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6415 - 64th Street, Delta, B.C.

INTER-OFFICE MEMORANDUM

DATE: December 22, 1981

TO: C. M. H. Jennings

COPIES TO: B. W. Downing, H. R. Stockford

FROM: J. B. Gammon

SUBJECT: Albert Creek property, northern B. C.

Please find attached the following reports:

6-079-81	The use of geochemical sections and related techniques for the interpretation of multielement soil geochemical maps of the ZAP claims area near Watson Lake, Y.T.
24-079-81	The use of Mimulus Guttatus as an indicator plant in northern British Columbia.

both by Dr. John A. C. Fortescue who you may recall meeting during your inspection visit to northern British Columbia last summer.

In his first report Fortescue concludes that his reinterpretation of the data lends weight to the hypothesis of a north-south striking silver bearing vein being present. In subsequent discussions at this office with Bruce Downing he agreed that alternative interpretations of the data were possible and more likely. However we were impressed by the usefulness of plotting data on the form shown on his Figures 3A, B, C and 4A, B and this approach was used for data from the British Silbak property (Report 11-003-81, Figures 19 and 20).

In his second report, on the indicator plant, he comes to the conclusion that sampling of the plant or spring waters gives inferior results to conventional stream sediment sampling with appropriate sample spacing at spring orifices. Fortescue's use of the ICP technique in this study, summarized on pages 31 - 32 with results presented in Tables 1-4, persuaded us of the validity of this technique, which gives 26 elements for $5.50, and prompted the submittal of Maid of Erin soil samples for ICP analysis.

J. B. Gammon

JBG:ik

THE USE OF _MIMULUS GUTTATUS_ AS AN INDICATOR PLANT IN NORTHERN BRITISH COLUMBIA

BY

John A.C.Fortescue

A report compiled under
contract to Falconbridge
Nickel Mines: December 7th
1981

PREFACE

At the Prospectors and Developers Meeting in Toronto in March 1981 Jim Mc Dougall suggested to me that I might be interested in investigating a plant which he had observed in the vicinity of certain springs in Northern British Columbia.

After preliminary discussions with Dr Ivor Elliott in June a proposal for work was submitted to him which was accepted by him in a letter dated August 4th 1981. Field investigations at the Zap Claims near One Ace Mountain in Northern British Columbia were completed on August 14th and 15th 1981 with the help of Bruce Downing and Karl Christensen. The sample material was brought to Vancouver and sent to the Acme Analytical Laboratories at 852 East Hastings Street for chemical analysis using using a multi-element Inductively Coupled Plasma (ICP) technique. Brief preliminary reports were prepared describing these activities. This report is the final definitive statement of the investigation and superceeds the other two which were essentially records of the investigation as it proceeded.

It has been a pleasure to work on this interesting investigation and I would like to thank Dr J.F. Gammon, Dr Ivor Elliott and the staff of Falconbridge Nickel Mines Ltd for their help and co-operation with the work as it proceeded under contract.

John Fortescue
Consultant Geochemist

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THE USE OF <u>MIMULUS</u> <u>GUTTATUS</u> AS AN INDICATOR PLANT IN NORTHERN BRITISH COLUMBIA

<u>Introduction</u> Prospectors in many parts of the world have used plants as aids to the discovery of mineral deposits since prehistoric times but it is only in this centuary that scientists have researched the details of such relationships. One of the centres of such research was the University of British Columbia in the 1940's and 1950's when Professor H.V.Warren, Dr R.E. Delavault and their co-workers made pioneer investigations into biogeochemical prospecting in the province and elsewhere.

Plant prospecting methods are divided into two groups, one involves the abundance and morphology of plant species associated with mineralization and the other relies upon the results of chemical analysis of common plants for information regarding the proximity of mineralization in driftcovered areas. The former are called <u>geobotanical methods</u> and the latter <u>biogeochemical methods</u>. In British Columbia biogeochemical methods have been used during the last thirty years by exploration geochemists often alongside techniques based on soil analysis or the analysis of stream, or lake sediments. Geobotanical methods based on indicator plants have been rare so that when Jim MacDougall suggested that he had observed an indicator plant near silver bearing springs research was needed to test the validity of this hypothesis.

The project commenced by a brief literature search continued with a two day field investigation and associated laboratory work and concluded with further research in the library and herbarium to round out the investigation. This report describes activities associated with each of these stages of the research.

<u>Objectives</u>

The research had three objectives :-

1)To provide information on the use of M. <u>guttatus</u> as a geobotanical indicator for silver mineralization in the Northern Cordillera

2)To provide information on the use of M. <u>guttatus</u> as a biogeochemical indicator for silver mineralization in the Northern Cordillera.

3)To establish the relative effectiveness of <u>M.guttatus</u> as an aid to prospecting compared with waters and stream sediments.

Preliminary Research During preliminary discussions with Jim Mac Dougall in June 1981 he presented me with copies of photographs of M.guttatus growing in the vicinity of springs in the Zap claims area. He also mentioned that the plant was known to occur in the vicinity of hot springs in that part of the Cordillera.

