 and 138 ppm and those for which no W assays exceed 14.8 ppm. Also shown are the locations of those auger drill holes for which W assays exceed 324 ppm, those for which W assays fall between 14.8 and 324 ppm, and those for which W assays are less than 14.8 ppm.

Again, percussion drilling reveals that the mine series contains weakly mineralised horizons throughout the contact aureole. Percussion drill holes intersected horizons with more than 138 ppm W in Investigators 24, 2, 21, 3 and 23. In Investigators 2, 3 and 6 most of the soil samples contained between 14.8 and 324 ppm W. In the centres of Investigators 3 and 6 and in an isolated auger hole in Investigator 22, soil samples contained more than 324 ppm W.

Thus Figures 7a, b and c suggest that there may be W ore bodies in contact with the zone of soil formation in Investigators 22, 3 and 6 and that there may be W ore bodies at depth in Investigators 24, 2, 21, 3 and 23.

Further testing for the possible Mo and W ore bodies in the various areas listed previously has been completed by means of diamond drilling. The results of the testing are set out in Table 5.

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TABLE 5

Area	Nature of Suggested Ore Body	Actual Diamond Drill Hole Intersections		
		DDH No.	Details of Relevant Intersections	Depth Interval (m)
INV. 2	Mo and W, at depth	INV.2-1	Pyroxene-garnet hornfels with moderate scheelite and minor molybdenite.	70.92- 75.44
		INV.2-2	Pyroxene-garnet skarn with minor scheelite.	50.89- 51.91
INV. 3	Mo and W, near surface	INV.3-2	Pyroxene-garnet hornfels with minor scheelite. Minor molybdenite.	16 - 21
		INV.3-1	Pyroxene-garnet hornfels, with minor to moderate scheelite. Trace molybdenite	26 - 33
	W, at depth	INV.3-4	Pyroxene-garnet hornfels with minor scheelite.	103.80-106.27
			Skarn with good scheelite.	40.88- 41.14
		INV.3-5	No relevant intersection	——
		INV.3-6	Banded biotite-pyroxene-calcite-garnet hornfels with minor scheelite.	45.59- 46.63
INV. 6	Mo and W, near surface	INV.6/4-3	Garnet calcite horizons with minor scheelite.	122.88-128.17
		INV.6/4-2	1.5 m at 0.76% WO_3 (average)	40.50- 42.0
			0.5 m at 0.16% Mo (average)	41.5 - 42.0
		INV.6/4-1	Disturbed garnet-pyroxene hornfels with minor scheelite	89.90- 92.21
INV. 21	Mo and W, at depth	INV.21-1	4.0 m at 0.53% WO_3 and 0.13% Mo.	87.80- 91.80
		INV.21-2	3.0 m at 0.54% WO_3 and 0.19% Mo.	110.3 -113.3
		INV.21-3	1.0 m at 0.07% WO_3 and 0.02% Mo.	131.3 -132.3
		INV.21-4	4.5 m at 0.40% WO_3 and 0.14% Mo.	87.6 - 92.1
		INV.21-5	2.0 m at 0.40% WO_3 and 0.10% Mo.	117.4 -119.4
		INV.21-6	No significant mineralisation	——
		INV.21-7	" " "	——
		INV.21-8	2.5 m at 0.07% WO_3	131.6 -134.1
INV. 22	W, near surface	INV.22-1	Pyroxene-garnet skarn with trace of scheelite (extension of surface anomaly).	124.22-127.54
			Pyroxene-garnet-calcite hornfels with minor scheelite.	144.17-147.83
			Pyroxene-biotite-garnet-calcite hornfels with minor scheelite	175.26-201.36

Table 5 cont'd

Area	Nature of Suggested Ore Body	Actual Diamond Drill Hole Intersections		
		DDH No.	Details of Relevant Intersections	Depth Interval (m)
INV. 23	W, at depth	INV.23-1 and 2	No mine series intersection	—
		INV.23-3	Probably no mine series intersection, no significant mineralisation.	—
INV. 24	W, at depth	INV.24-2	Pyroxene-garnet skarn with good scheelite, a weathered horizon.	14.28- 15.72
			Pyroxene-garnet hornfels with minor scheelite.	30.84- 32.51
			Podded pyroxene-garnet hornfels with minor scheelite	60.54- 67.71

Table 5: Results of diamond drilling in areas suggested by this study to be possible sites of Mo or W ore bodies.

4. The determination of basement rock type from soil sample assays

Figures 8, 9, 10, 11 and 12 show some values of the distribution functions, as percentages, for the populations of Cu, Ni, Zn, Mo and W concentrations in samples of soil derived from four rock types of the granite contact aureole, namely mine series, volcanics, overlying siltstone and underlying siltstone. Thus, for example, Figure 8 indicates that in a collection of samples of soil overlying mine series rocks, 50% of the samples would be expected to contain 100 ppm Cu or less; 85% of the samples would be expected to contain 200 ppm Cu or less; and 15% of the samples would be expected to contain 200 ppm Cu or more.

For Cu, Ni and Zn populations the values of the distribution functions given in the figures were calculated by assuming that each population is log-normal with mean, μ, equal to the sample mean, $\bar{x}$, and variance, σ^2, equal to $\frac{n}{n-1}S^2$ where S^2 is the sample variance and n the sample size. The assumption that these populations are log-normal is based on experience gained both in the preliminary study of Cu, Ni, Zn, Mo and W in rocks of the contact aureole and in the present study which has concentrated on Mo and W in fresh and weathered rocks of the contact aureole.

For Mo and W, inferred distribution functions were used to obtain the required values.

$\bar{x}$ and $\sqrt{\frac{n}{n-1}}\,S$ for the samples of Cu, Ni and Zn populations in soils derived from the four rock types of the contact aureole are tabulated in Appendix 4. Graphs of the inferred distribution functions for Mo and W populations in soils derived from the overlying and underlying siltstones are given in Appendix 5.

From the figures it is apparent that the mine series is distinguished by high Cu, Zn and W content and the volcanics by high Ni content. The underlying siltstone is distinguished from the overlying siltstone by the low Ni and high Mo contents of the former.

The method of statistical hypothesis testing can be applied to the problem of determining parent rock type given soil sample assays. Suppose, for example, a soil sample is known to be either a weathered volcanic or a weathered overlying siltstone. The Ni assay provides the best test. A null hypothesis, Ho, and an alternative hypothesis, Hi are adopted as follows.

Ho : The sample is a weathered volcanic.

Hi : The sample is weathered overlying siltstone.

A suitable test statistic, k, with which to test Ho, is then chosen. Ho is rejected if

Ni assay in ppm $<$ k ppm.

Two types of error are possible in the execution of the test.

A Type I error is the incorrect rejection of Ho (when it is true). A Type II error is the incorrect retention of Ho (when it is false). The probabilities, α and β, of Type I and Type II errors respectively, are equally important in this application and both depend on k.

α = P (assay in ppm $< k | Ho$ is true)

β = P (assay in ppm $> k | Ho$ is false)

where $P(A|B)$ is the probability that event A occurs given that event B occurs. k is best chosen such that $\alpha = \beta$. From Figure 10 it can be seen that the appropriate value for k is 245 ppm and for this value, $\alpha = \beta = 0.16$. Thus, if the Ni assay were 100 ppm, Ho would be rejected and the probability of an incorrect rejection would be 0.16 . (In actual fact, α and β would be only approximately 0.16 because of the original assumption that the Ni population in weathered volcanics is log-normal.)

GEOPEKO LIMITED

R. V. SMART
STUDENT GEOLOGIST.

M. C. Rogers

approved by M. C. ROGERS
SUPERVISING GEOLOGIST.

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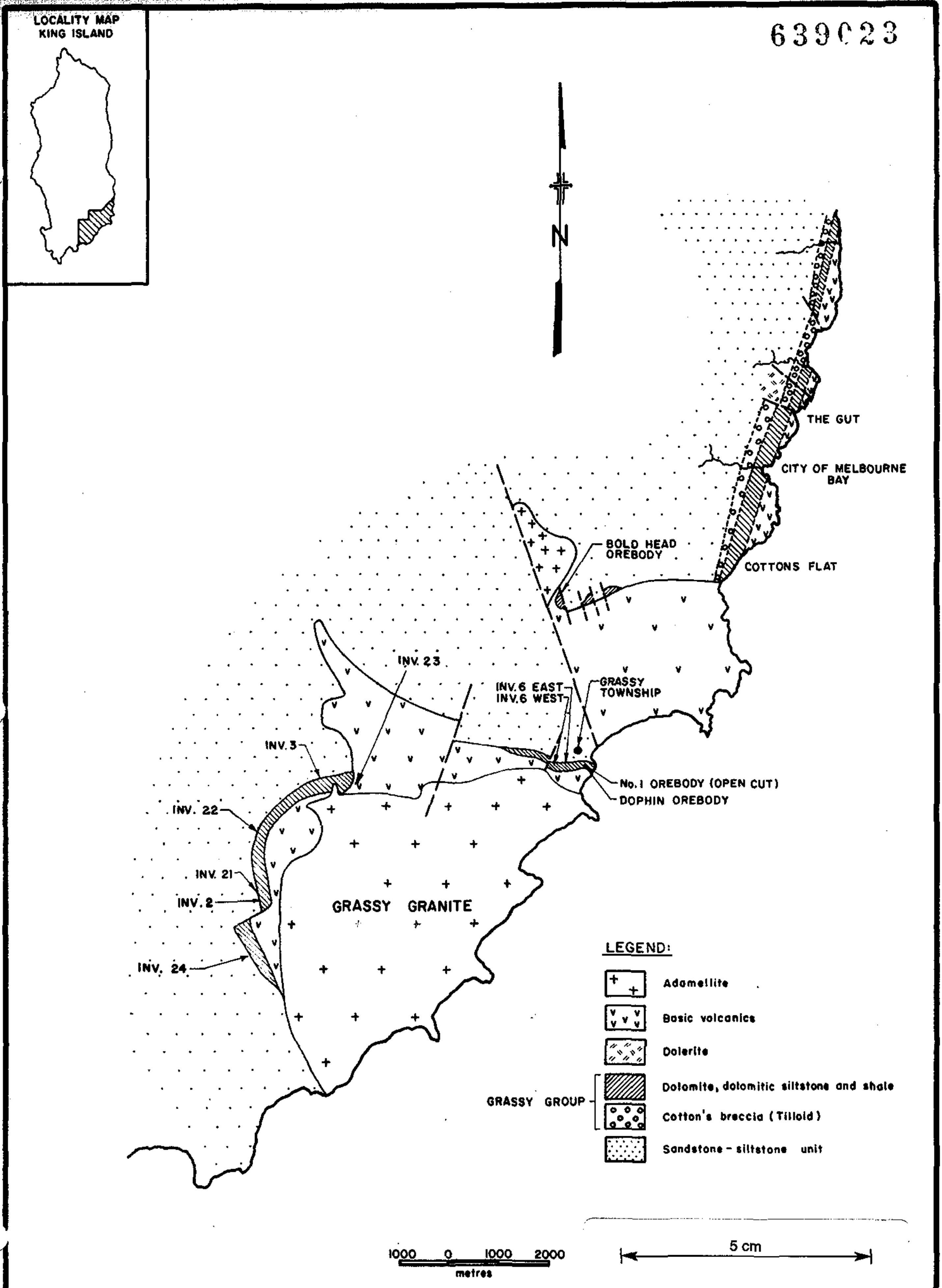

Location Map S.E. King Island Showing Major Geological Units

Figure: 1

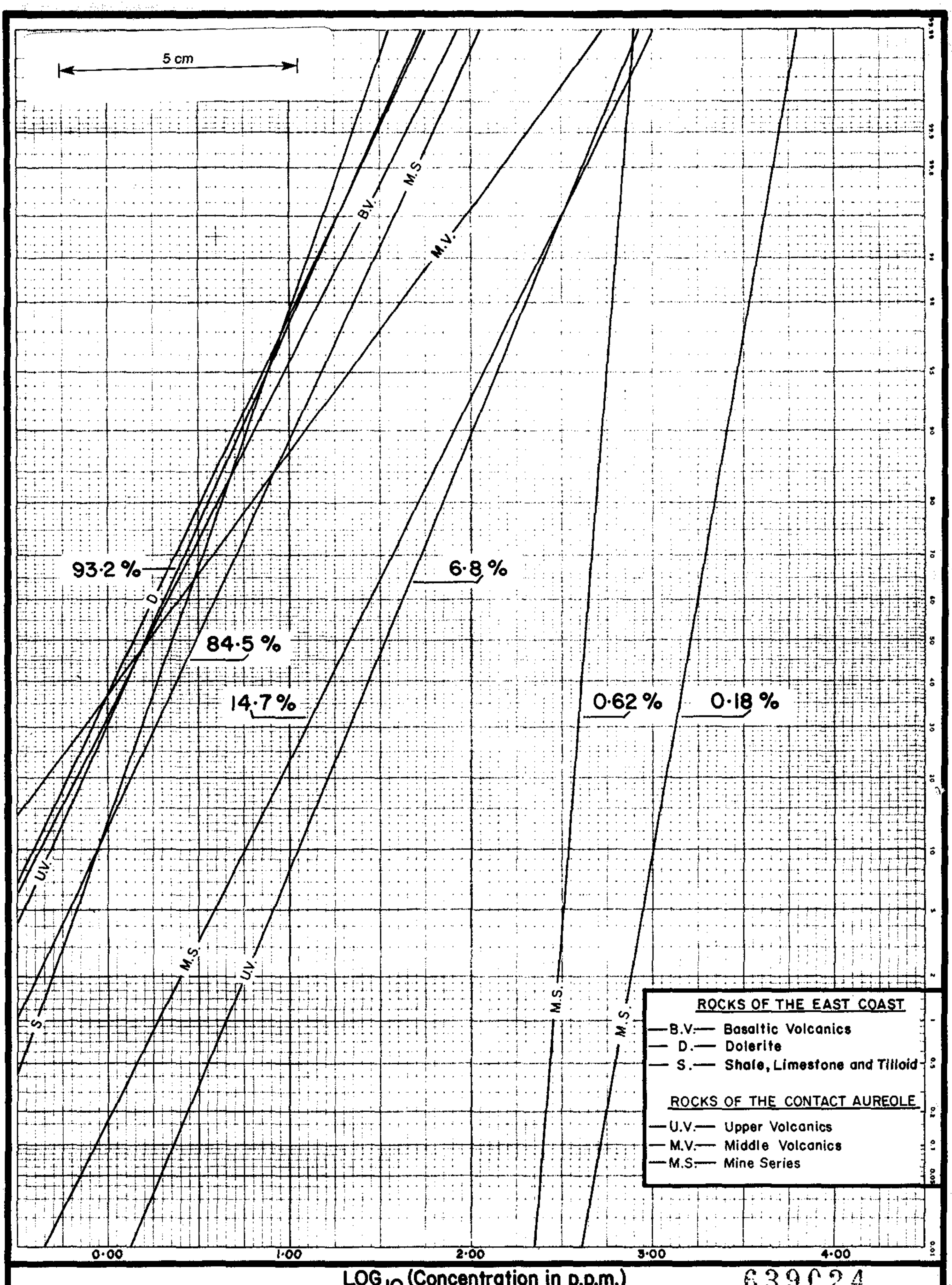

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FIGURE 2: Distribution functions for component normally distributed populations of logarithms of Mo concentrations in rocks of the East coast and of the Granite Contact Aureole. Vertical scale is percentage, "probability divisions".

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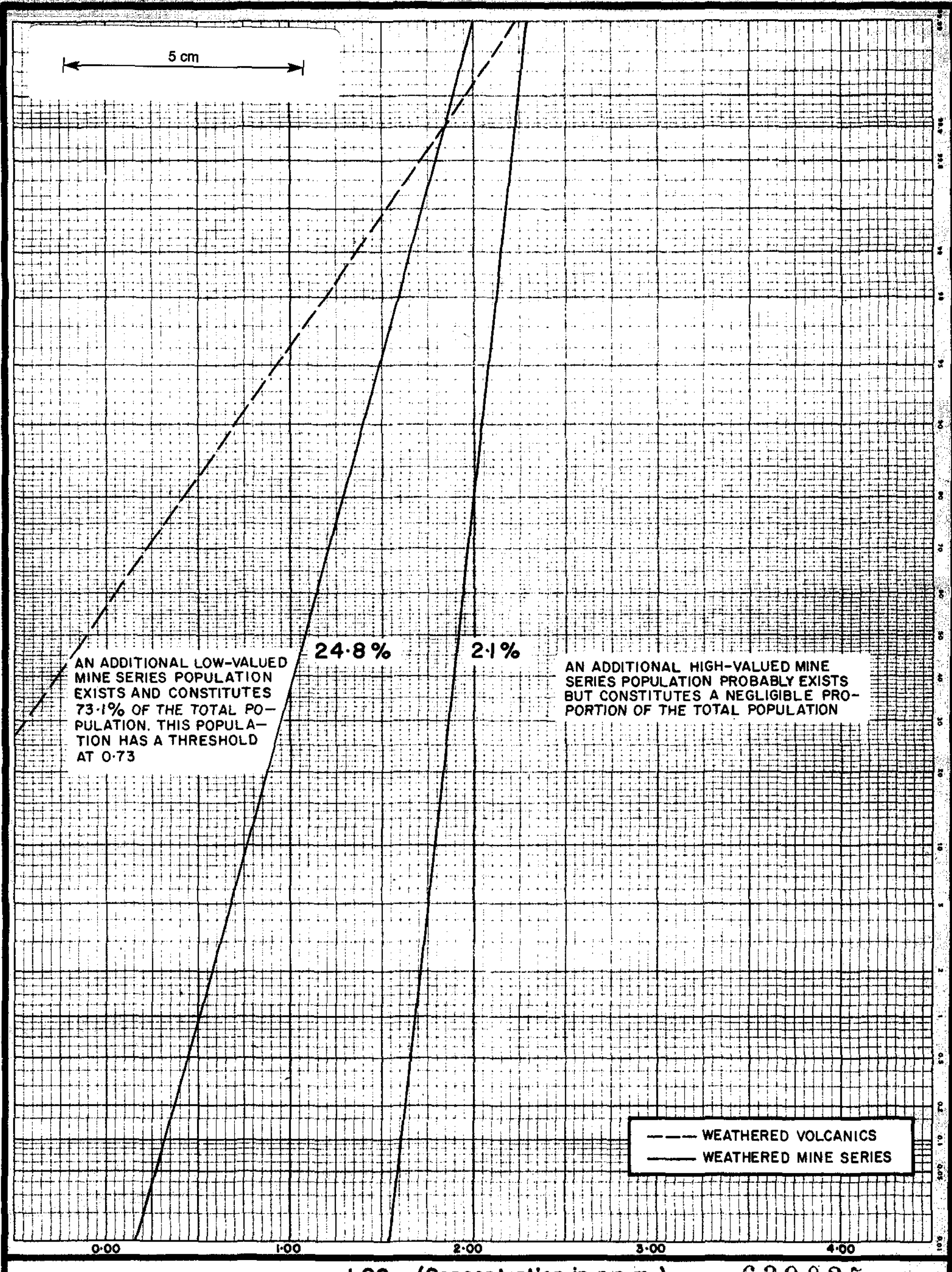
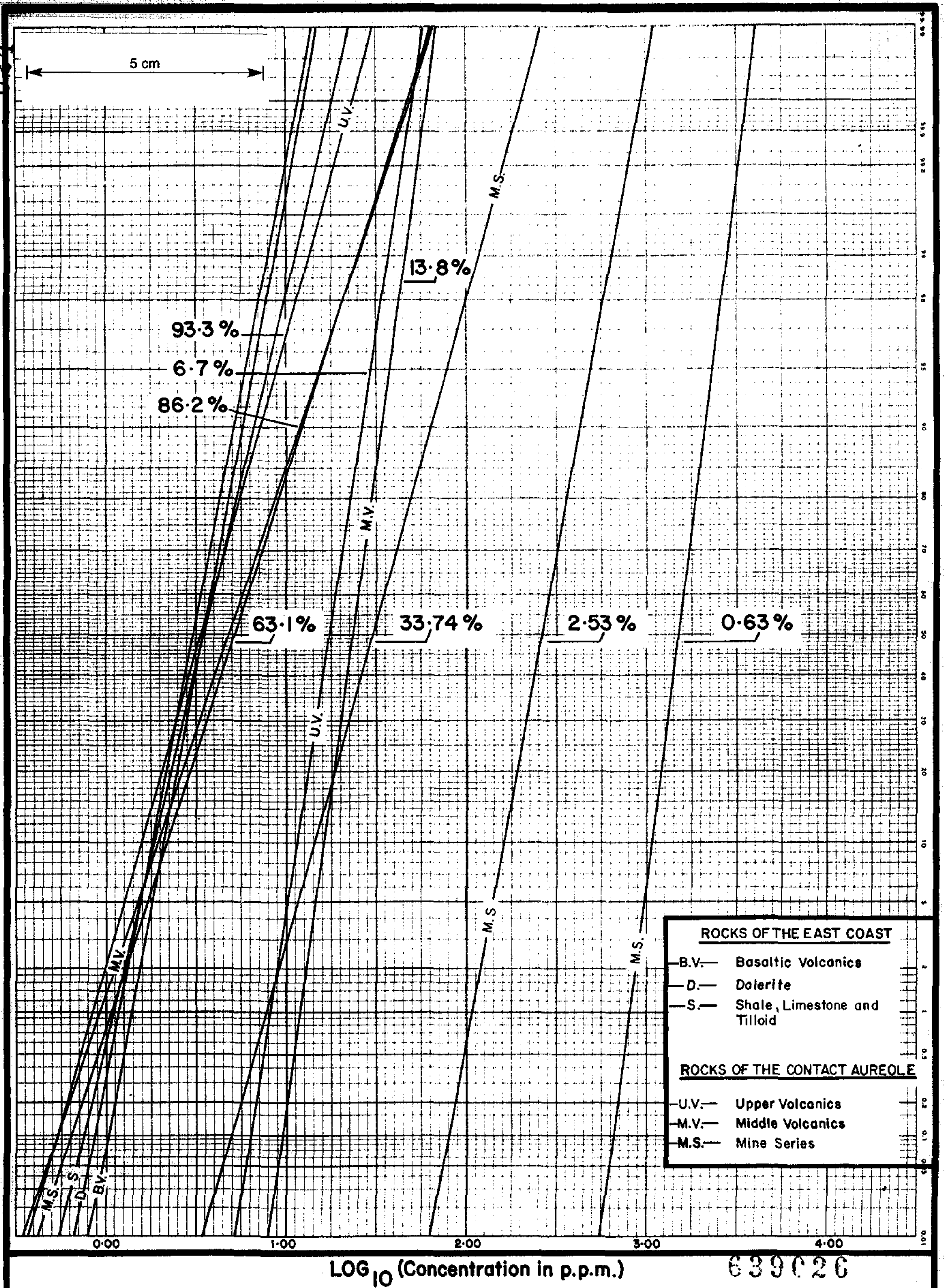


C39025

FIGURE 3: Distribution functions for component normally distributed populations of logarithms of Mo concentrations in Weathered rocks of the Granite Contact-Aureole. Vertical scale is percentage, "probability divisions".