T.M.C. Taylor(1974) in his description of the Figwort Family in British Columbia described the plant as follows :-

Mimulus guttatus DC Annual,or perennial by stems rooting at the nodes, by creeping rootstocks,or by stolons. Stems stout and erect or weak and more or less reclining,up to 55cm tall,mostly simple,commonly glabous and puberulent or pubescent above.Leaves variable,mostly rounded-ovate or obate oblong, up to 15cm long,many-nerved,coarsely and irregularly dentate often with small projections at the base of the blade; petioles usually much longer than the blades,upper leaves sessile; internodes generally longer than the leaves. Inflorescence mostly racemose,sometimes solitary or few flowered; pedicels less than twice as long as the calyx ,rarely slender and elongated. Calyx glabrous or pubescent,campanulate,often dotted or tinged with red 8-17 mm long,longer and much inflated in fruit,teeth short,upper tooth longer. Corolla up to 4cm long,yellow,the throat usually spotted with red,ridges densely hairy,nearly closing the throat,strongly 2-lipped. Capsule broadly oblong,constricted at or short stipitate.

Common in wet places of Western North America from Alaska and Yukon south to New Mexico. Common throughout the Province.(pp 95 & 97).

Taylor's map for the distribution of M. guttatus is reproduced as Figure 1 and his drawing of the plant as Figure 2.

Other writers on the species including Porsild (1974),Clark(1976) and Abrams(1951) were consulted for further information and the aspects of the plant important in relation to prospecting are :-

1)M. guttatus is a common plant in damp areas which is found by mineral springs(Porsild). It blooms from May to September(Clark). It can be identified as patches of intense yellow far up on the faces of cliffs and in Alpine Meadows(Clark).

2)M. guttatus is a very variable species. For example Abrams(1951) lists three subspecies and one variety of the plant. Clark(1976)notes that it is a 'very plastic species .... impoverished plants-dwarfed by the relatively huge flowers-may be only a few inches high ...but in wet and fertile soil robust plants may approach 3 feet,with succulent, hollow,squarish stems as thick as one's thumb.'

In summary,from the viewpoint of geobotanical prospecting the plant has the advantage of living in damp areas and near mineral springs,it is easily recognised by its yellow flowers and it blooms throughout the summer. Disadvantages are that it is found in any wet place and not specifically around mineral springs or showings. Another potential disadvantage is that the plant is very variable in form being large or small with considerable variation in the form of particular organs. Consequently,unless a very specific form(and/or colour) of the plant

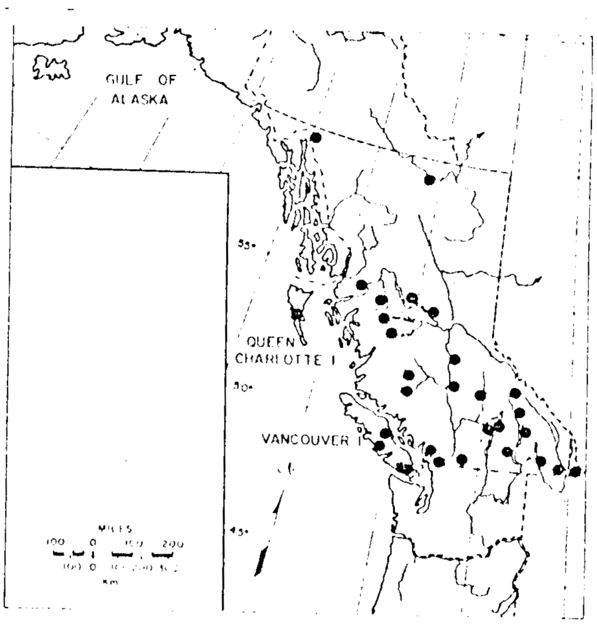


Figure 1 Map showing the range of Mimulus guttatus DC in British Columbia (from Taylor(1974)

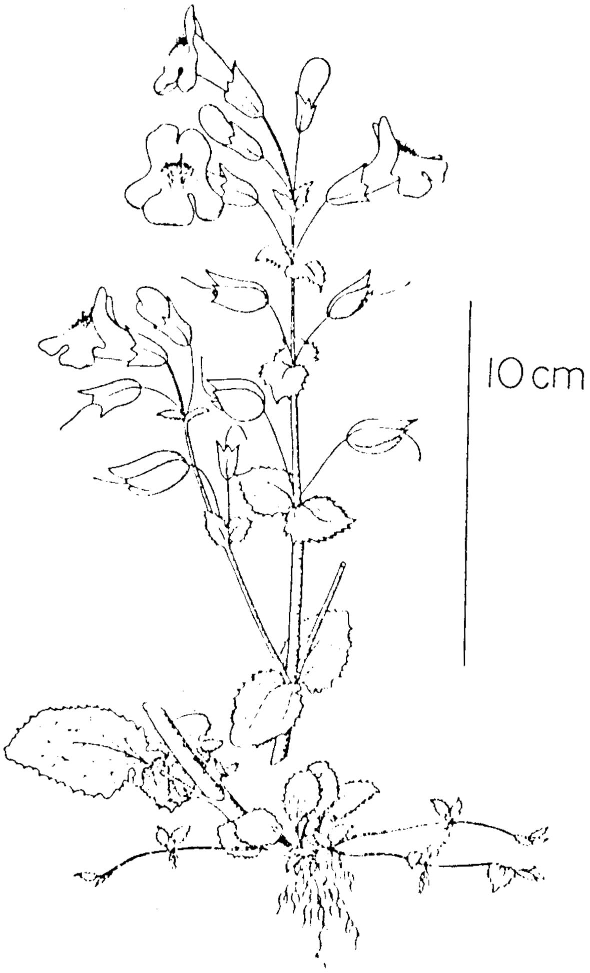


Figure 2 Yellow Monkey Flower (Mimulus guttatus DC)(from Taylor 1974)

is associated with mineralization it would be difficult to use as a specific geobotanical indicator species.

From the viewpoint of biogeochemical prospecting the plant has several advantages. It is easily recognised on the ground or, under favourable conditions, from a helicopter. The plant grows in clumps which are suitable for sampling throughout the summer and not just at one period of the summer, and enough of the material for a chemical analysis can frequently be got from a small number of individual plants.

These considerations were considered together during the planning of the field investigation to be completed in a maximum of two days at the Zap claims area.

2)The Field and Laboratory Investigation

The field activity was designed to establish if M.guttatus could be used as the basis for a plant prospecting method for silver(and, possibly other elements)in Northern British Columbia and the adjacent Yukon. Preliminary discussions suggested that at least two springs occurred in the Zap claims area where M. guttatus was common and high silver and other metals were known in the waters. It was also evident that the plant was found in the vicinity of other springs in the same area which were not known to be associated with mineralization. The problem resolved itself into the design of a suitable conceptual model which could be used to sample mineralised and control springs in exactly the same manner in order to produce evidence for the use of M.guttatus as a geobotanical or biogeochemical indicator and in doing so to discover other plants associated with M.guttatus which might be indicators themselves.

The conceptual model is shown in Figure 3. It allows for the positioning of a grid area (marked with ropes) at a spring origin(or along a creek) 5m wide and 10m long. The grid area is divided into four quarters to facilitate rapid ecological mapping . Is was planned to collect the following samples for chemical analysis from each plot :-

A)Two 1 l samples of water from the spring(or stream)one to be acidified with HNO_3 at the site and the other allowed to remain in its natural state. Both samples to be filtered on site through a filter paper.

B)Five samples of stream sediment to be collected at 2m intervals downstream from the spring across the plot.