639026

FIGURE 4: Distribution functions for component normally distributed populations of logarithms of W concentrations in rocks of the East coast and of the Granite — Contact Aureole. Vertical scale is percentage, "probability divisions".

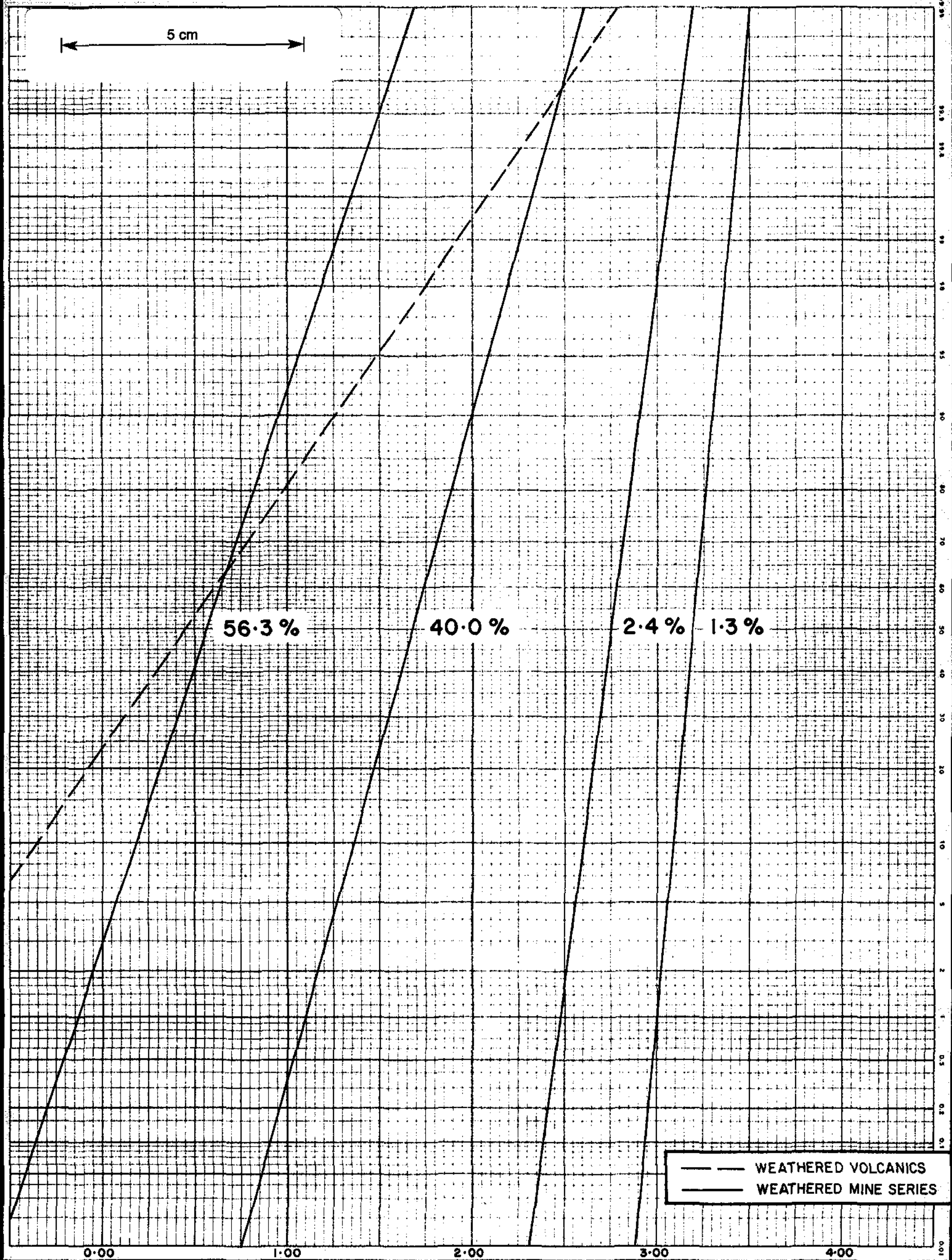
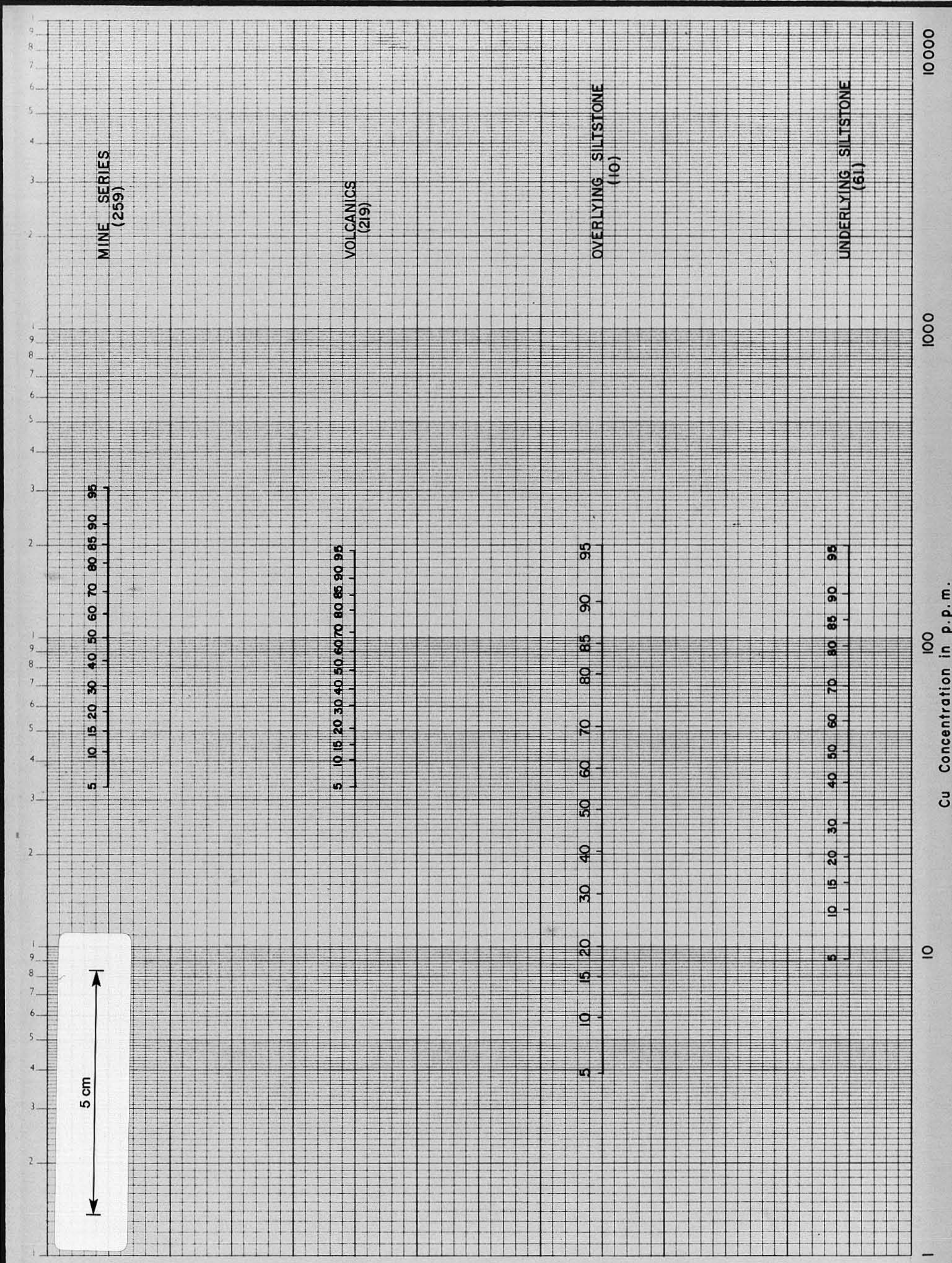


FIGURE 5: Distribution functions for component normally distributed populations of logarithms of W concentrations in Weathered rocks of the Granite Contact Aureole. Vertical scale is percentage, "probability divisions".

026



639C28

FIGURE 8: Some values for the distribution functions as percentages for the populations of Cu concentrations in samples of soil derived from four rock types of the Granite Contact Aureole. Sample sizes indicated in parentheses.

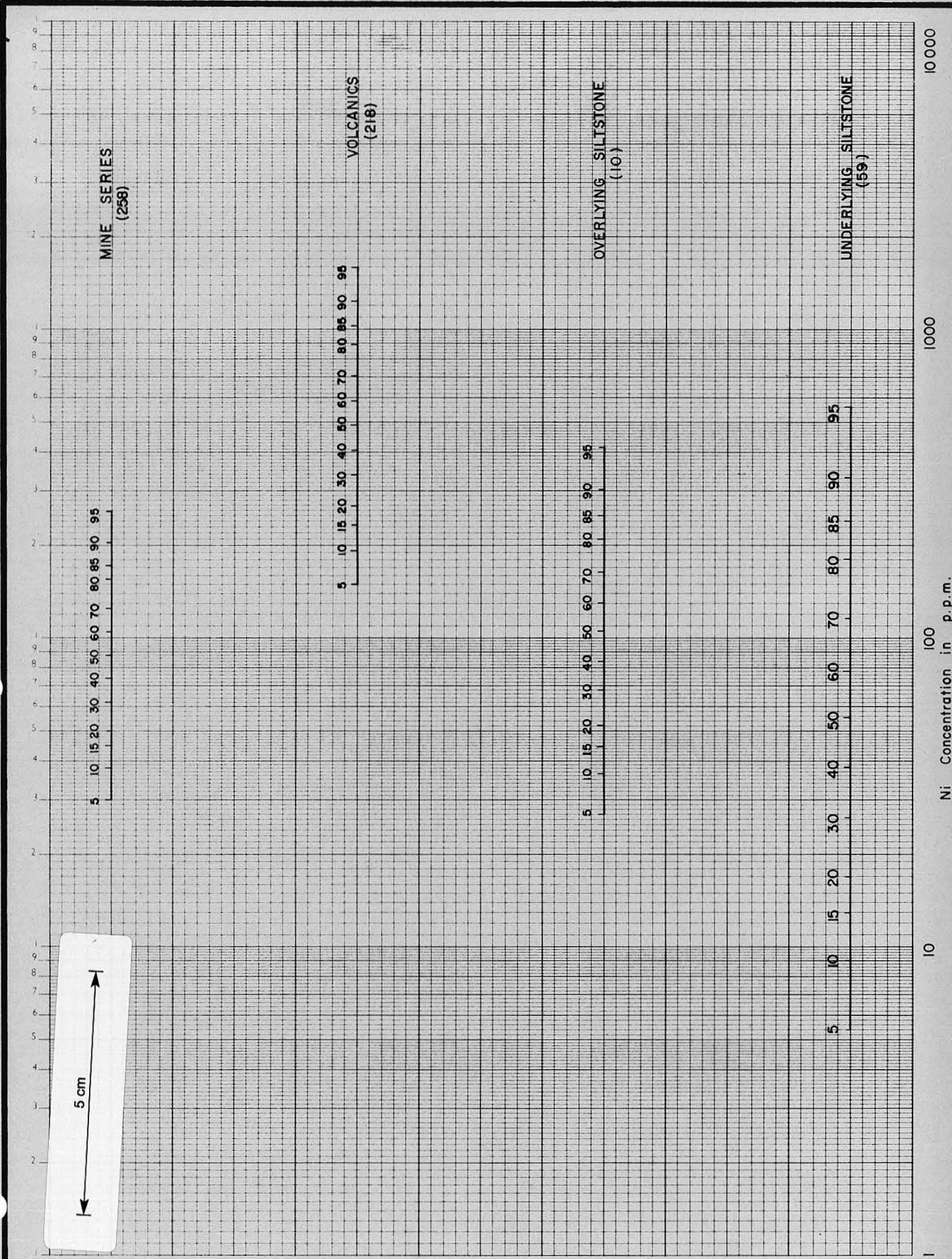
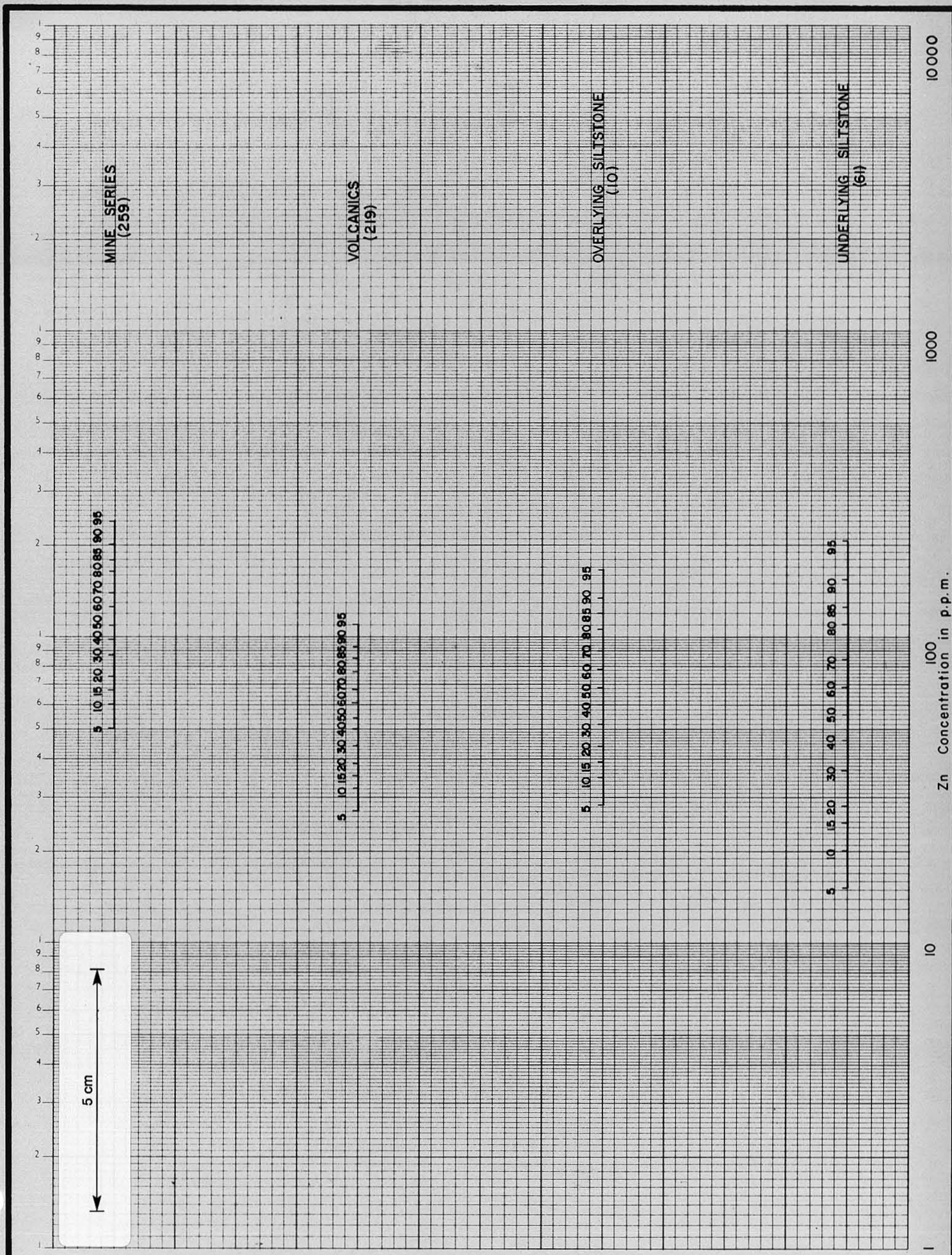


FIGURE 9: Some values for the distribution functions as percentages for the populations of Ni concentrations in samples of soil derived from four rock types of the Granite Constant Aureole. Sample sizes indicated in parentheses.

028



639020

FIGURE 10: Some values for the distribution functions as percentages for the populations of Zn concentrations in samples of soil derived from four rock types of the Granite Contact Aureole. Sample sizes indicated in parentheses.