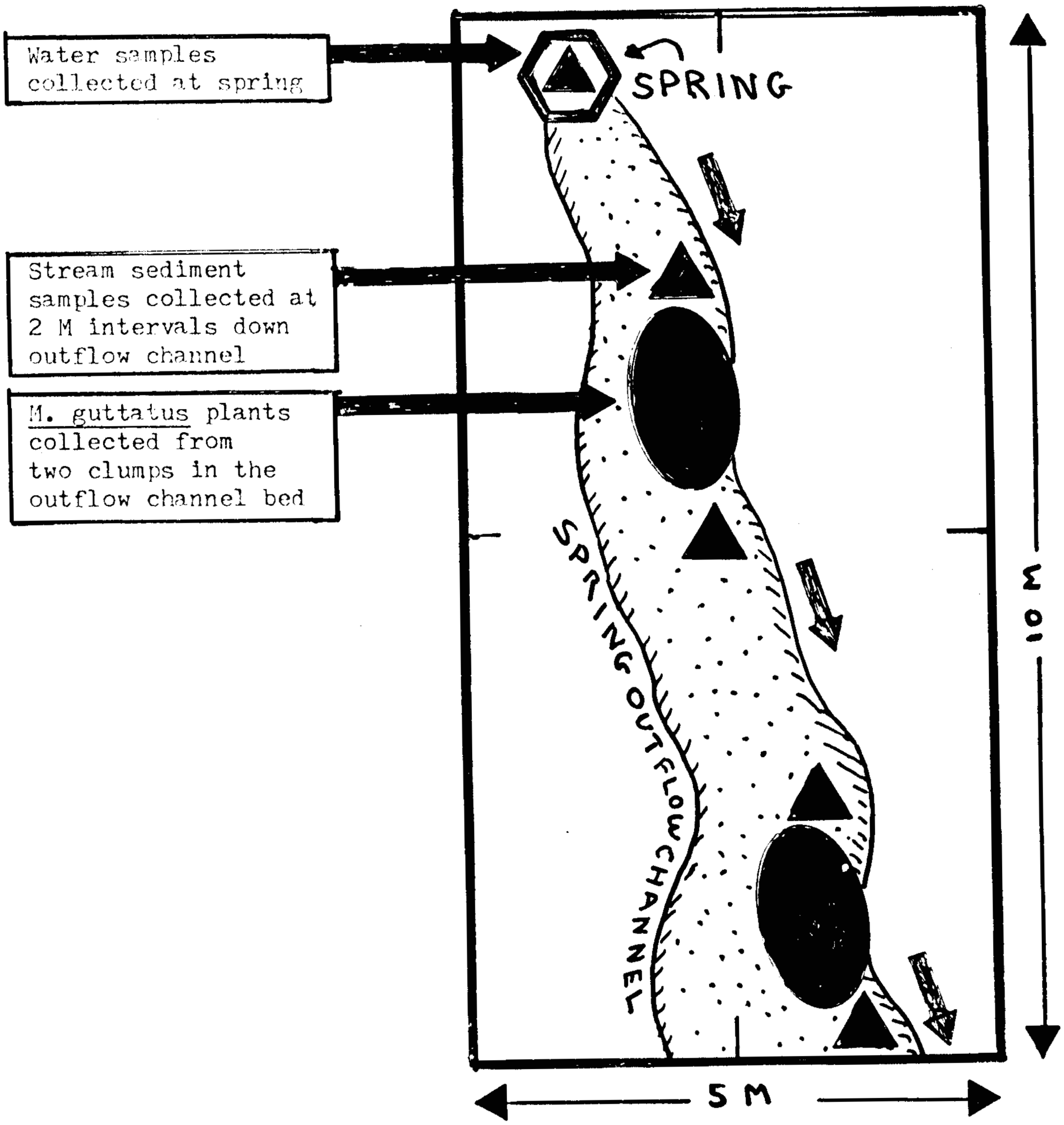


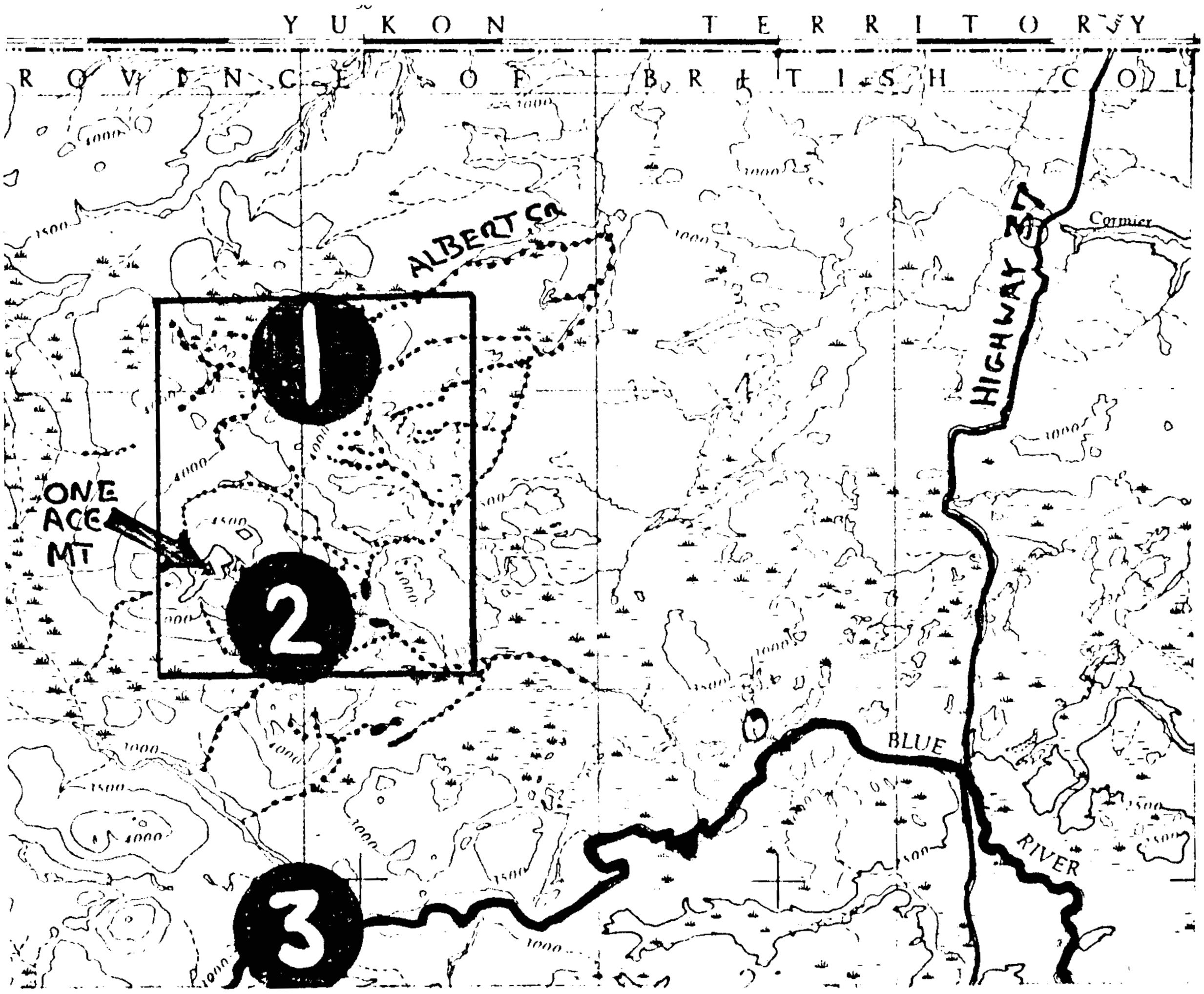
Figure 3 Idealised conceptual model of sample plot.

C)One ,or more,samples of foliage and roots of <u>M. guttatus</u>

In addition a plot map(supported by coloured pictures if light conditions are favourable),an estimate of the temperature of the spring water at the origin,and a set of herbarium plant samples for comparitive purposes.

The Field Investigation The fieldwork was completed on August 14th and 15th 1981. On the first day the trip to the Zap claims was made by road from Watson Lake. That day three plots were sampled; Plot A located at a small spring just beside DDH A1 on Line 5 West ; Plot B located at a large spring at line 5W 10+70 N, and Plot C located some 60 M down the outflow stream from the spring in Plot B (4+75W 4+80N).

On the second day a helicopter was used to examine a marl lake and a canyonside spring at the Blue River Claim group in search of a control plot. Eventually M. guttatus was spotted in the tufa deposit southeast of One Ace Mountain where Plot D was located at59.50/129.32 close to the drill road.(Map 1).*



Map (1) Xerox of the 1:250,000 scale topographic map of the One Ace Mountain area showing (1)location of plots A,B and C, (2)Location of plot D and (3) area where no M. guttatus was located.

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*The exact locations of the springs and plots sampled are on detailed Company maps which are not included in this report.

Description of the Sampled Plots Using the conceptual model (Figure 3) as a guide a series of plot maps were drawn to illustrate the general features of each of the four plots and to indicate the sampling points within them. These maps are supplimented by coloured plates which were chosen to provide further information on each area studied.