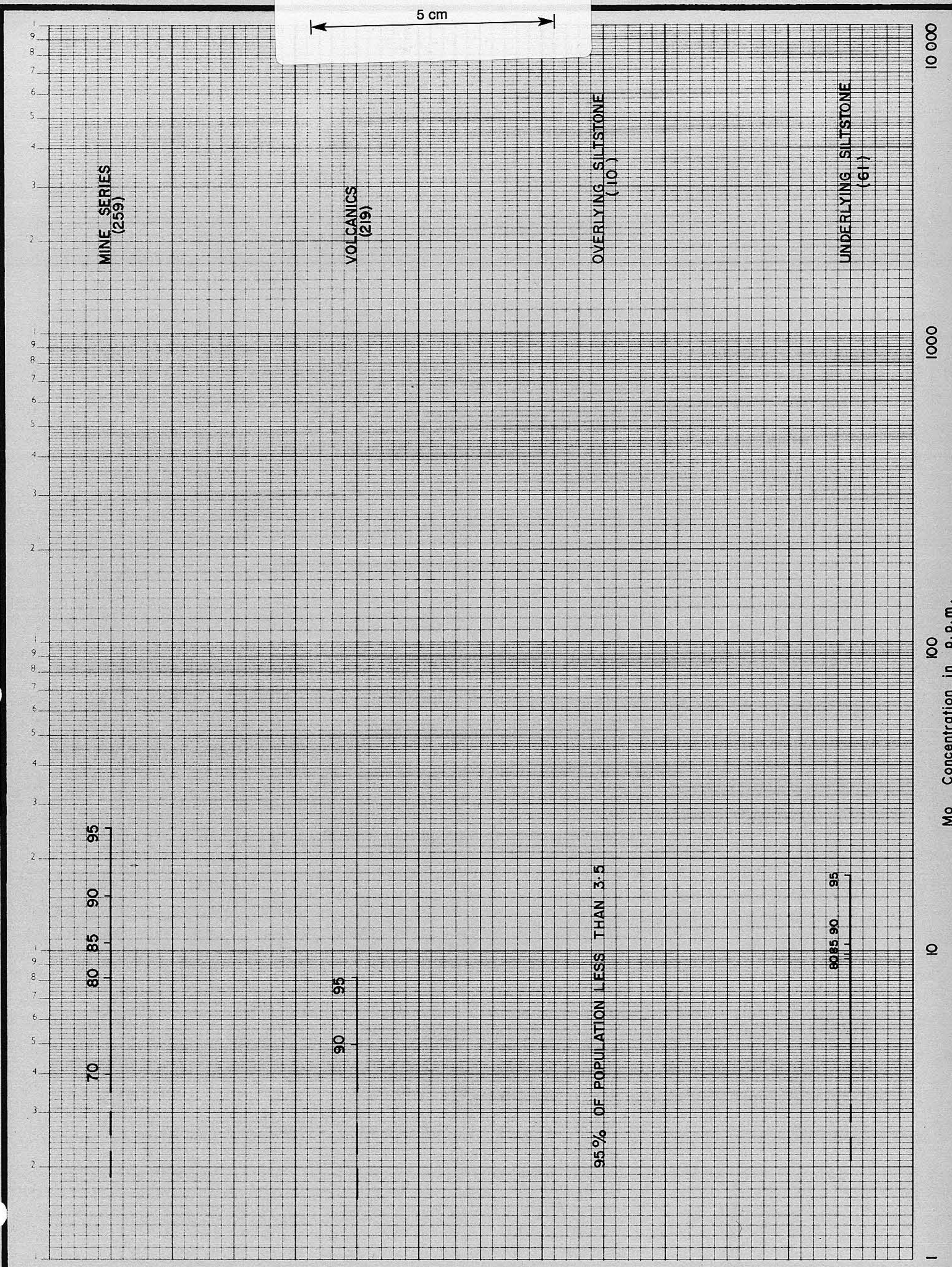


FIGURE II: Some values for the distribution functions as percentages for the populations of Mo concentrations in samples of soil derived from four rock types of the Granite Contact Aureole. Sample sizes indicated in parentheses.

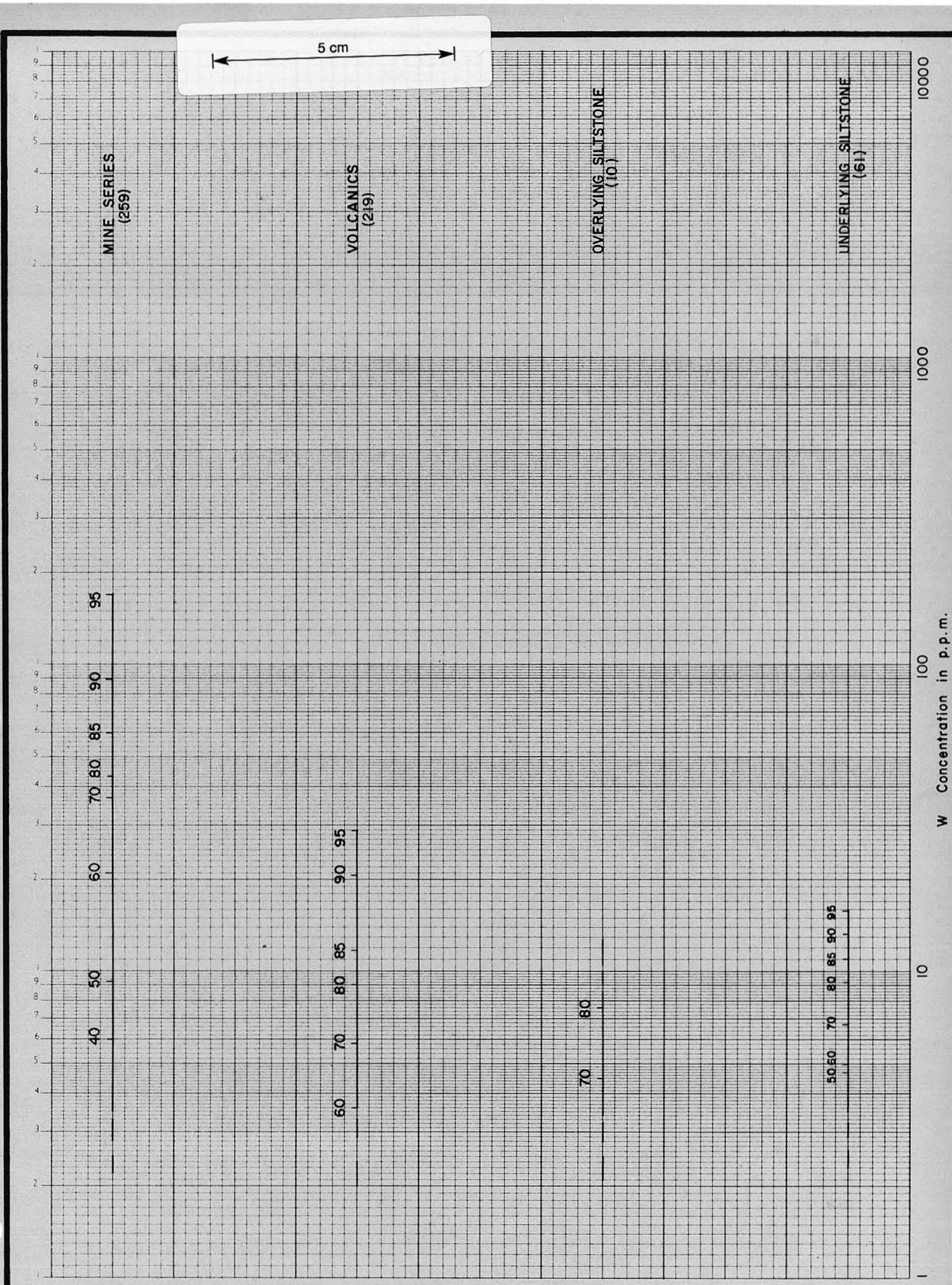


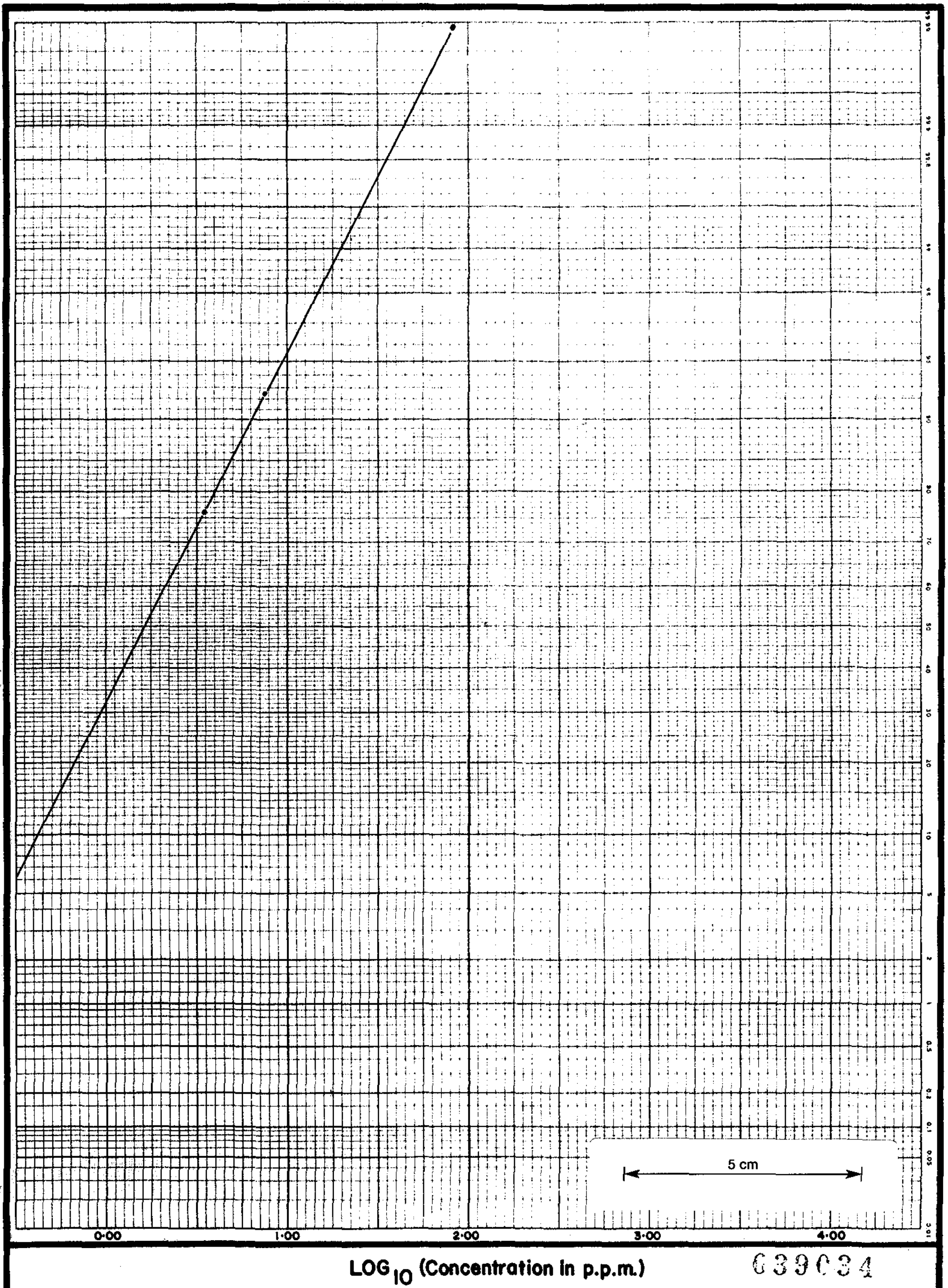
FIGURE 12: Some values for the distribution functions as percentages for the populations of W concentrations in samples of soil derived from four rock types of the Granite Contact Aureole. Sample sizes indicated in parentheses.

APPENDIX 1

Graphs of inferred distribution functions

The following are graphs of the inferred distribution functions for the populations of logarithms of Mo and W concentrations in the rock and soil types of Table 1, excluding fresh and weathered overlying and underlying siltstone. Also shown are graphs of the distribution functions for the component normally distributed populations constituting each population.

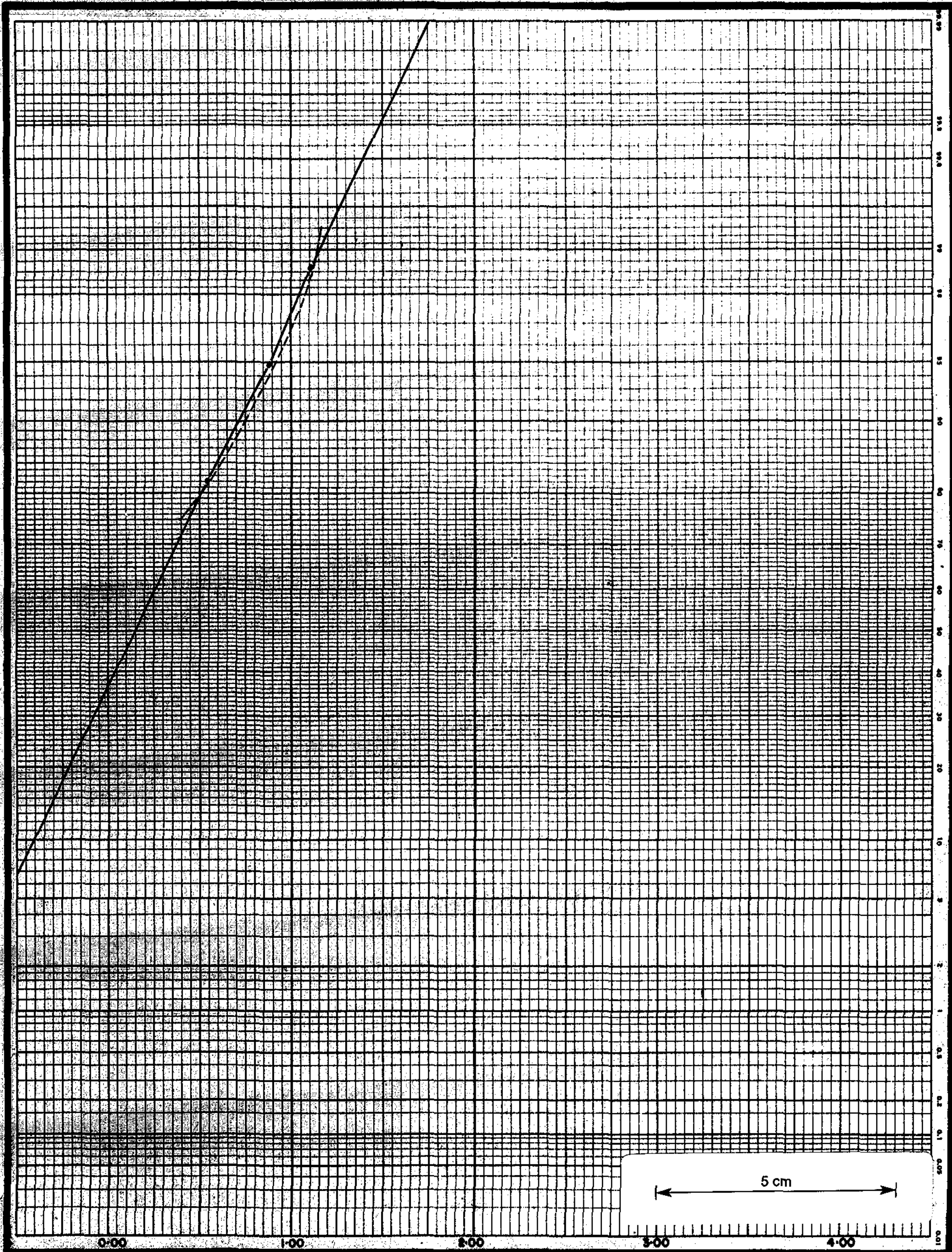
On each graph, the vertical scale is percentage with "probability divisions". Points of inflexion representing threshold values have been marked thus: X



039034

Mo IN BASALTIC VOLCANICS

033

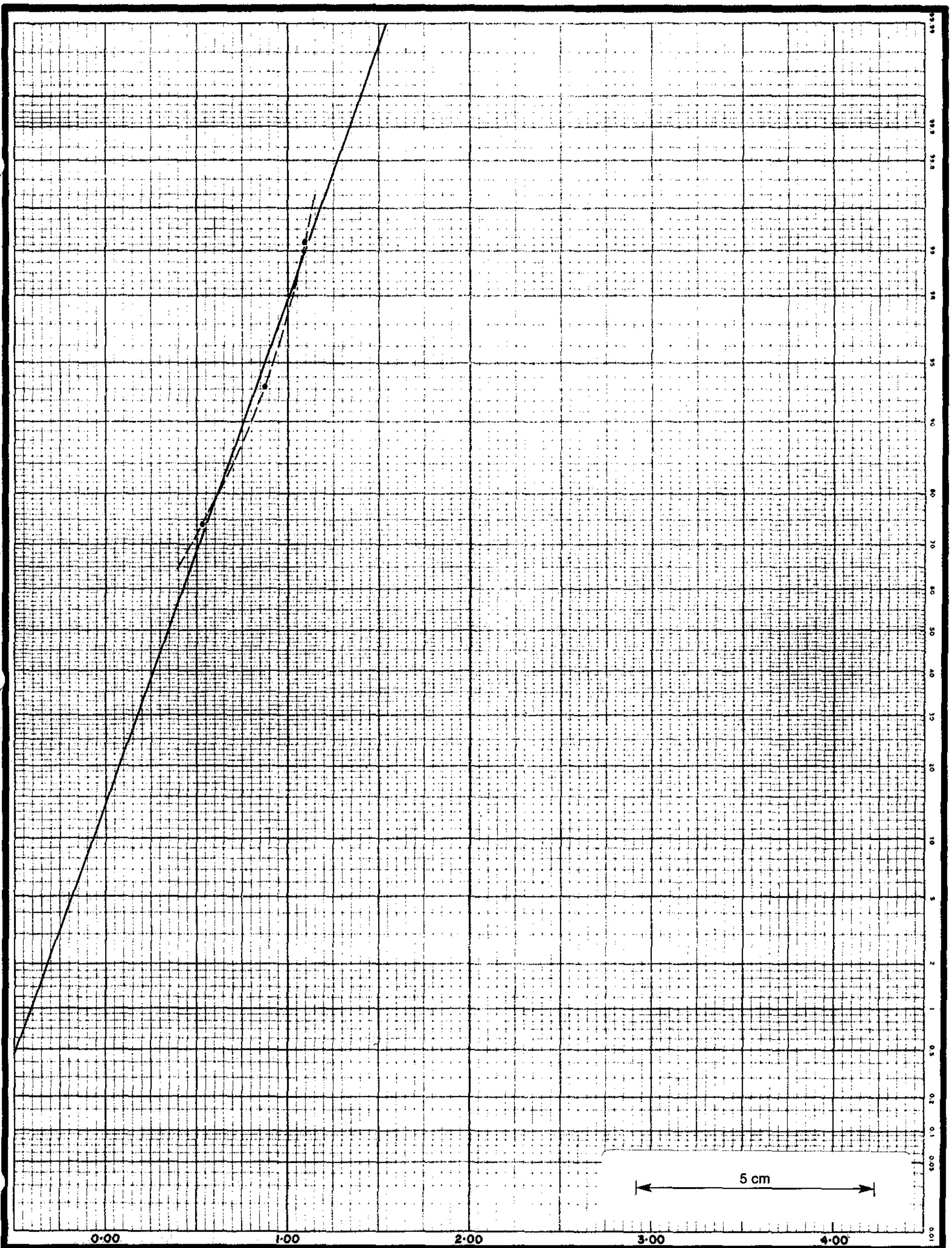


LOG$_{10}$(Concentration in p.p.m.)

C39035

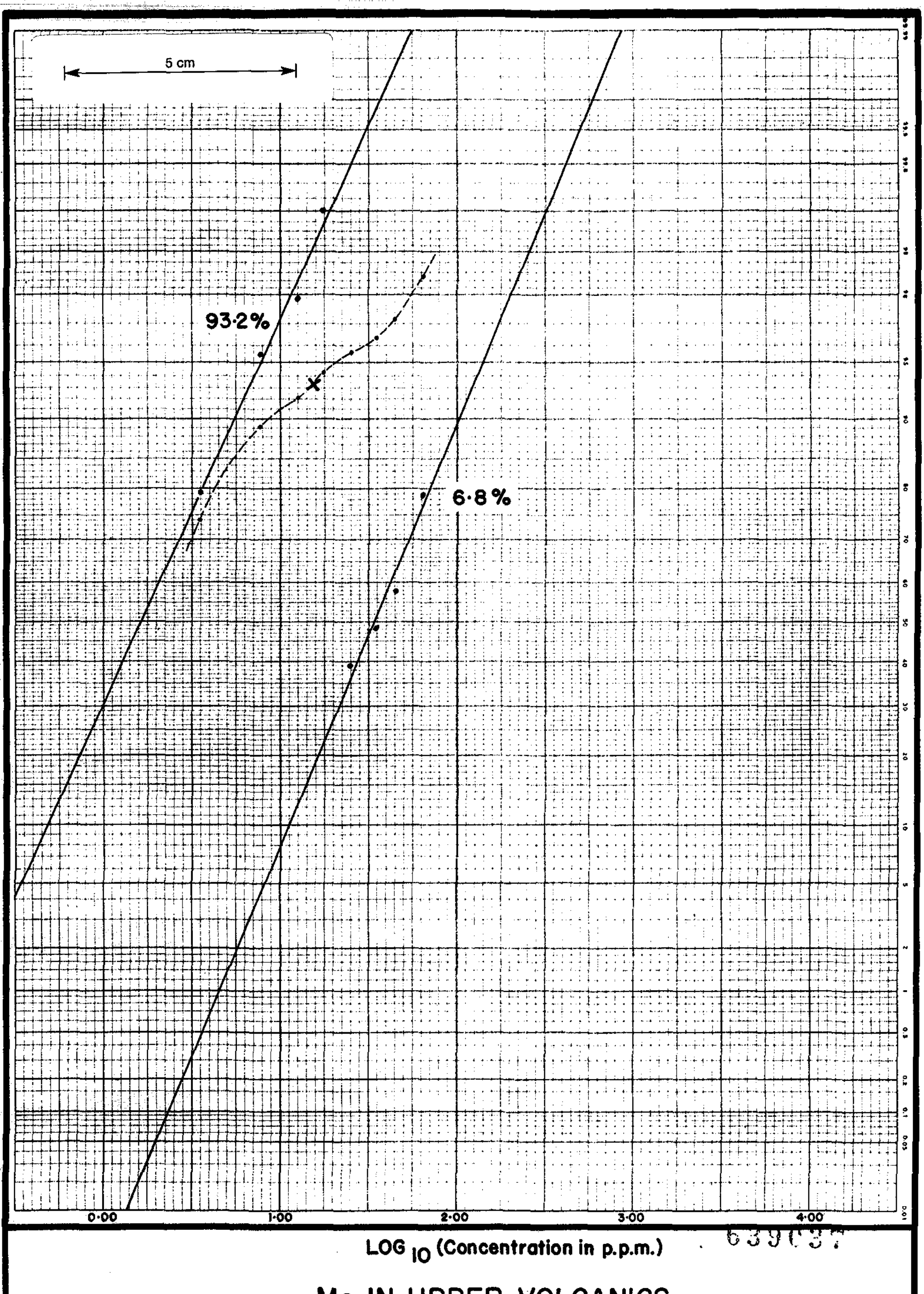
Mo IN DOLERITE

A1-2



LOG$_{10}$ (Concentration in p.p.m.) 639036

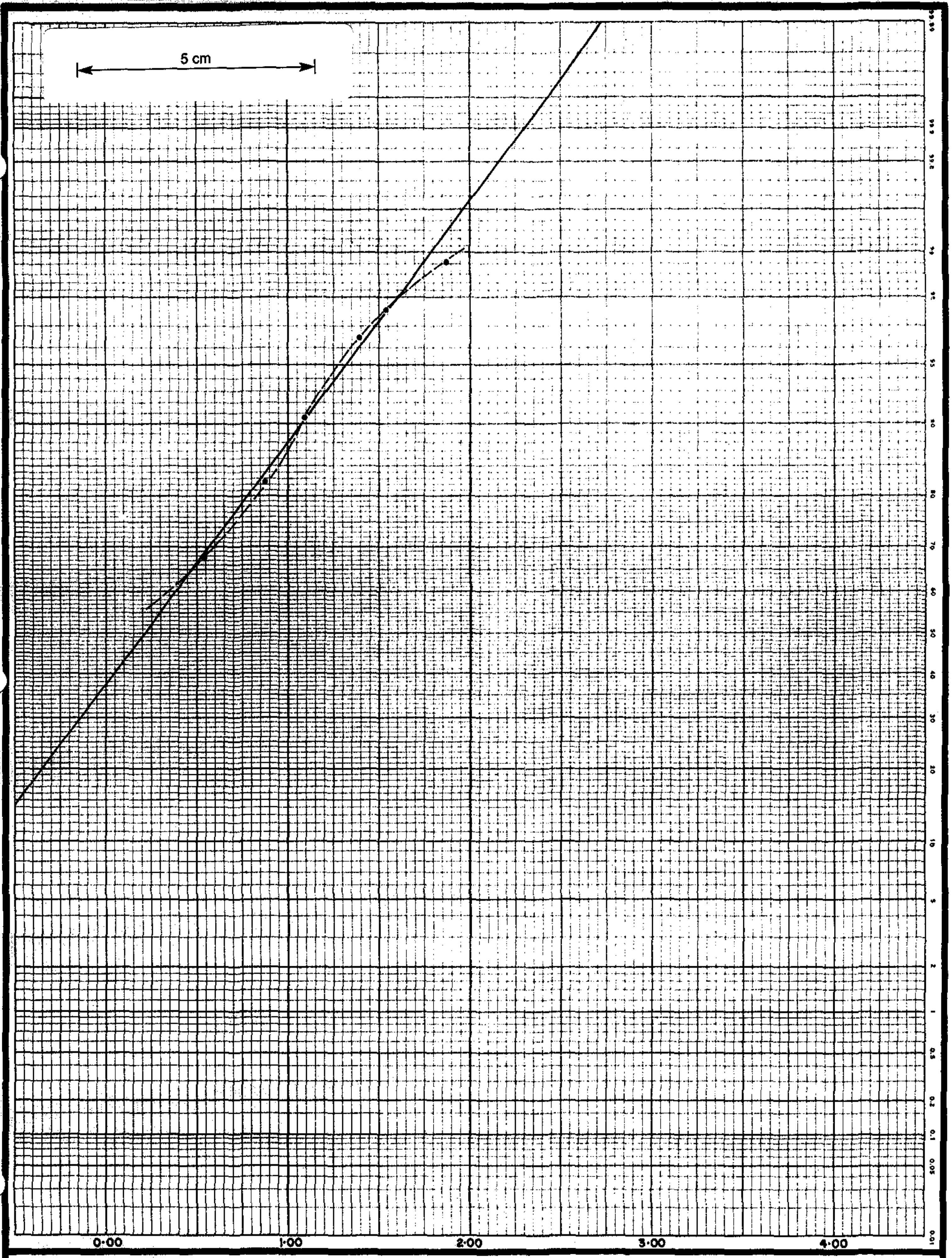
Mo IN SHALE, LIMESTONE AND TILLOID



Mo IN UPPER VOLCANICS

A I-4

036



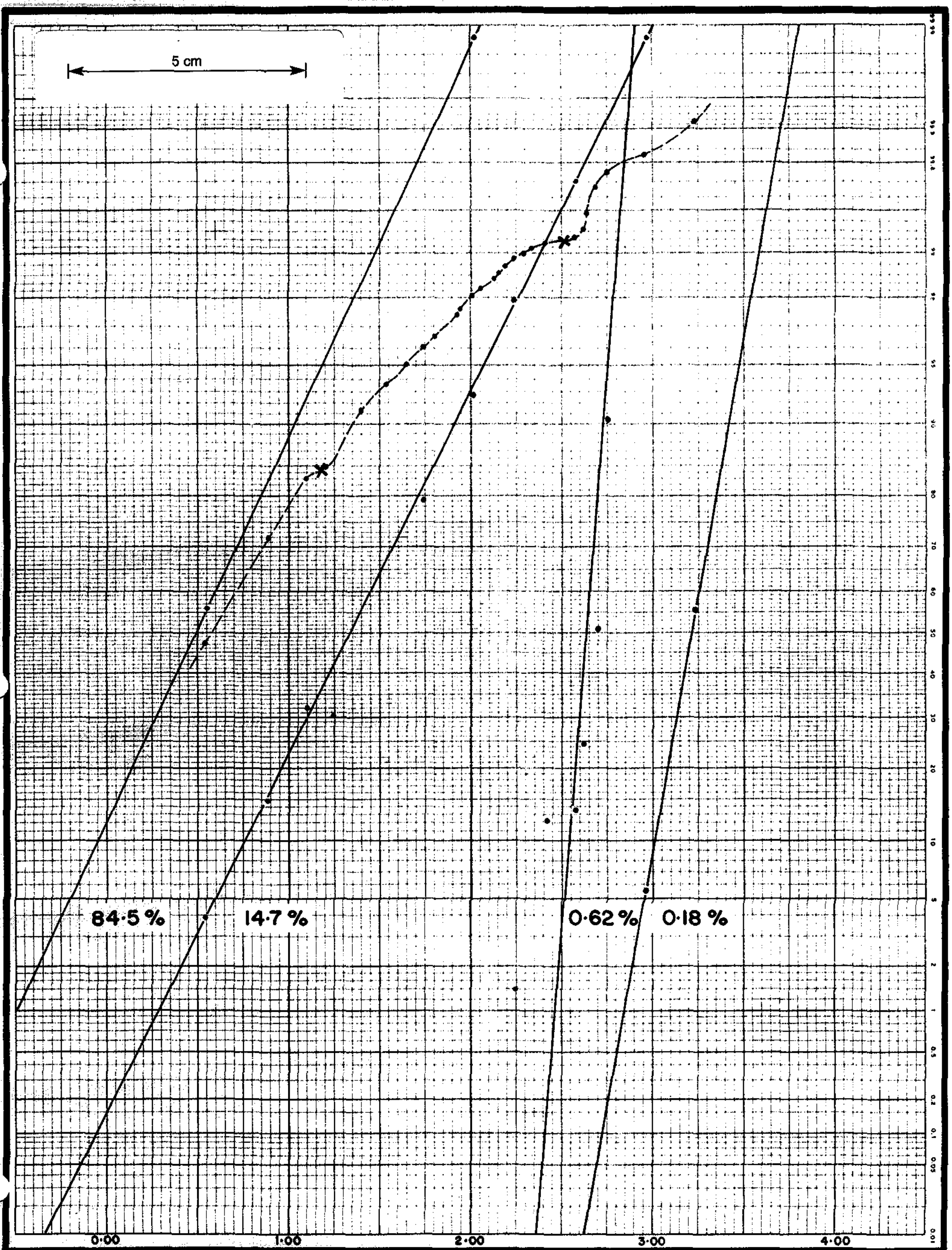
LOG_{10} (Concentration in p.p.m.)

639038

Mo IN MIDDLE VOLCANICS

A1-5

037

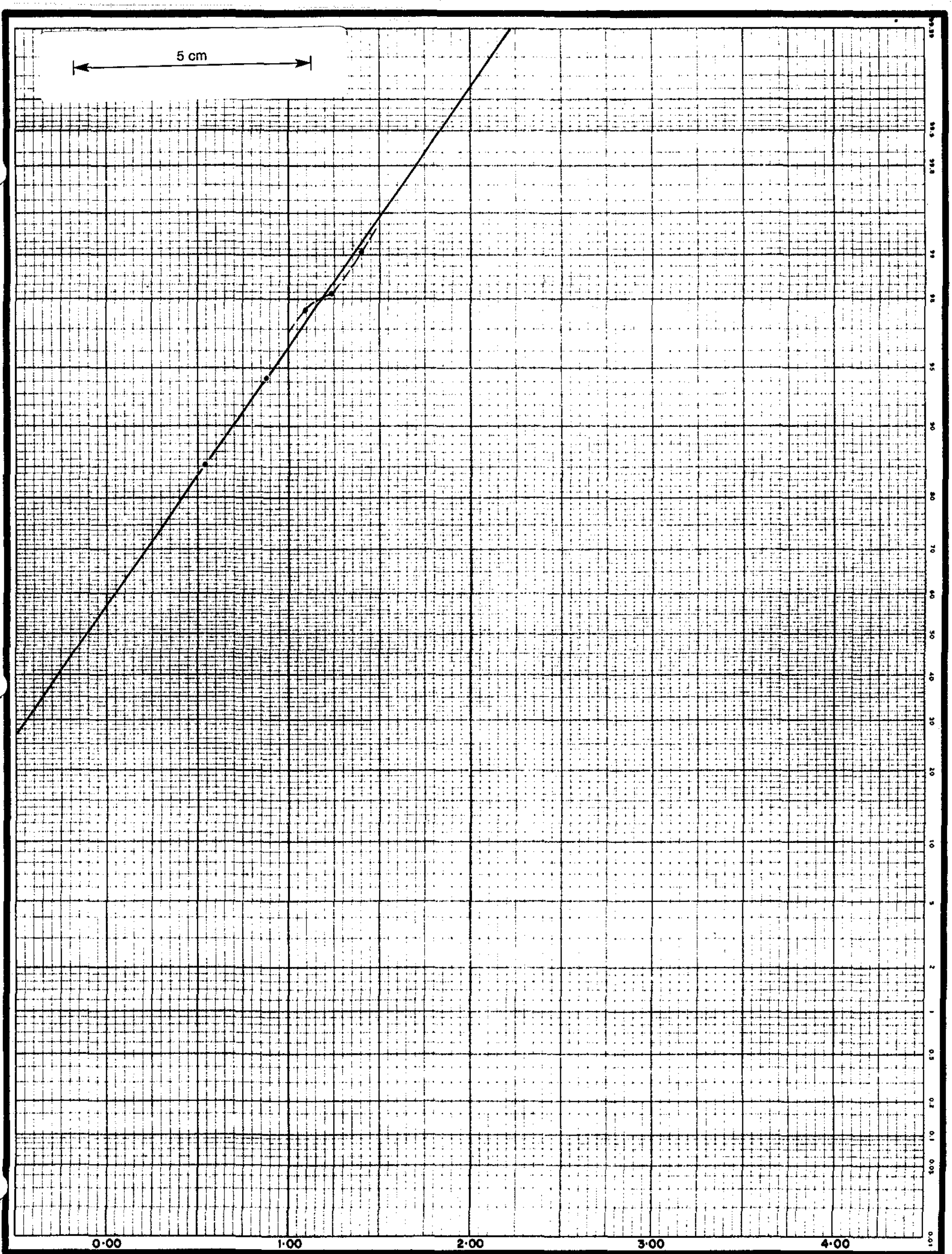


LOG_{10} (Concentration in p.p.m.)

639039

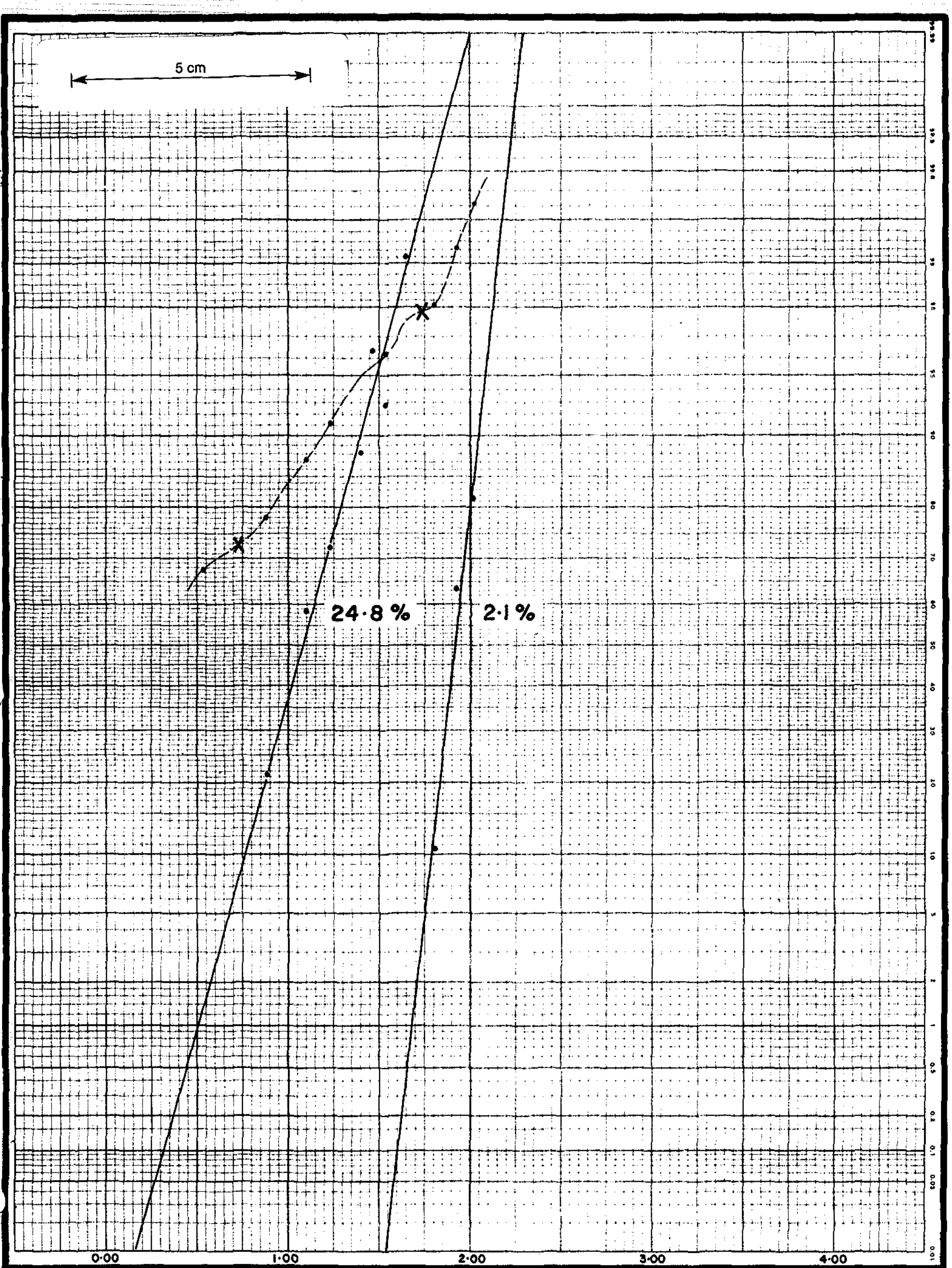
Mo IN MINE SERIES

A1-6



LOG_{10} (Concentration in p.p.m.)   639040

Mo IN WEATHEARED VOLCANICS

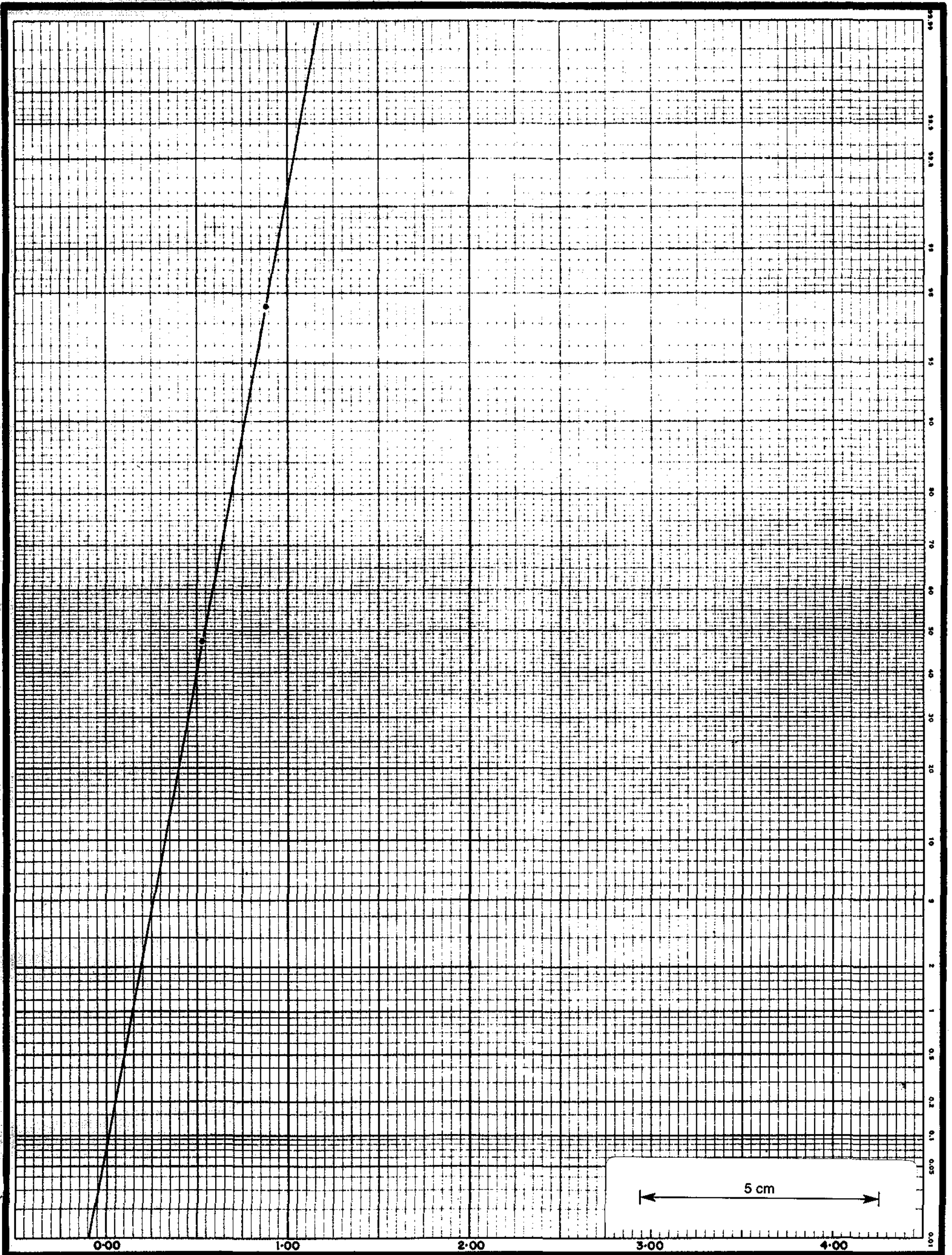


LOG$_{10}$ (Concentration in p.p.m.)