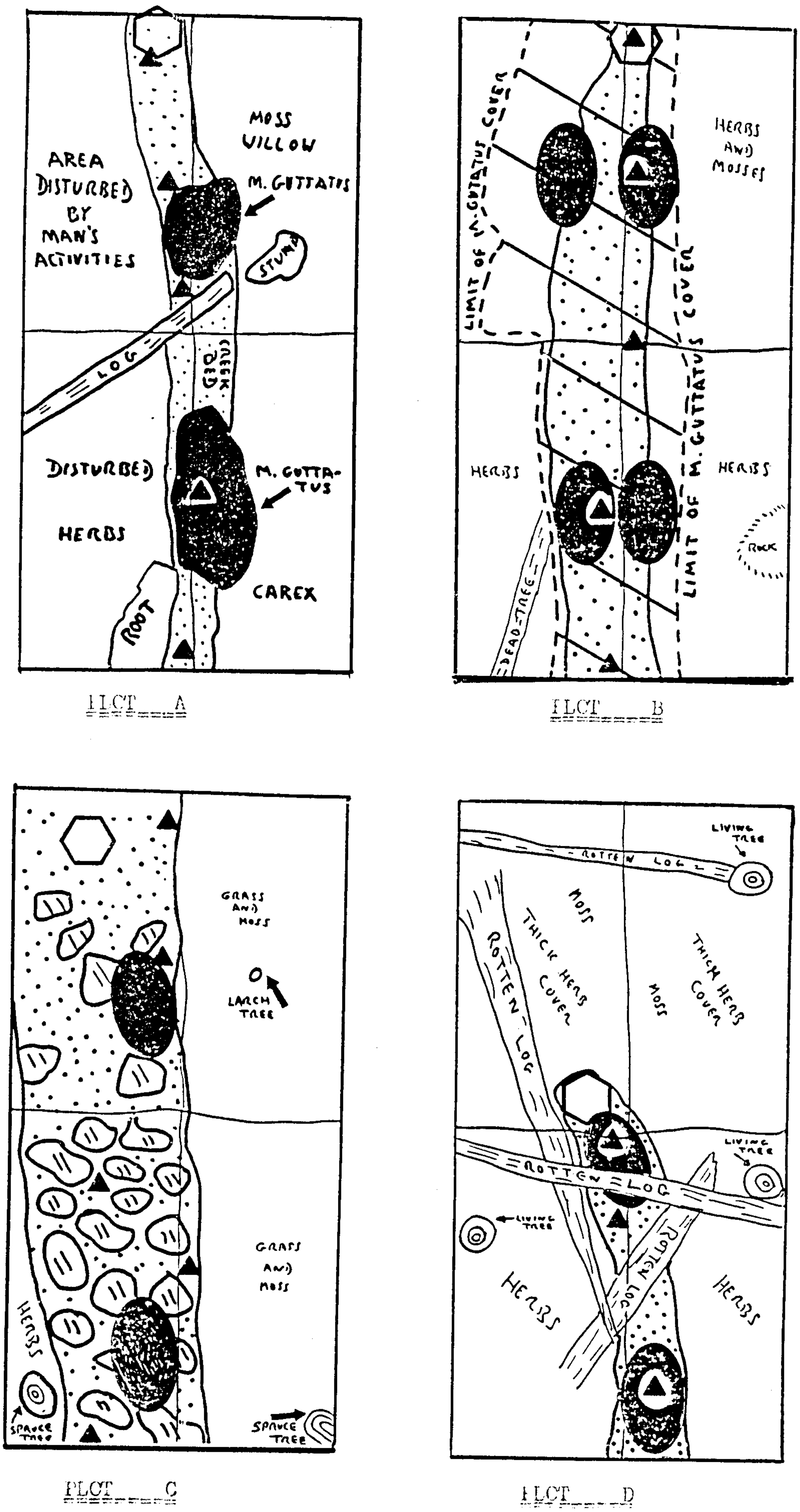
Plot A The spring issues from the bottom of a drift covered slope which forms the limit of the floodplain of the Albert Creek. Beyond the plot the creek outflow flows into a grassy area with no trees. Otherwise the area is covered with a black spruce forest 10-15m high which does not form a closed canopy. The Sphagnum moss cover of the forest floor can be seen in the background of Figure 5. The area close to the spring was disturbed by bulldozing and diamond drilling operations about a year prior to the sampling. Since than the spring has formed a definite channel within which two clumps of M. guttatus were growing (Figure 5.

Using a simple thermometer the temperature of the spring outflow was measured as 16°C, with a pH of 6.4(measured by ph papers). There was no iron staining or tufa associated with this spring. Samples of water, sediment and plant material were collected for chemical analysis and a set of herbarium plants were collected within the plot.

Plot B Here a large spring with a channel bed nearly 5m wide at the source forms a small creek which flows into the Albert Creek. At the spring there is a large clump of M. guttatus which was sampled in each quarter of the plot (Figure 4). The area is covered with black spruce forest with the best tree growth on the bank above the spring. In the floodplain the outflow of the spring flows through spruce with willow and sphagnum moss cover. The area of the spring appeared to be little disturbed although there had been blasting further up the slope. The plot are was an ideal one for the collection of M.guttatus because the plants were 30-50cm high.

The temperature of this spring was measured at 8°C with no iron staining or tufa in the immediate vicinity of the spring. The M.guttatus were common further down the creek bed beyond the plot as indicated on Figure 6.

Plot C Plot C was located about 60 m downstream in the channel of the Plot B spring. This plot was located to discover if the expected geochemical anomaly in the spring waters, sediment and M.guttatus could be detected away from the source. Plot C was located because it included two small clumps of M.guttatus which were suitable for sampling. The creek bed at this point was full of boulders with the water running in between them (Figure 4)(Figure 7). A green moss with black roots in the streambed was



PLOT A

PLOT B

PLOT C

PLOT D

Figure 4

Sketch maps of the four sampled plots. For interpretation of symbols see conceptual model Figure 3.