639041

Mo IN WEATHERED MINE SERIES

AI-8

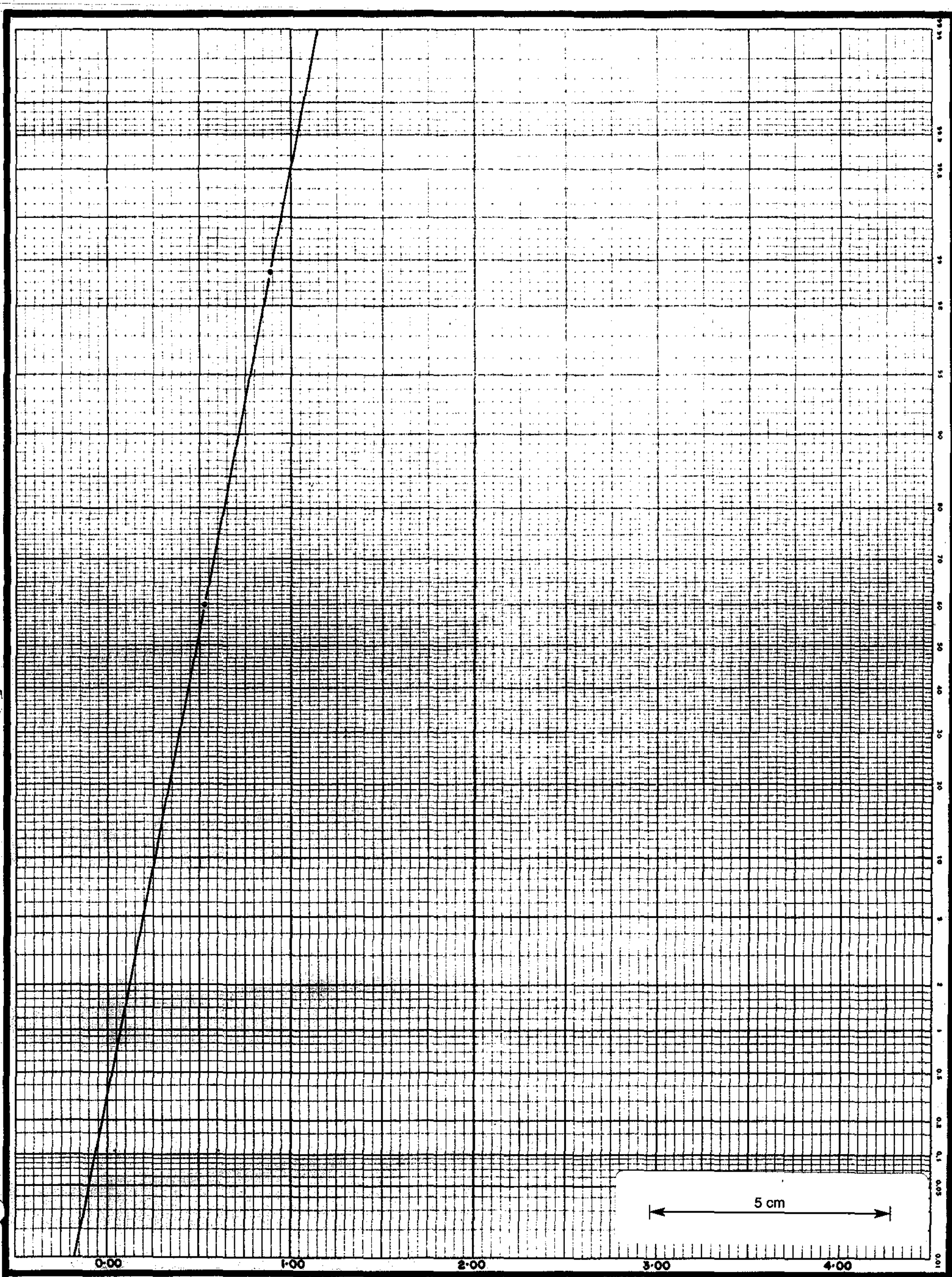


LOG$_{10}$ (Concentration in p.p.m.)

639042

W IN BASALTIC VOLCANICS

AI-9



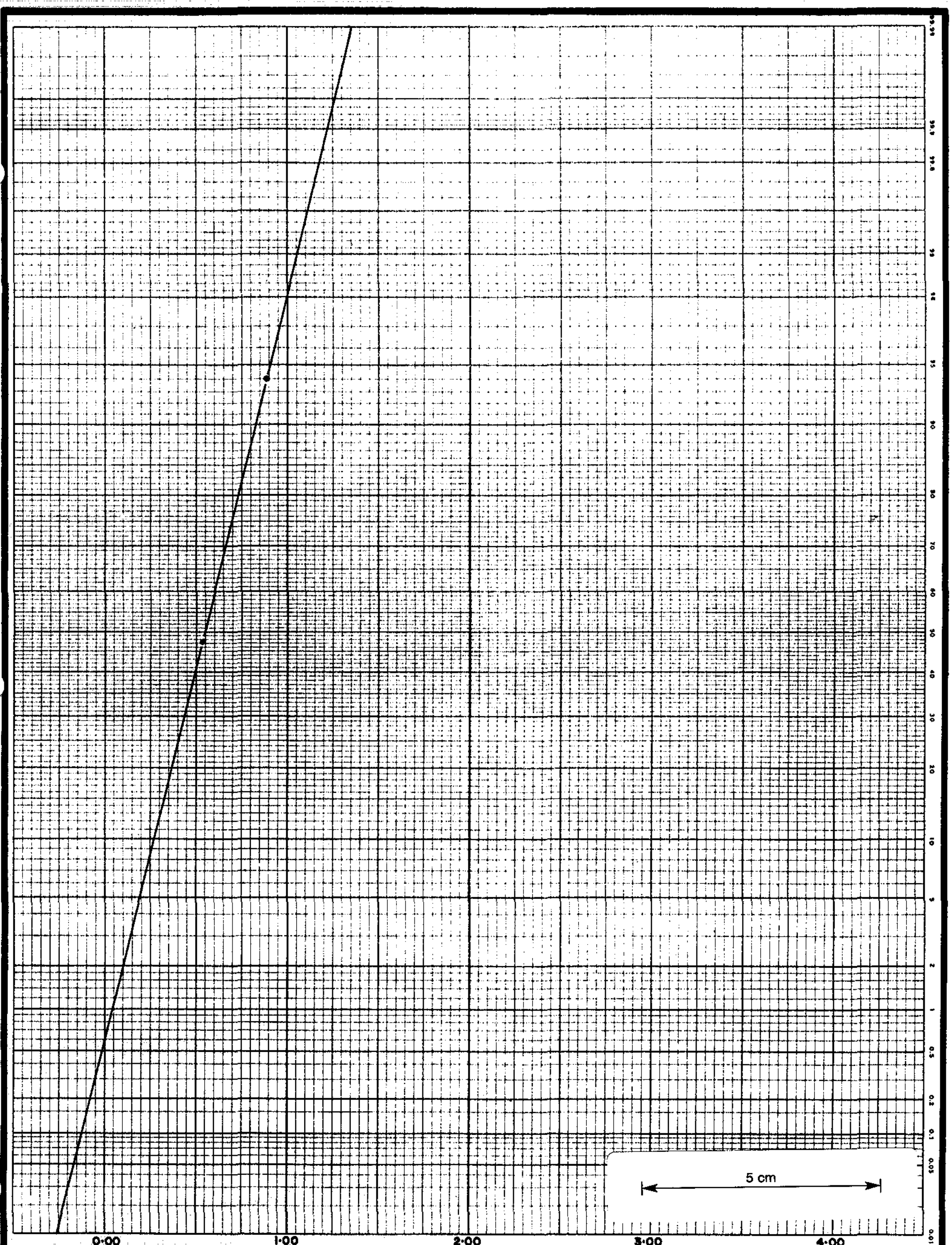
LOG$_{10}$ (Concentration in p.p.m.)

639043

W IN DOLERITE

AI–10

042



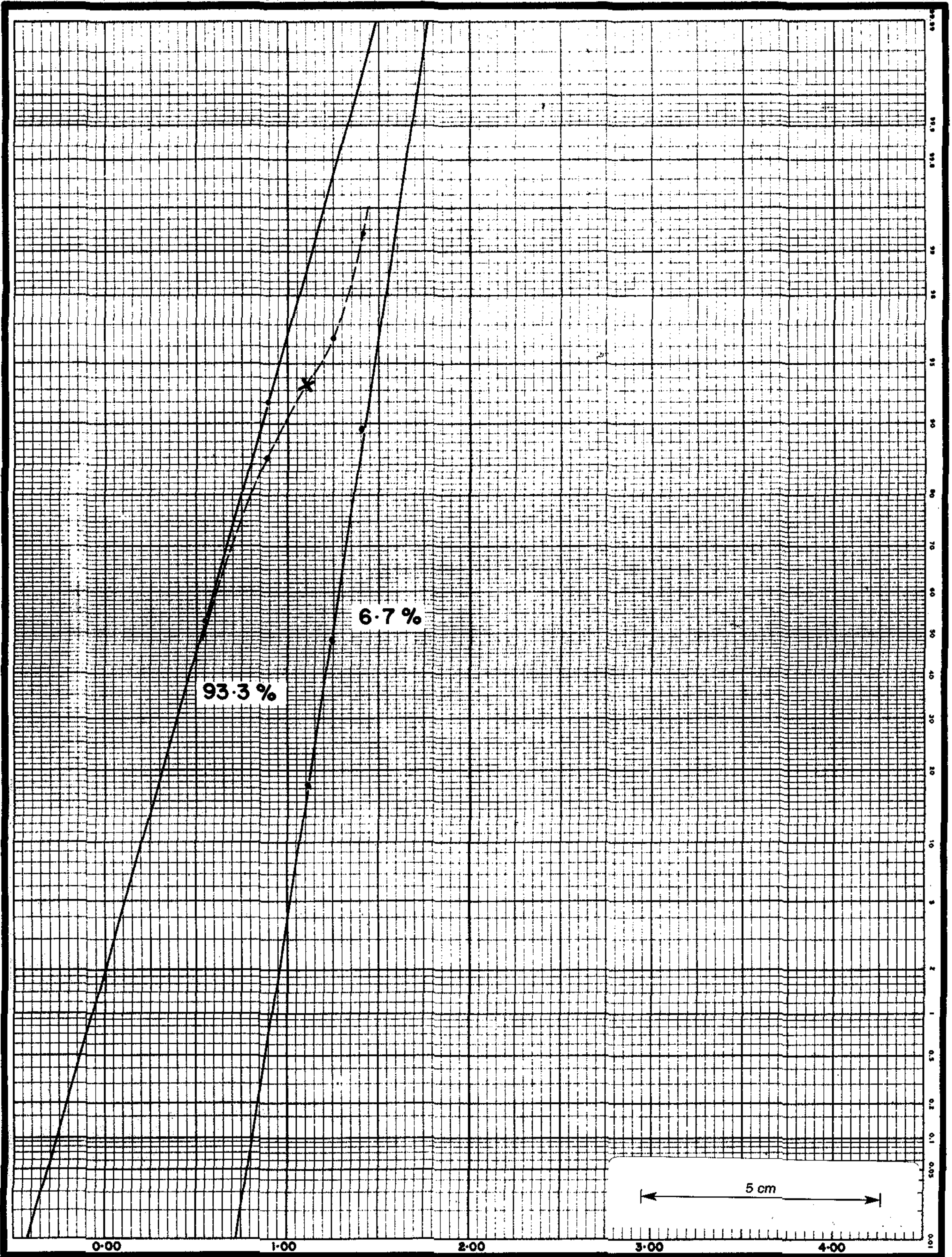
LOG$_{10}$ (Concentration in p.p.m.)

639044

W IN SHALE, LIMESTONE AND TILLOID

AI—II

043



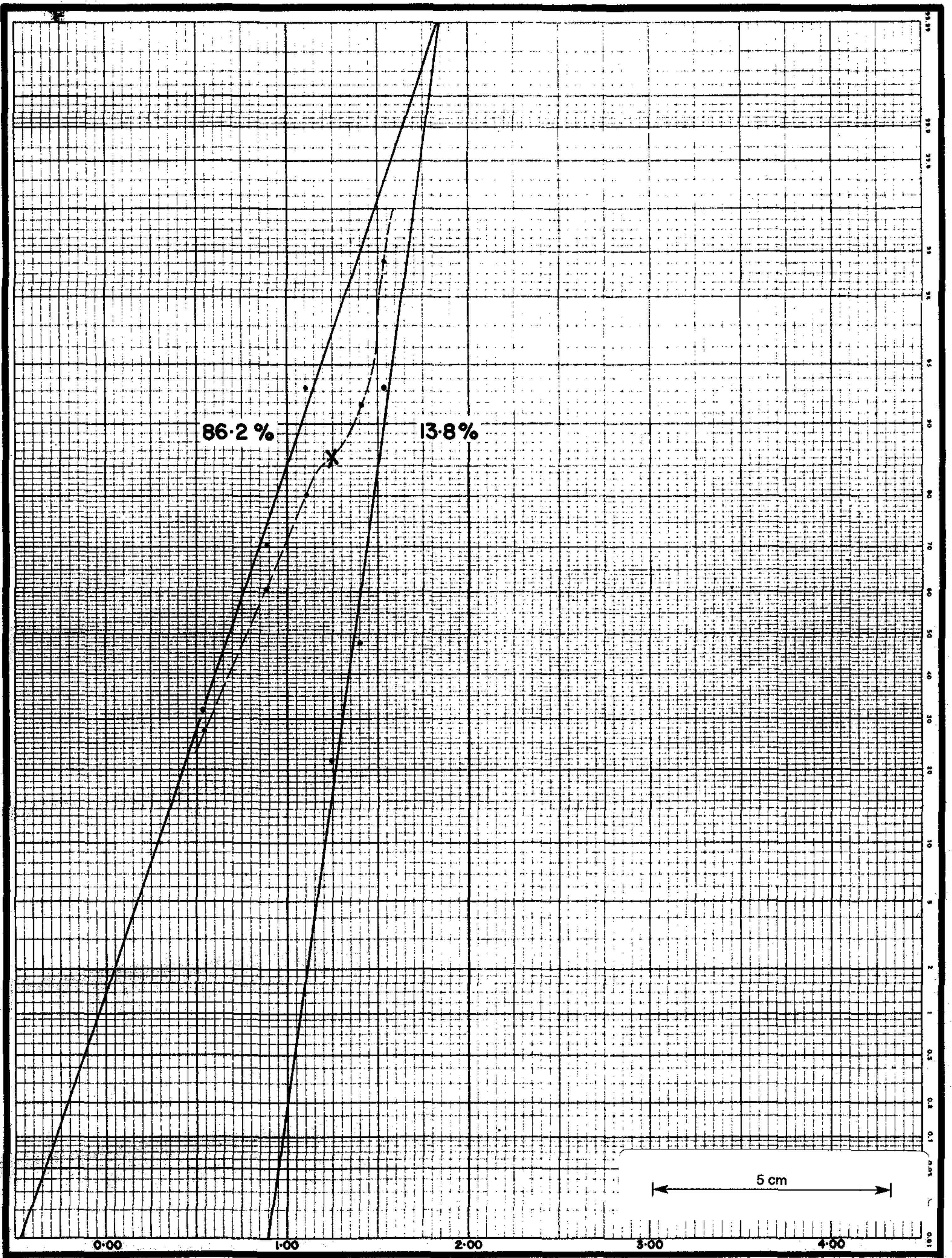
LOG_{10}(Concentration in p.p.m.)

639045

W IN UPPER VOLCANICS

A1-12

044

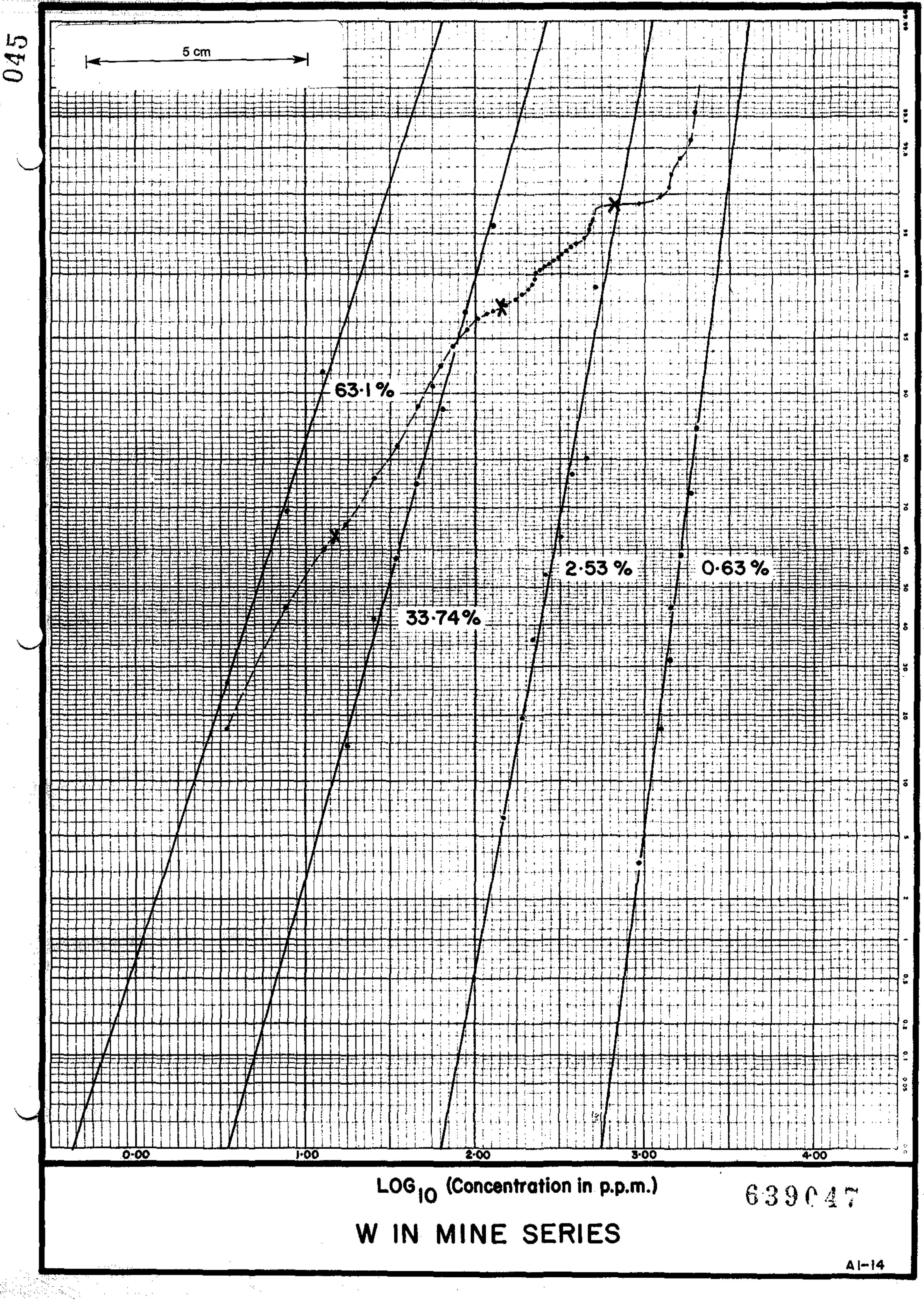


LOG$_{10}$ (Concentration in p. p. m.)