Figure 5 View of Plot A from the northwest showing the two clumps of M. guttatus growing in the spring outflow bed.

Figure 6 General view of Plot B with outflow creek in the background. Note the large area of M. guttatus to the right of the photograph which extends to the spring

Figure 7 View from the centre of plot C looking downstream. Note the rocks in the streambed and the patch of M.guttatus near the plot marker.

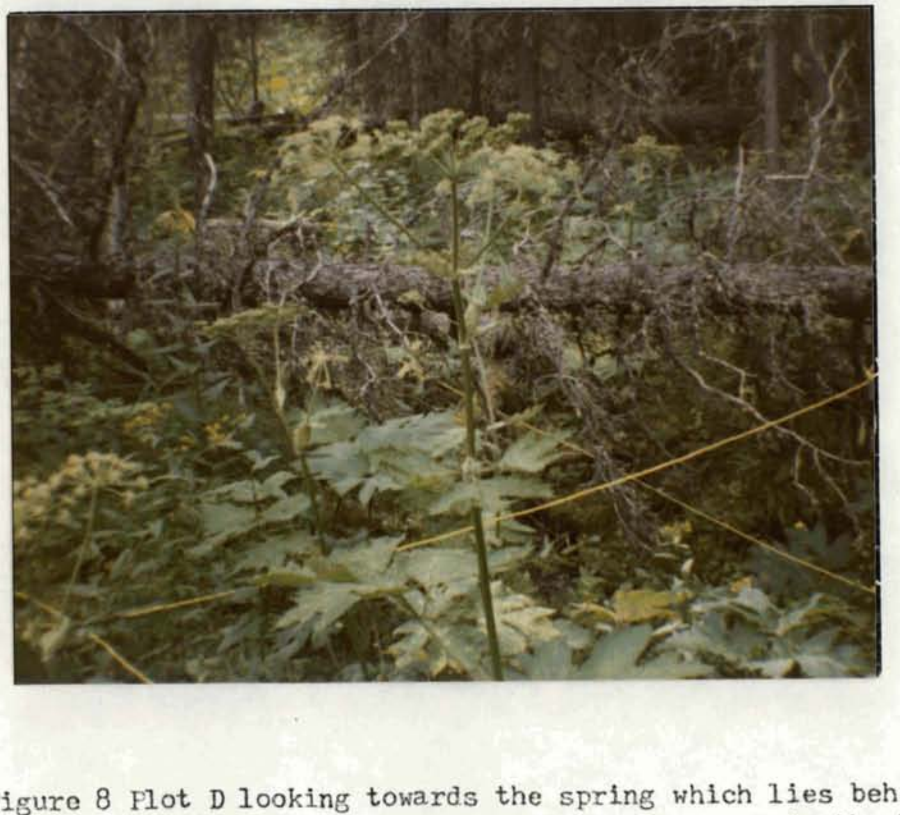


Figure 8 Plot D looking towards the spring which lies behind the log upstream from the patch of M.guttatus . Note the lush herb vegetation at this site compared with the others.

sampled from this plot for chemical analysis. The temperature of the water in the plot was $8^{\circ}C$ with a ph of 6.1. In general the growth of M.guttatus in plot C was poor compared with that in plot B.

Plot D This plot is situated some distance from the other three (Map I). The spring selected for sampling is one of a series which are found in the area which also includes marl and tufa deposits. M.gutattus was difficult to find in bloom is the area except under a dense forest with a well developed herb vegetation layer(Figure 8). Practical difficulties resulted in the positioning of the plot with the spring outflow within the plot area(Figure 4). Although the vegetation at plot D was decidedly more lush than in the other three plots it was considered a suitable control plot for comparitive purposes.

The temperature of the spring was measured to be $13^{\circ}C$ with a pH of the water of 7.2. Because the spring was located within the plot two samples of stream sediment were collected outside the plot margin downstream from it. No marl was found in the immediate vicinity of the plot but within the general area extensive deposits of marl and tufa were observed in small creek beds which were common in the area.

Sample Preparation and Chemical Analysis

Herbarium specimens were collected from each of the four plots in order to establish the general vegetation cover types involved and,more important,to discover if any rare plants were associated with M. guttatus in plots A,B and C. The plants were dried and pressed and set aside for identification by Dr C. Brayshaw at the British Columbia Provincial Museum in Victoria

Samples of foliage of M.Guttatus were placed in paper bags and allowed to become air dry without moulding by frequent changes of bags. Samples of M. guttatus root material were found to be matted together and mixed with mineral matter of the stream bed. Crude washing was completed in the stream in the field and another washing with metal free water was carried out after drying and disecting the root mass in the laboratory. Stream sediment samples were oven dried and then passed through an 80 mesh sieve. The -80 mesh material was extracted with a mixture of hot nitric and hydrochloric acid prior to chemical analysis of the extract. Two samples of tufa from the vicinity of plot D were collected for chemical analysis. Samples of water were kept cool and divided into two parts. One part was retained at Falconbridge (Delta) offices and the other passed to ACME Industries for chemical analysis.