639046

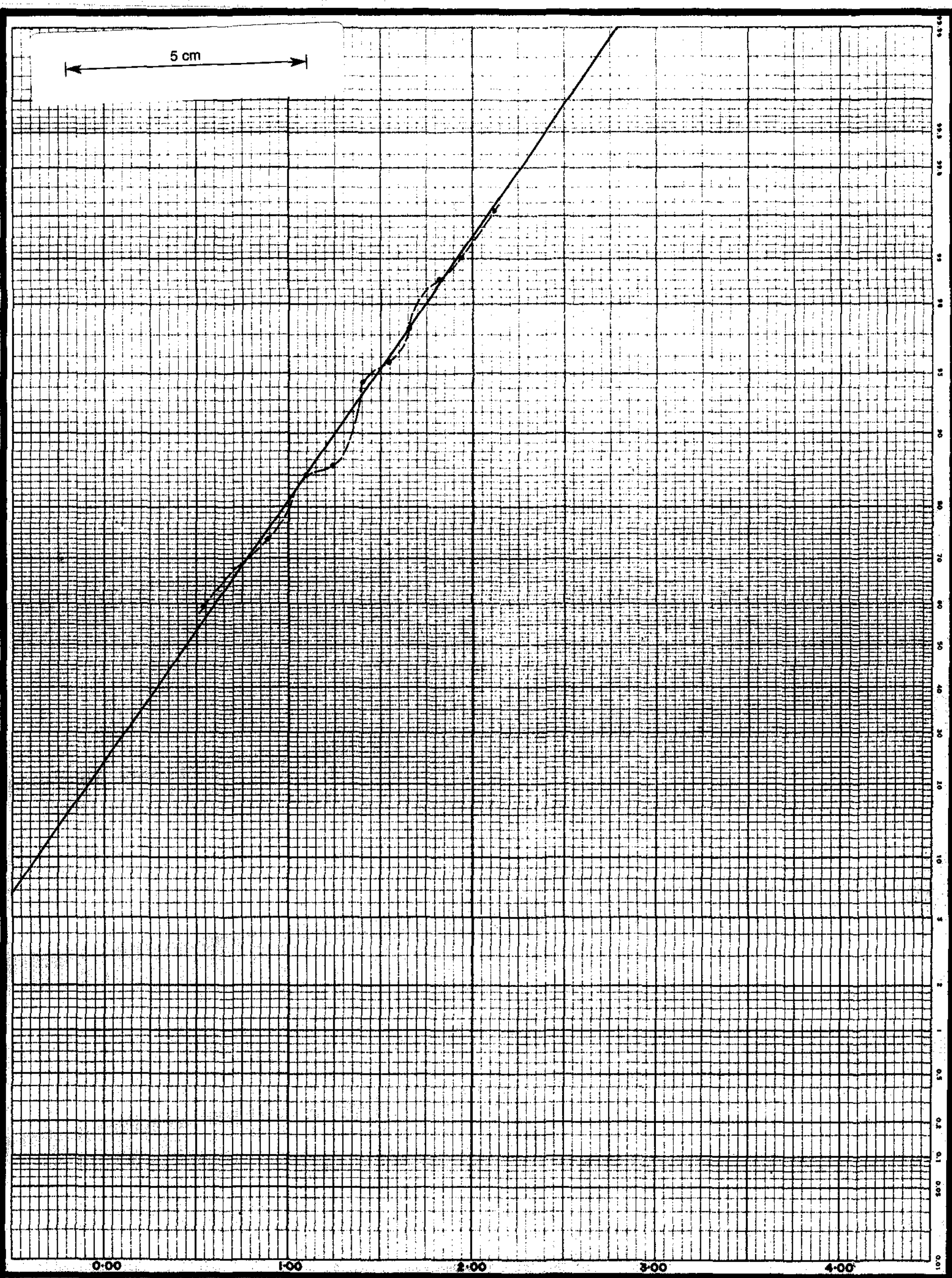
W IN MIDDLE VOLCANICS

A1-13



045
5 cm
63·1%
33·74%
2·53 %
0·63 %
0·00
1·00
2·00
3·00
4·00
LOG10 (Concentration in p.p.m.)
639047
W IN MINE SERIES
A1-14

046

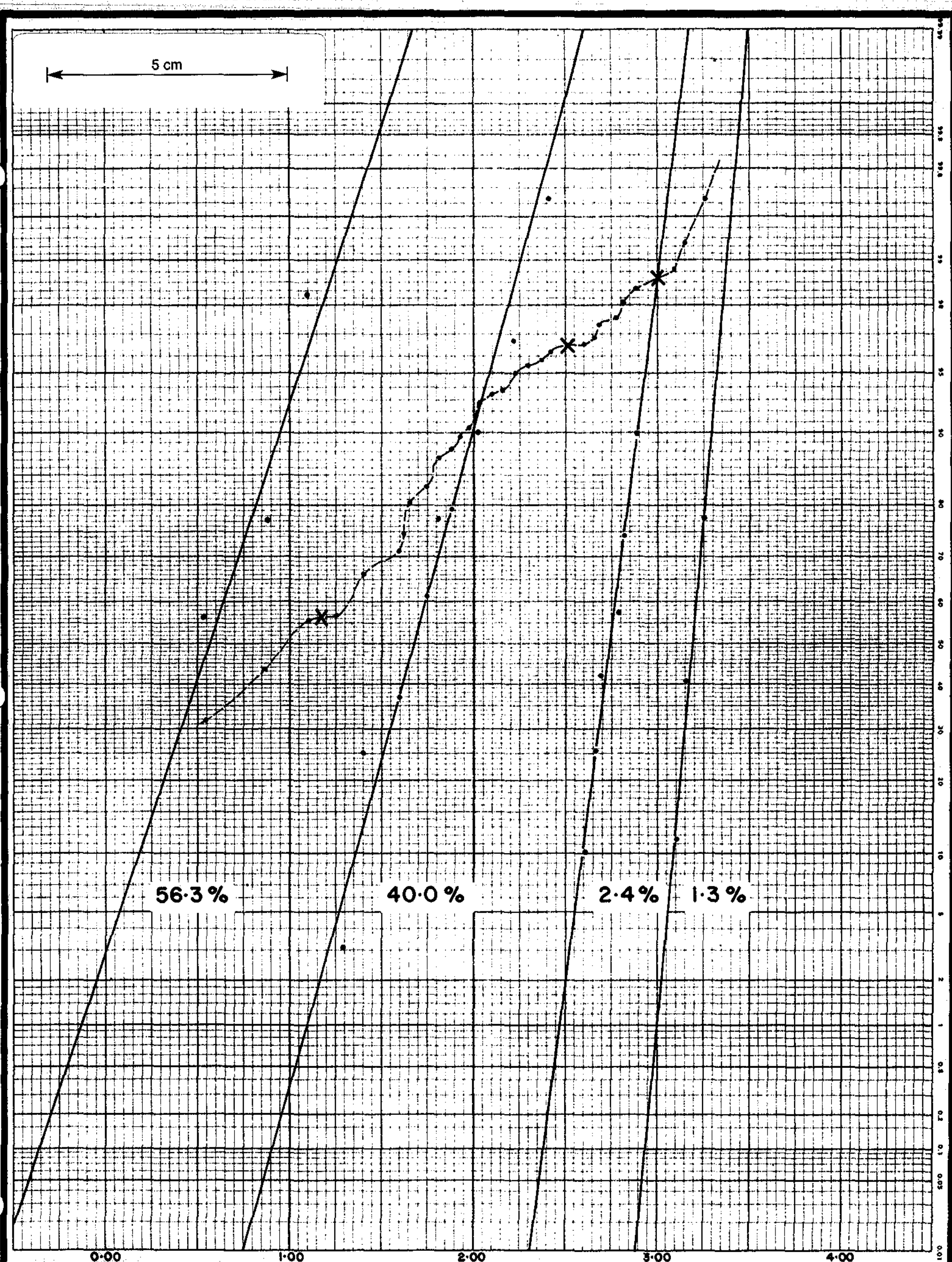


639C48

LOG$_{10}$ (Concentration in p.p.m.)

W IN WEATHERED VOLCANICS

A 1-15



LOG$_{10}$ (Concentration in p.p.m.)

639049

W IN WEATHERED MINE SERIES

A1-16

048

APPENDIX 2

The method used to infer distribution functions for populations of elemental concentrations in various rock and soil types from observations of the samples

The concentration (p.p.m.) of an element in a given rock or soil type has been regarded as a continuous* random variable, X^1, and the population of concentrations has been assumed to be infinite in size. (This is a reasonable assumption because of the immensity of the number of percussion hole, auger hole or hand specimen type samples - whichever is appropriate - that could be collected from the given rock or soil type before that particular rock or soil type was exhausted.)

A more convenient random variable than X^1 is

$$X = \log_{10} X^1 .$$

The assays constituting the sample are measured rather than true concentrations so they are regarded as a random variable, S^1, which is discrete.** The sample is finite. The appropriate sample random variable corresponding to the population random variable, X, is

$$S = \log_{10} S^1 .$$

The distribution function for X,

$$F(x) = P(X \leqslant x), \text{ ***}$$

is continuous. The distribution function for S,

$$G(x) = P(S \leqslant x),$$

is a step function. An example is graphed in Figure 14.

In order to produce an inferred distribution function for X, a number of values, xi, are chosen, and F(x) is inferred to take the value G(xi) when x = xi and interpolated values when x ≠ xi. But depending on the choice of the values, xi, the inferred distribution function, F(x), can vary greatly (Figure 15).

* A continuous random variable is a random variable whose value may be any real number in some interval.

** A discrete random variable can assume only a finite or countably infinite number of values.

*** P(E) is the probability that event E will occur.

The assays used in this study have always been reported as one of the following list:
<2, 2, 5, 10, 15, 20, 30, 40, ...(increasing by 10 hereafter). The accuracy of the assaying is not as good as the reported figures imply. (The laboratory quotes their relative error in Mo and W assays of less than 100 ppm as about 30%. So the true value of assays reported as 50 ppm may be as low as 35 ppm or as high as 65 ppm, rather than between 45 and 55 ppm as is implied by the fact that assays of 40 ppm and 60 ppm are reported as well as assays of 50 ppm.) Never-the-less, the frequency of occurrence of each of these figures is likely to be approximately constant regardless of the accuracy. That is because, for example, those assays which should have been reported as 50 (i.e. true value between 45 and 55) but were not are compensated for by those assays which should have been reported as 40 or 60 but were reported as 50. So the accuracy of the assaying is assumed to be as good as the reported figures imply.

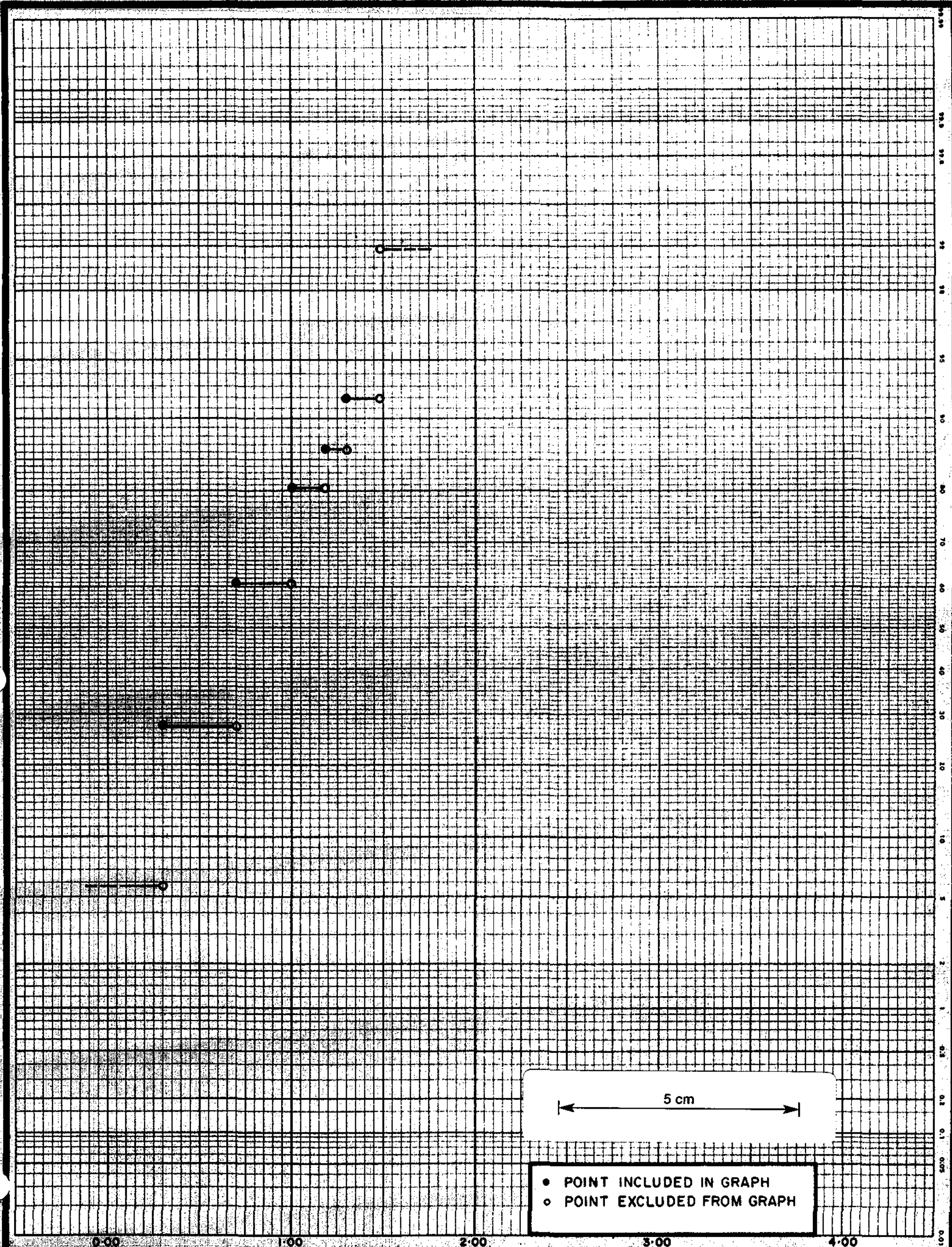
It is also assumed that the sample is truly representative of the population.

Under these assumptions,

$$F(xi) = G(xi) \text{ (precisely)}$$

when the values xi are
3.5, 7.5, 12.5, 17.5, 25, 35, 45, ... (increasing by 10 hereafter).

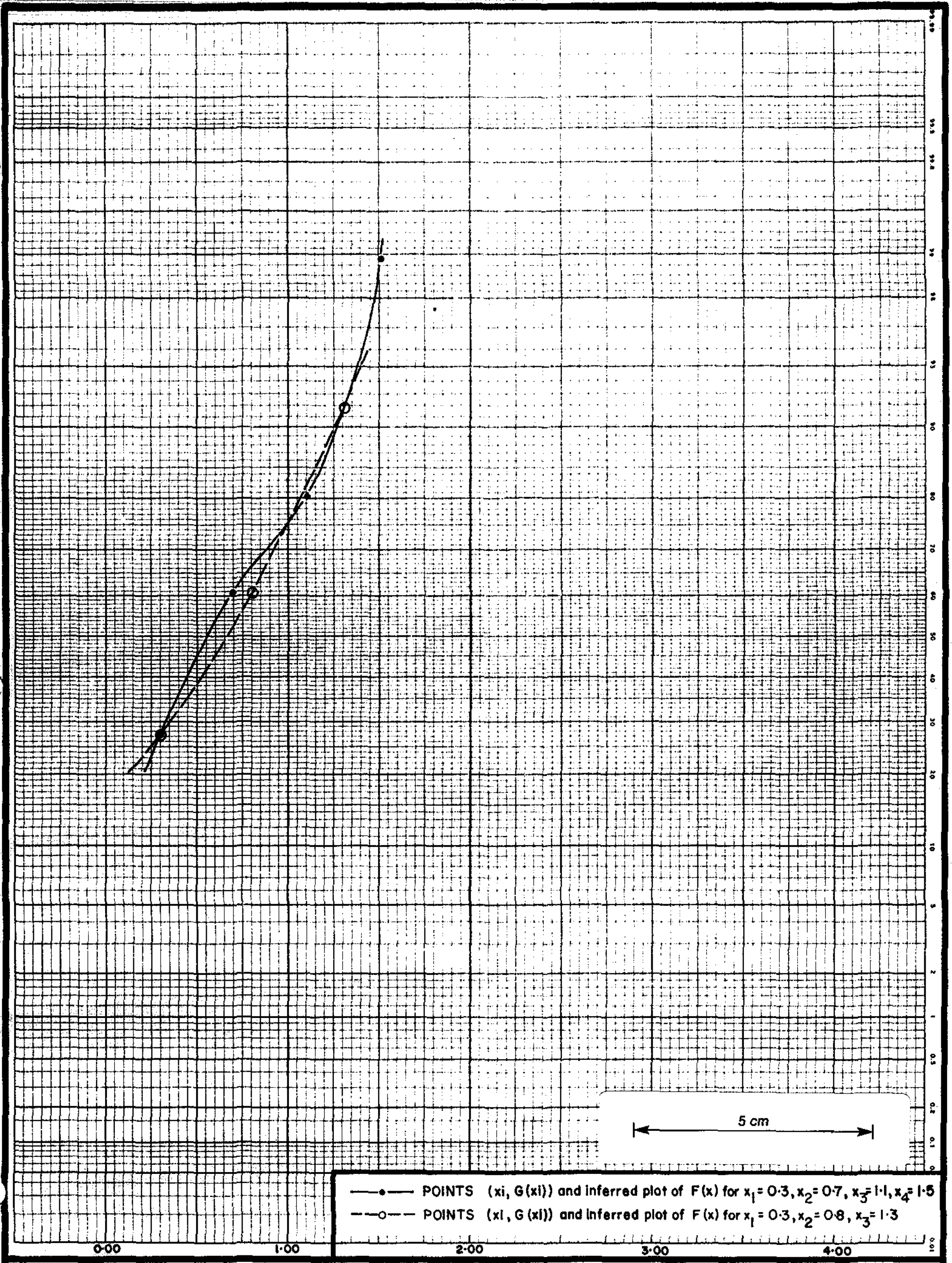
Since the first assumption is reasonable and the second inescapable, F(x) is inferred to take the values G(xi) when $x = xi$ and interpolated values when $x \neq xi$, where the values xi are those listed above.



LOG$_{10}$ (Concentration in ppm.) 639052

FIGURE 13: G (x) for the population of W concentrations in the middle volcanics. Vertical scale is percentage, "probability division."

051



LOG_{10} (Concentration in p.p.m.)

639053

FIGURE 14: Plots of the inferred distribution functions for W populations in the middle volcanics, obtained by using two different sets of values, xi. Vertical scale is percentage, "probability divisions".

APPENDIX 3

The determination of inferred distribution functions for east coast shale, limestone and tilloid

In order to produce inferred distribution functions for east coast shale, limestone and tilloid combined which would be comparable with those for mine series rocks, the samples of populations of elemental concentrations in shale and in limestone and in tilloid were combined in approximately the proportions of pelitic, calcareous and marble podded rocks in the contact aureole. These proportions are set out in Table 6 for three sections of the contact aureole and as calculated for the entire contact aureole.

TABLE 6

Source of Data for Section of Contact Aureole	Fraction of Contact Aureole in Section	Fraction of Mine Series in Section of Contact Aureole Constituted by Rock Type		
		Pelitic	Calcareous	Marble Podded
INV. 21	0.7	0.22	0.37	0.42
INV. 6	0.2	0.47	0.45	0.08
OPEN CUT PIT	0.1	0.58	0.32	0.09
WEIGHTED MEAN OF ABOVE	1.0	0.31	0.38	0.32

Table 6: Fractions of the mine series in three different sections of the contact aureole and in the contact aureole as a whole composed of pelitic, calcareous and marble podded rocks.