The following samples were submitted for chemical analysis by ACME Industries

Water Samples (Filtered in the field,one acidified and one natural from each plot)--------------- 8 samples
M.guttatus samples
  foliage----------------------- 11 samples
  roots ------------------------ 11 samples
Stream Sediment (five samples from each plot) 20 samples
Moss samples (from Plot C only)-------------- 2 samples
Tufa/Marl (from Plot D area only)------------ 2 samples

Total 54 samples

Sample preparation

Waters were analysed by ICP without preconcentration.
Plant material was dried at 80°C. 0.5g of dried material was digested with 3ml 3:1 HNO_3 /HCl/water (1:1:1) at 90°C for 1 hour.
Sediment and Tufa material crushed,passed an 80 mesh sieve,extraction and determination identical with the method for plant material.

Chemical Analysis

Chemical analysis of the waters and extracts was carried out in ACME Industries laboratories, 852 E.Hastings St. Vancouver. Determination of element concentrations was done by an ICP instrument (Jarrell-Ash ATOMCOMP System). Further information regarding the nature and performance of this instrument is included in Appendix B. ACME Industries stress that the technique used involves a partial extraction for Ca,P,Mg,Al,Ti,La and W and a total extraction for Ag,Mo,Cu,Pb,Zn,Ni,Co,Mn,Fe,As,U,Th,Cd,Sb,Bi, V,and B. All these element contents are determined simultaniously by the instrument during a two minute period. Such a method is ideal for the M.guttatus project because it provides information on so many elements some of which may be below detection in the plant material unless M.guttatus is an accumulator plant.

The performance of the Scan ICP analyses completed on the M.guttatus by ACME Industries is evident from Table 1. Three replicates of each of three samples a water,a M. guttatus foliage sample and a stream sediment were done and ploted on the table. The replicates considered suitable for compatative purposes (underlined on the table) are Waters -Zn,Cu,Sb,Mg,Ca, Ba,Mn ; M. guttatus (foliage) -Ag,Pb,Zn,Cu,Bi,B,Mg,Ca,Al,Ba,Fe,Mn,Ni,P ; and Stream Sediments -those for M. guttatus plus W,Co,V,U,Th,La,andCd. In summary the water samples were suitable for 7 elements,the M.guttatus

	ACME Sample M-1(&M2)			Water			M.Guttatus(foliage)			Stream Sediment		
Element	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
Ag	.3	.26	.31	-	.0029	.0038	.62	.64	.64	.22	.23	.19**
Pb	38	39	40	.0242	-	-	.87	2.0	.93	1.8	2.2	2.2
Zn	180	189	184	.0108	.0124	.0124	55	55	55	130	130	130
As	8	12	15	-	-	-	-	-	-	12	12	11
Cu	28	30	30	.0046	.0045	.0023	8.2	8.4	8.5	17	17	17
Mo	2.0	1.0	1.1	.0031	-	.0026	.36	.52	.45	-	.05	-
Bi	2.0	1.0	.74	.0478	.0192	.0262	1.0	.94	1.1	9.0	9.5	9.2
Sb	3.0	-	-	.0441	.0527	.0403	-	-	-	.32	.55	.87
W	1.0	1.0	-	-	-	-	-	-	-	3.4	4.0	3.6
B	12	6.3	7.0	-	-	-	34	34	34	4.4	4.5	4.6
Mg	.67%	.58%	.58%	19.4	19.4	19.4	.31%	.31%	.31%	.28%	.28%	.28%
Ca	.52%	.56%	.56%	32.0	31.7	31.8	1.2%	1.2%	1.2%	39%	39%	40%
Al	1.9%	1.7%	1.7%	-	-	-	.01%	.01%	.01%	.07%	.07%	.07%
Ti	.07%	.1%	.1%	-	-	-	-	-	-	-	-	-
Ba	.023%	.03%	.03%	.1523	.1602	.1631	.01%	.01%	.01%	.02%	.02%	.02%
Fe	2.50%	2.46%	2.46%	-	-	.0321	.021%	.019%	.021%	.020%	.021%	.020%
Mn	800	820	806	.0035	.0035	.0035	1.2	1.1	1.0	9.4	9.4	9.4
Ni	32	38	37	-	-	-	.89	1.1	1.1	2.6	2.7	2.2
Co	12	17	16	.0017	-	.0002	.07	.10	.16	.49	.40	.51
V	54	58	57	.0002	-	-	.15	.07	.06	1.2	1.2	1.3
P	.11%	.10%	.10%	.0135	.0116	-	.29	.29	.30	-	-	-
U	3	.86	.52	.0109	-	-	-	-	-	8.2	9.8	10.0
Th	3	2.4	2.4	.0008	.0020	-	.11	-	.11	.13	.14	.10
La	8	11	11	-	-	-	-	-	-	.13	.10	.09
Cd	2.0	1.8	2.0	-	-	-	-	-	-	.58	.56	.47

Key (A) Standard M-1 from ACME Brochure
(B) Standard M-2 between BFCE and AFCA
(C) Standard M-2 between CFCE and DFCA

(D),(E) and(F) replicates of sample BFWB
(G),(H) and(I) relpicates of sample BFBC
(J),(K) and(L) replicates of sample DFCE

** Sets of replicates underlined are acceptable for the study.

Table I Precision and accuracy of the ACME ICP Scan Multielement Method as applied to M.guttatus project (foliage) 14 elements and the stream sediment 21 elements. This data set provides an interesting introduction to the wide scope of the ICP method and its performance with respect to particular elements.*

DISCUSSION OF RESULTS

M. guttatus as a geobotanical indicator plant in Northeastern B.C.

Other writers (Taylor(1974), Porsild(1974)) have noted that *M. guttatus* is found in damp places and in the vicinity of mineral springs. The study of the four plots supports these general observations. In addition our investigation indicated that the plant grows near warm springs with pH in the range 6.0 - 7.5. Experience with the four plots suggests that the presence ,or absence, of the plant at a spring is not directly related to the presence of silver in waters. It is likely that water temperature and ph are also important in defining the habitat for the plant to live in the area. We conclude that although *M. guttatus* may occur at silver rich springs in the area it is not a specific indicator of this element because it is found in springs with low amounts of this element.