053

APPENDIX 4

$\bar{x}$ and $\sqrt{\frac{n}{n-1}}\,s$ for the samples of Cu, Ni and Zn populations in soil derived from mine series, volcanics, overlying siltstone and underlying siltstone

Element	$\bar{x}$ and $\sqrt{\frac{n}{n-1}}\,s$ in Rock Type							
	Mine Series		Volcanics		Overlying Siltstone		Underlying Siltstone	
	$\bar{x}$	$\sqrt{\frac{n}{n-1}}\,s$	$\bar{x}$	$\sqrt{\frac{n}{n-1}}\,s$	$\bar{x}$	$\sqrt{\frac{n}{n-1}}\,s$	$\bar{x}$	$\sqrt{\frac{n}{n-1}}\,s$
Cu	2.00	0.29	1.90	0.23	1.45	0.52	1.64	0.40
Ni	1.95	0.28	2.69	0.31	2.03	0.36	1.75	0.61
Zn	2.04	0.20	1.74	0.18	1.84	0.23	1.75	0.34

APPENDIX 5

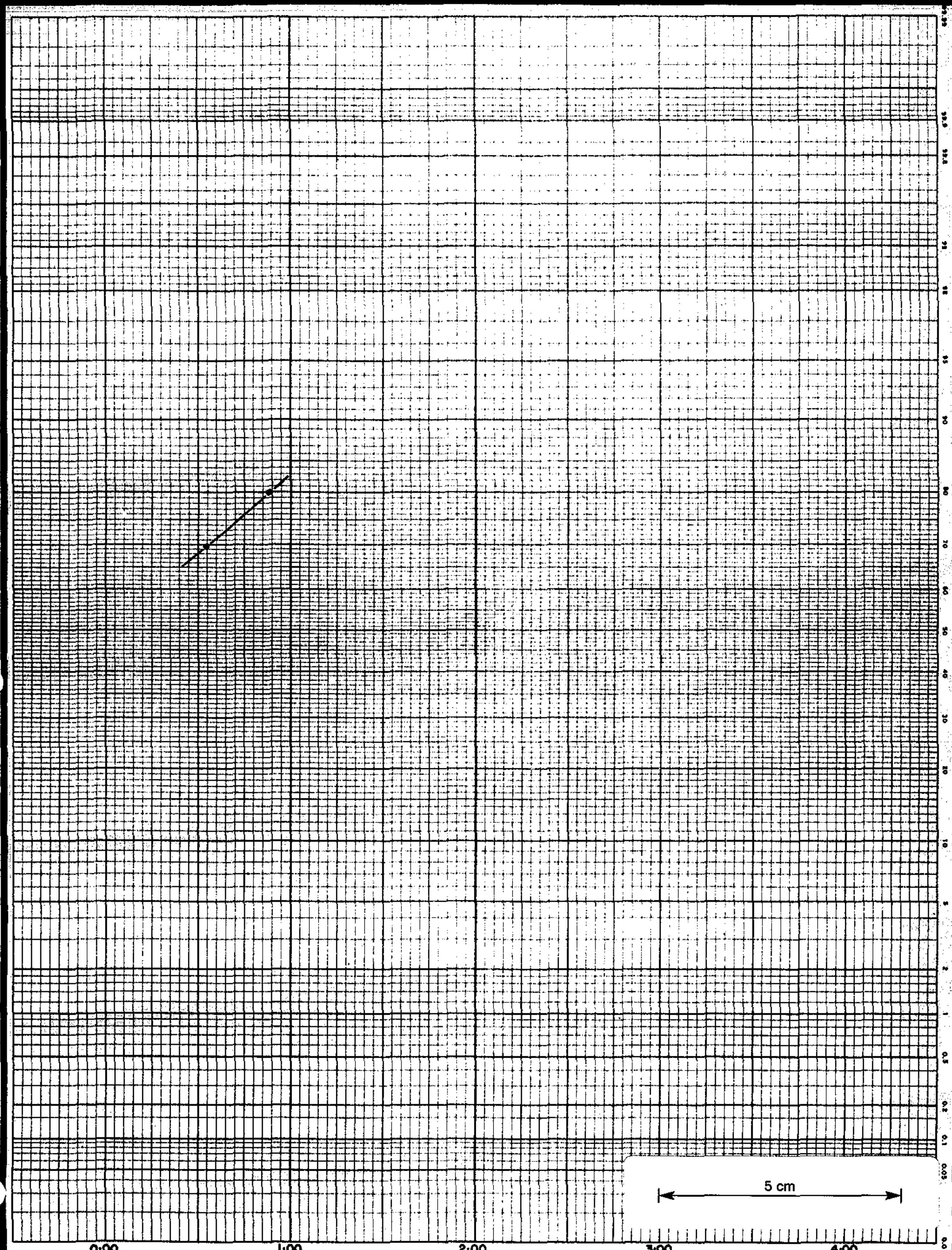
Additional graphs of inferred distribution functions

The following are graphs of the inferred distribution functions for the populations of logarithms of Mo concentrations in weathered underlying siltstone and of W concentrations in weathered overlying and underlying siltstone.

On each graph, the vertical scale is percentage with "probability divisions".

No Mo assay exceeded 2 ppm in the sample of the population of Mo in weathered overlying siltstone.

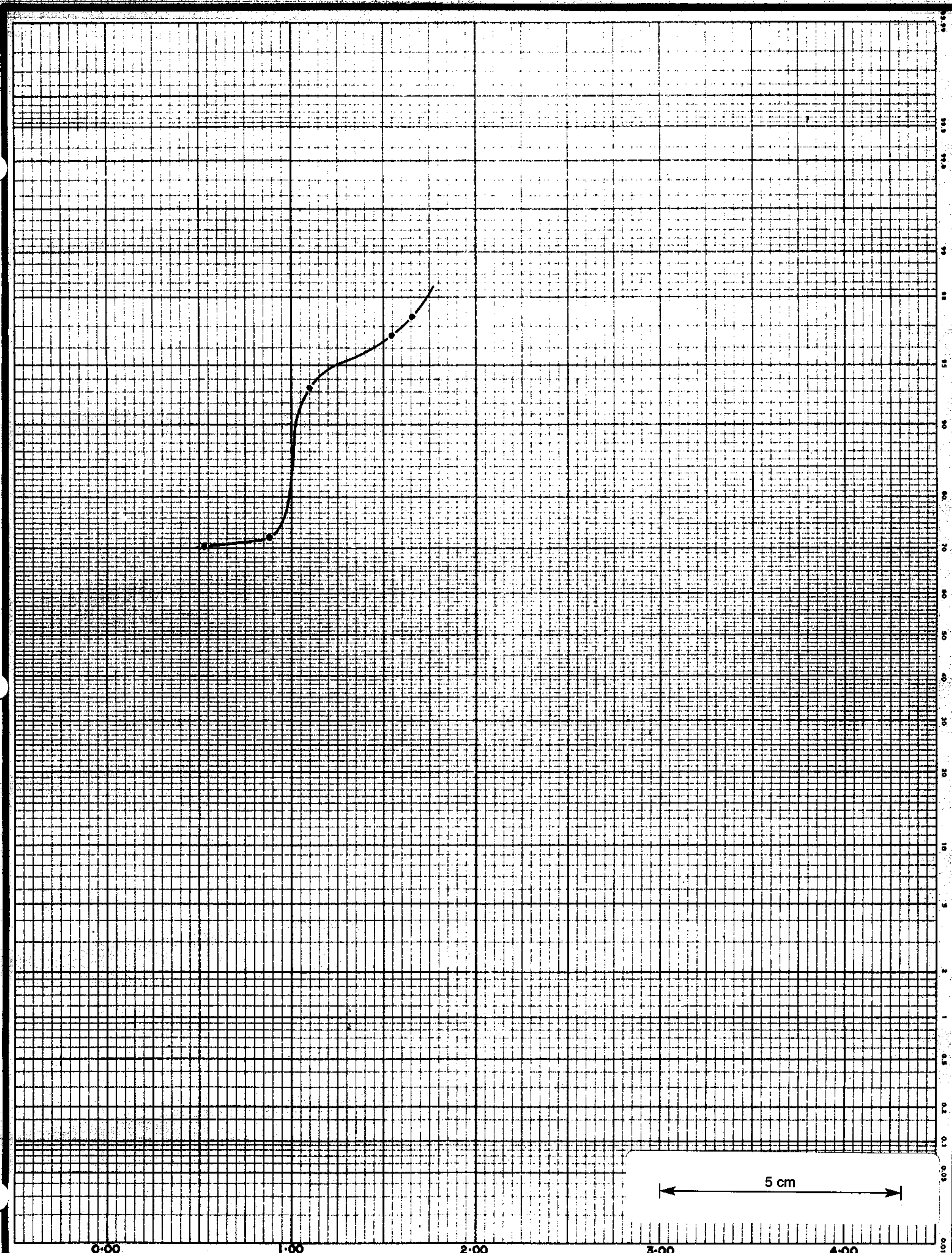
055



LOG$_{10}$ (Concentration in p.p.m.) 639057

W IN WEATHERED OVERLYING SILTSTONE

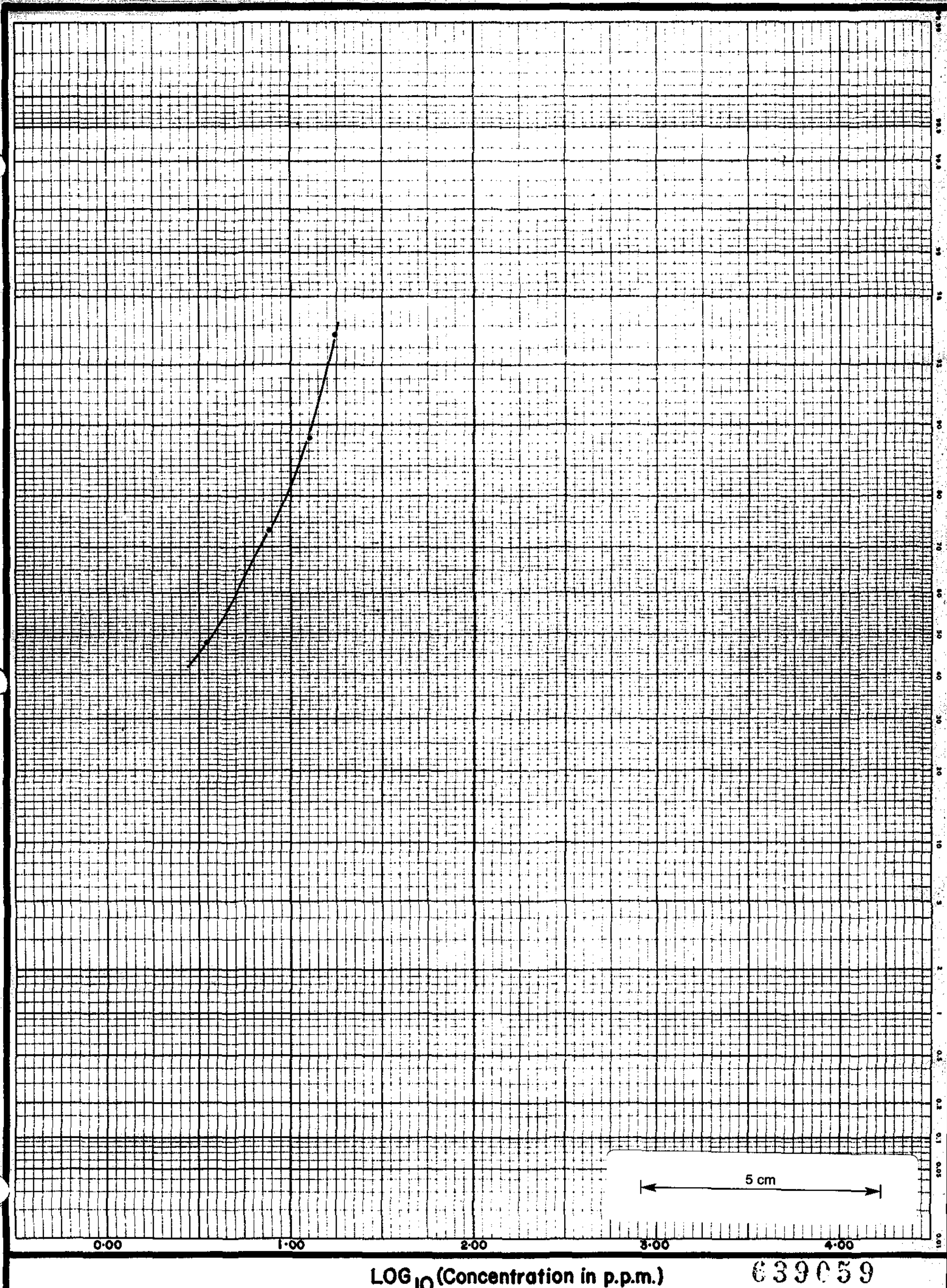
A5-1



LOG_{10} (Concentration in p.p.m.) 639058

Mo IN WEATHERED UNDERLYING SILTSTONE

057



639059

W IN WEATHERED UNDERLYING SILTSTONE

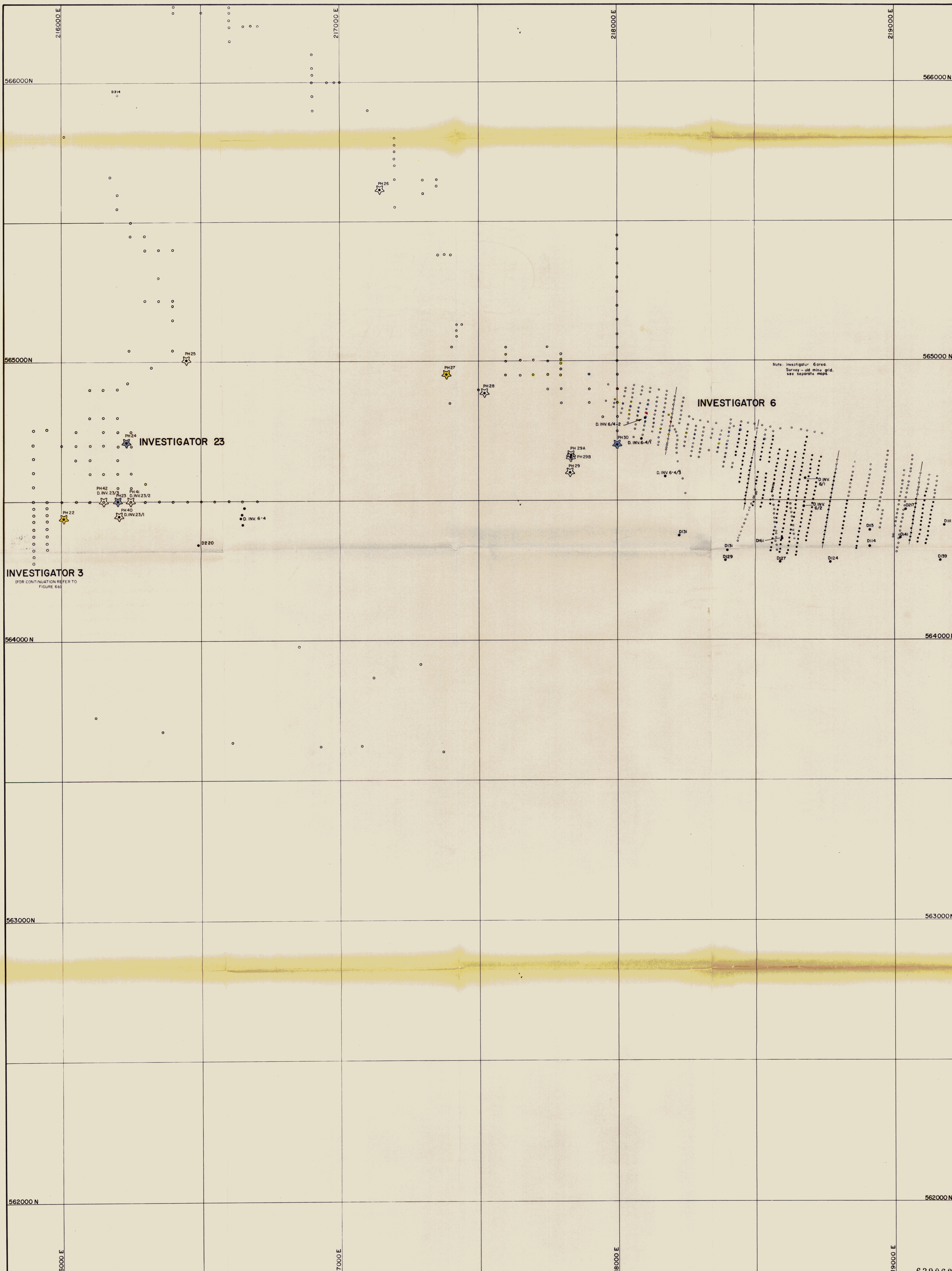
A5-3

REFERENCES

Rogers, M. C., and Smart, R. V., 1974. Evidence Supporting That Cottons Breccia and the P.G.H. Unit have the Same Origin. Geoscript, Vol. 2, No. 11, pp 25 -40.

ACKNOWLEDGEMENTS

The early work undertaken by Mr. Simon Gatehouse, Company Geochemist, on this study is gratefully acknowledged.



LEGEND

PH 6	☆	Percussion drill hole for which no samples of mine series were assayed.
PH 51	☆ (yellow)	Percussion drill hole yielding no sample with more than 14·8 p.p.m. Mo.
PH 32A	☆ (blue)	Percussion drill hole yielding some samples with between 14·8 and 323 p.p.m. Mo.
PH 33	☆ (red)	Percussion drill hole yielding some samples with more than 323 p.p.m. Mo.

- o Auger drill hole which did not definitely reach mine series rock.
- o Auger drill hole yielding sample with less than 5·4 p.p.m. Mo.
- o Auger drill hole yielding sample with between 5·4 and 323 p.p.m. Mo.
- o Auger drill hole yielding sample with more than 323 p.p.m. Mo.

NOTE:

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

SCALE: 1 : 5000 m.

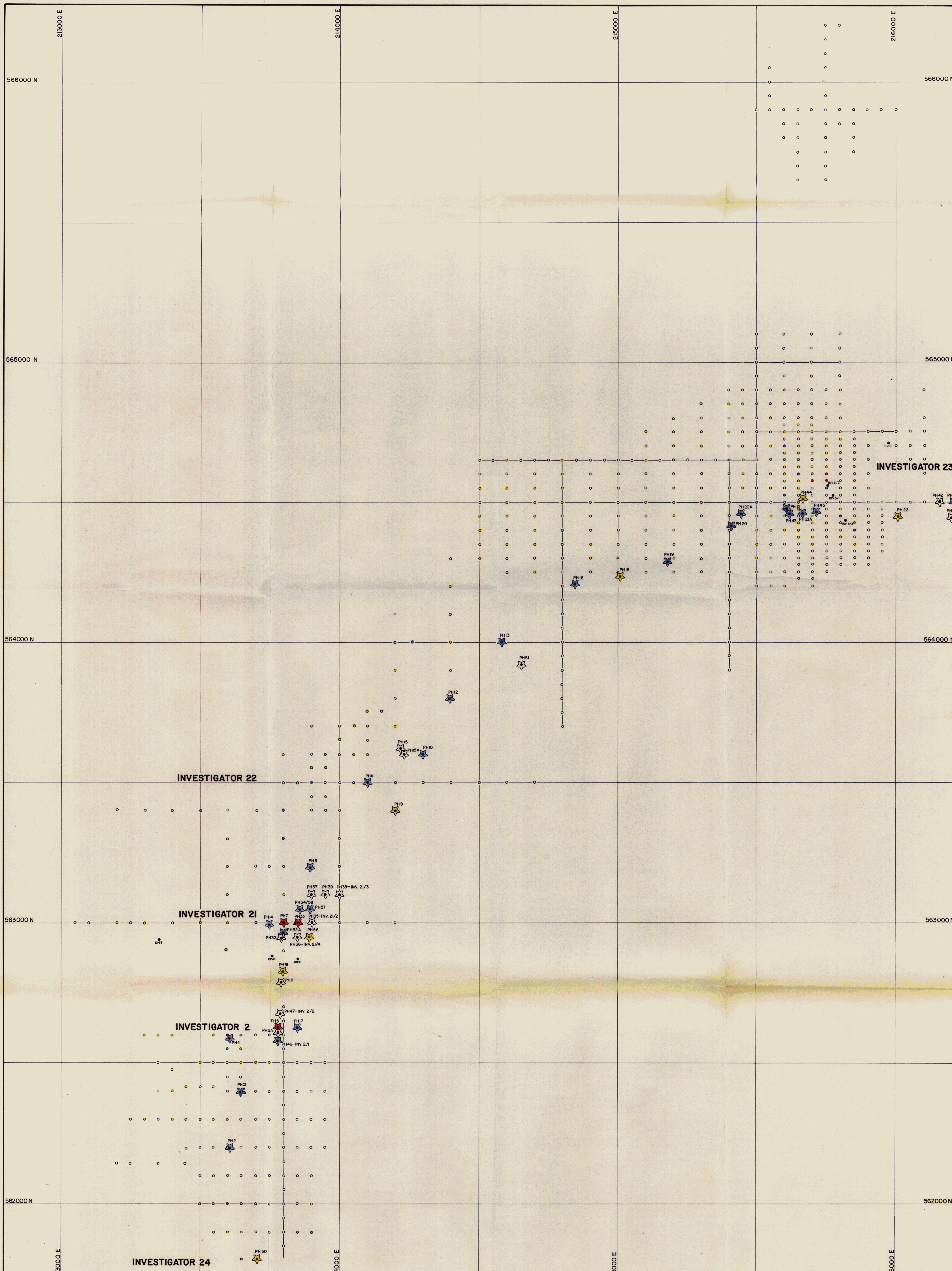
No. KF5-

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: M.C.R.

FIGURE 6a.: The locations of percussion and auger drill holes which produced — samples of mine series or weathered- mine series with anomalous concen_ trations of Mo.—

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9

3682



639063

LEGEND

PH 6	☆	Percussion drill hole for which no samples of mine series were assayed.
PH 51	☆	Percussion drill hole yielding no sample with more than 14·8 p.p.m. Mo.
PH 32A	☆	Percussion drill hole yielding some samples with between 14·8 and 323 p.p.m. Mo.
PH 33	☆	Percussion drill hole yielding some samples with more than 323 p.p.m. Mo.

- ○ Auger drill hole which did not definitely reach mine series rock.
- ○ Auger drill hole yielding sample with less than 5·4 p.p.m. Mo.
- ● Auger drill hole yielding sample with between 5·4 and 323 p.p.m. Mo.
- ● Auger drill hole yielding sample with more than 323 p.p.m. Mo.

NOTE:

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: MCR

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

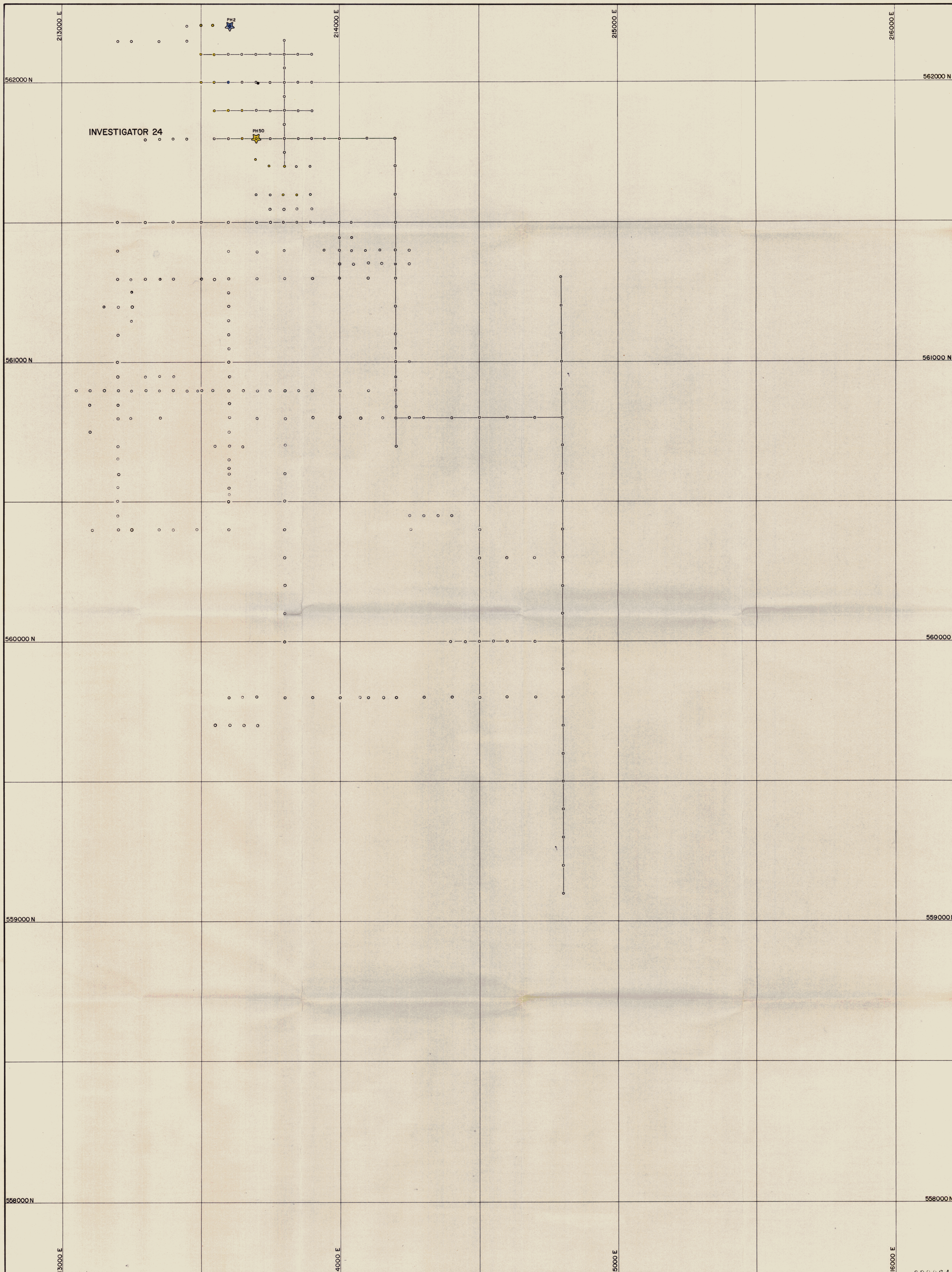
SCALE: 1:5000m.

No. KF4-

FIGURE 6b: The locations of percussion and auger drill holes which produced samples of mine series or weathered-mine series with anomalous concentrations of Mo.

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9

3683



LEGEND

PH 6	☆	Percussion drill hole for which no samples of mine series were assayed .
PH 51	☆	Percussion drill hole yielding no sample with more than 14·8 p.p.m. Mo .
PH 32A	☆	Percussion drill hole yielding some samples with between 14·8 and 323 p.p.m. Mo .
PH 33	☆	Percussion drill hole yielding some samples with more than 323 p.p.m. Mo .

- o Auger drill hole which did not definitely reach mine series rock .
- o Auger drill hole yielding sample with less than 5·4 p.p.m. Mo .
- o Auger drill hole yielding sample with between 5·4 and 323 p.p.m. Mo .
- o Auger drill hole yielding sample with more than 323 p.p.m. Mo .

NOTE :

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

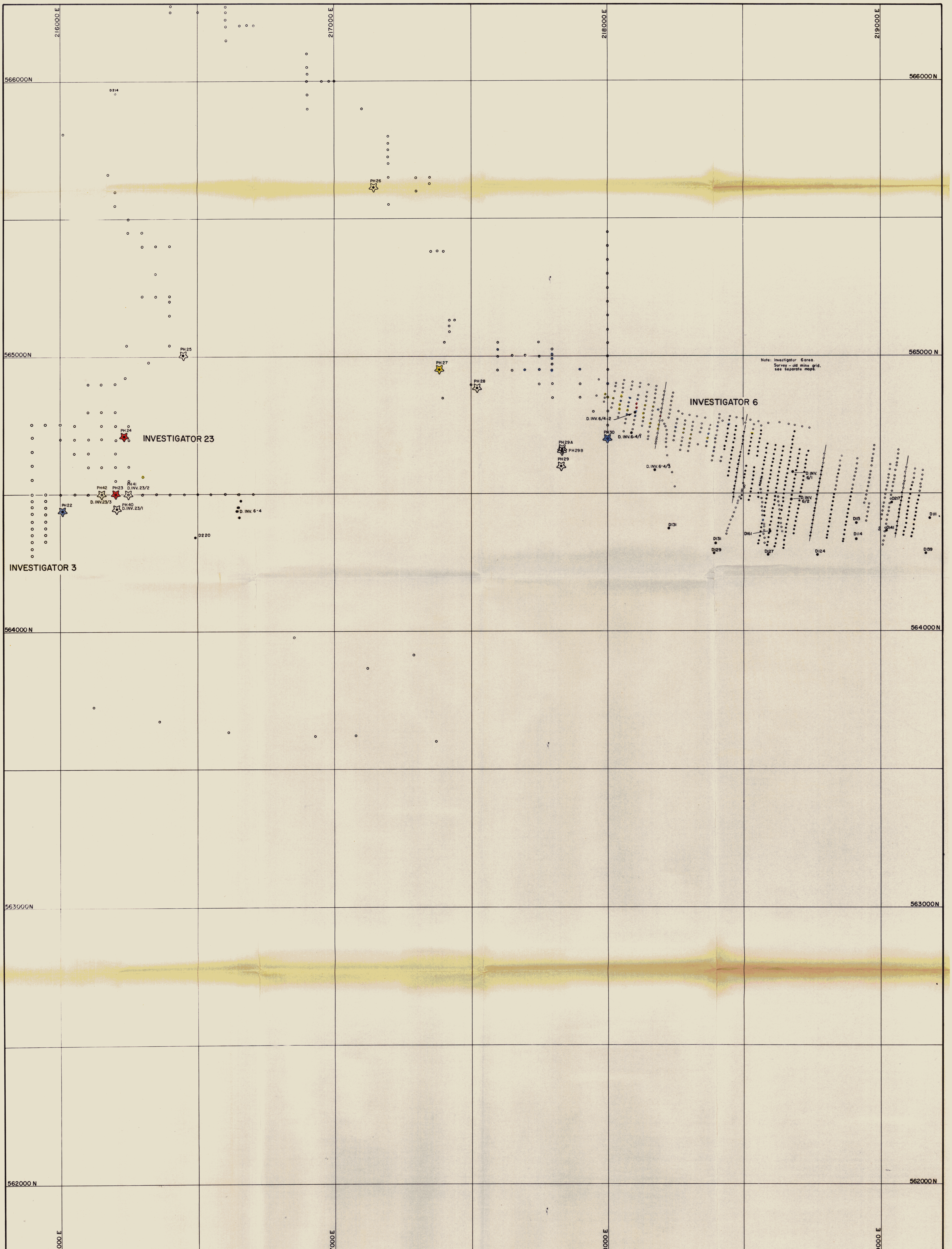
SCALE: 1 : 5000 m.

No. KF7-

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: M.C.R.

FIGURE 6c : The locations of percussion and auger drill holes which produced— samples of mine series or weathered— mine series with anomalous concentrations of Mo .

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9



LEGEND

PH 6	☆	Percussion drill hole for which no samples of mine series were assayed.
PH 51	☆ (yellow)	Percussion drill hole yielding no sample with more than 14·8 p.p.m. W.
PH 32A	☆ (blue)	Percussion drill hole yielding some samples with between 14·8 and 138 p.p.m. W.
PH 33	☆ (red)	Percussion drill hole yielding some samples with more than 138 p.p.m. W.

- ○ Auger drill hole which did not definitely reach mine series rock.
- ○ Auger drill hole yielding sample with less than 14·8 p.p.m. W.
- ○ Auger drill hole yielding sample with between 14·8 and 324 p.p.m. W.
- ○ Auger drill hole yielding sample with more than 324 p.p.m. W.

NOTE:

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: M.C.R.

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

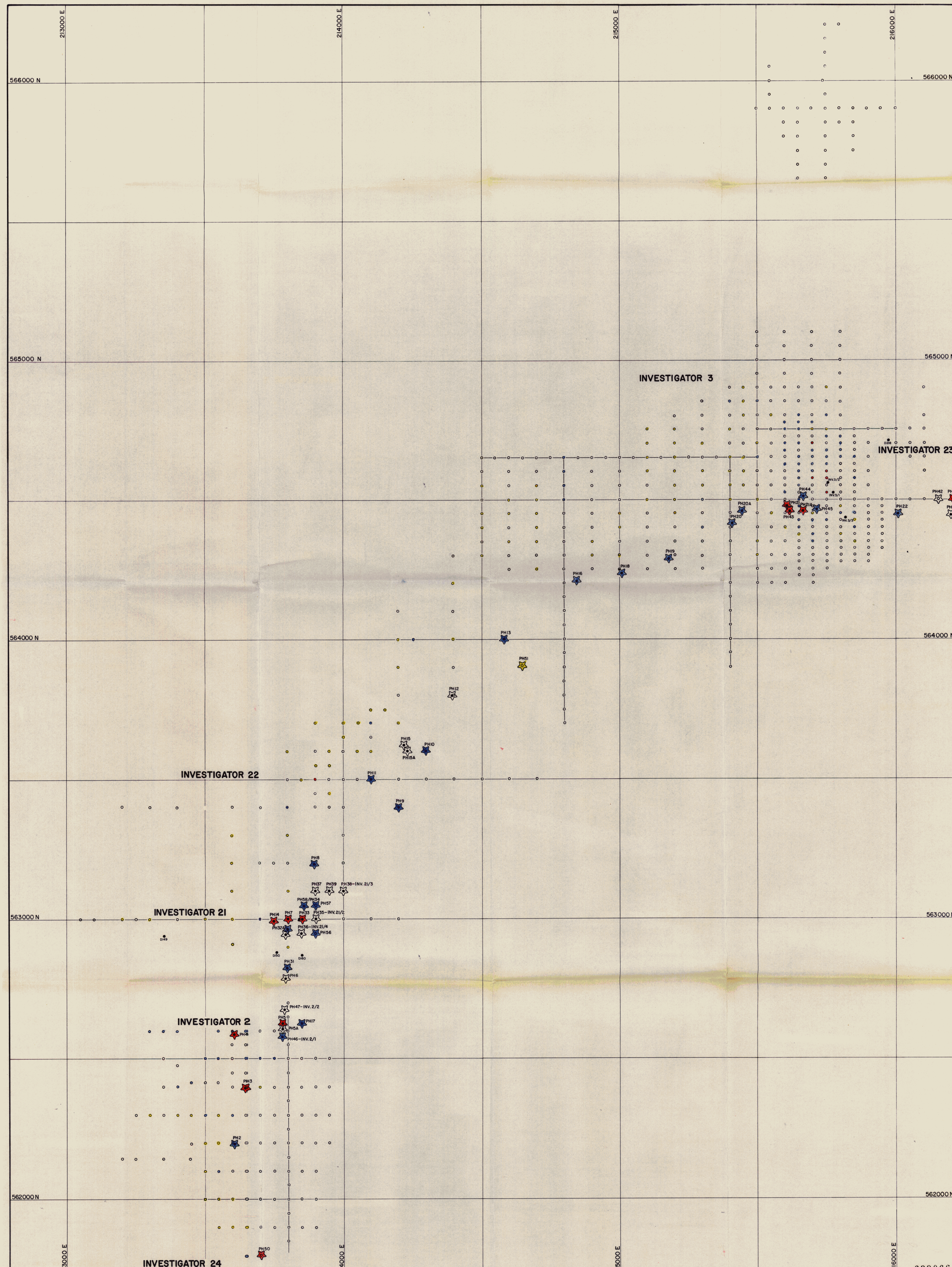
SCALE: 1 : 5000 m.

No. KF5-

FIGURE 7a: The locations of percussion and auger drill holes which produced samples of mine series or weathered mine series with anomalous concentrations of W.

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9

3685



LEGEND

PH 6	Percussion drill hole for wich no samples of mine series were assayed.
PH 51	Percussion drill hole yielding no sample with more than 14·8 p.p.m. W.
PH 32A	Percussion drill hole yielding some samples with between 14·8 and 138 p.p.m. W.
PH 33	Percussion drill hole yielding some samples with more than 138 p.p.m. W.

- Auger drill hole which did not definitely reach mine series rock.
- Auger drill hole yielding sample with less than 14·8 p.p.m. W.
- Auger drill hole yielding sample with between 14·8 and 324 p.p.m. W.
- Auger drill hole yielding sample with more than 324 p.p.m. W.

NOTE:

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: M.C.R.

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

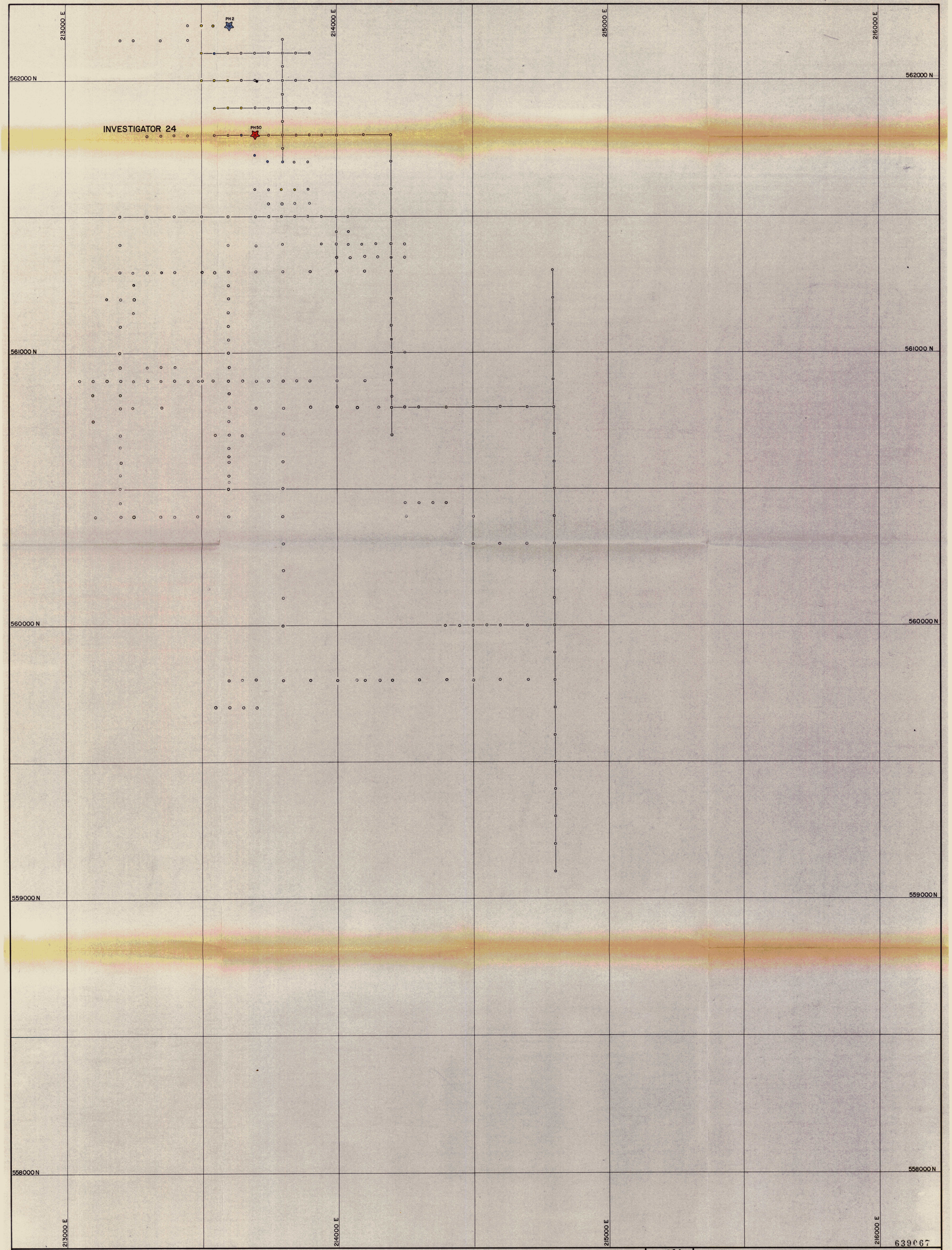
SCALE: 1:5000m.

No. KF4-

FIGURE 7b: The locations of percussion and auger drill holes which produced samples of mine series or weathered mine series with anomalous concentrations of W.

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9

3686



LEGEND

PH 6	Percussion drill hole for which no samples of mine series were assayed.
PH 51	Percussion drill hole yielding no sample with more than 14·8 p.p.m. W.
PH 32A	Percussion drill hole yielding some samples with between 14·8 and 138 p.p.m. W.
PH 33	Percussion drill hole yielding some samples with more than 138 p.p.m. W.

- Auger drill hole which did not definitely reach mine series rock.
- Auger drill hole yielding sample with less than 14·8 p.p.m. W.
- Auger drill hole yielding sample with between 14·8 and 324 p.p.m. W.
- Auger drill hole yielding sample with more than 324 p.p.m. W.

NOTE:

1. Co-ordinate system is the integrated co-ordinate system based on Australian Geodetic Datum.

5 cm

DATE: March 1975
GEOLOGIST: R.S.
DRAWN: O.S.
CHECKED: M.C.R.

GEOPEKO LIMITED
KING ISLAND GROUP

75-1080

SCALE: 1 : 5000 m.

No. KF7-

FIGURE 7c: The locations of percussion and auger drill holes which produced samples of mine series or weathered mine series with anomalous concentrations of W.

KF1	KF2	KF3
KF4	KF5	KF6
KF7	KF8	KF9

3687