If we accept the proposition that *M. guttatus* grows where there is significant silver in the waters and where silver is minimal the next point is to examine the form of individual plants taken from the four plots in order to discover if some easily recognisable feature of plants from silver rich springs can be found. Clearly, we must be careful here because all writers who describe *M. guttatus* from a botanical viewpoint note that the form of the plant is very variable. Eight individual plants from Plot A (see Figure 4 & 5) were prepared as herbarium specimens (Figure 9 & 10). Xerox copies of the pressed plants were reduced 60% twice to produce these Figures. It is evident that these eight plants are broadly similar to the specimen of *M. guttatus* on Figure 2. The only obvious departure from the general form of the specimens is No A3(Figure 9) which has larger leaves and fewer flowers than the others. The specimens from Plot B(Figure 11) are similar to those from plot A except that the plants are somewhat thinner. So far so good we have a form of *M. guttatus* typical of silver rich springs. Further downstream from Plot B at Plot C we find(Figure 12) representatives of two different forms of *M. guttatus* one (including C5, C6, C7 & C8) with small stems and leaves and the other (including C9, C10, C11, & C12) with

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*A more detailed description of the data in Table 1 appeared in a

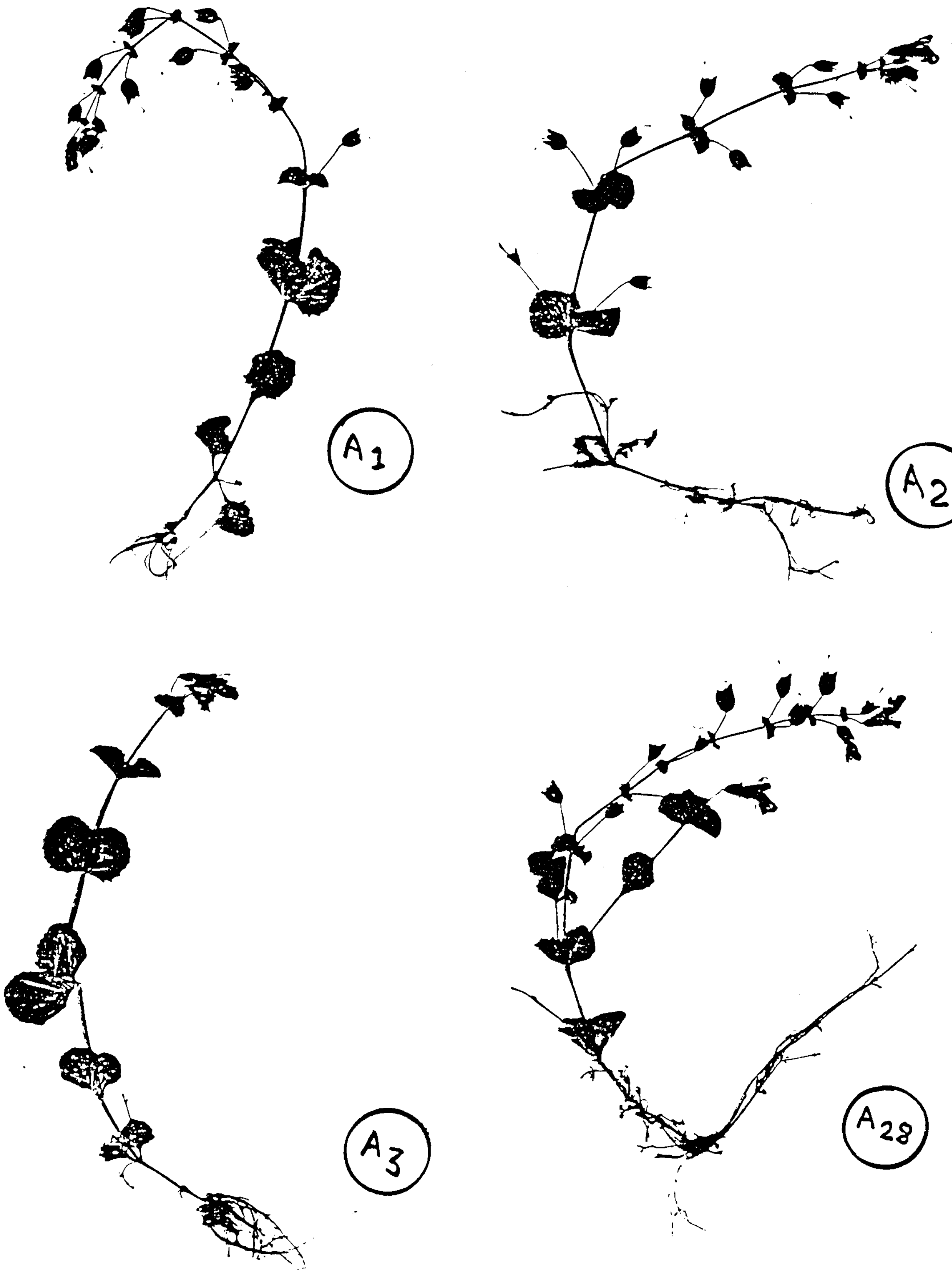

Figure 9 Xerox copies of four specimens of M. guttatus from Plot A
(The diameter of the circle is 5cm)

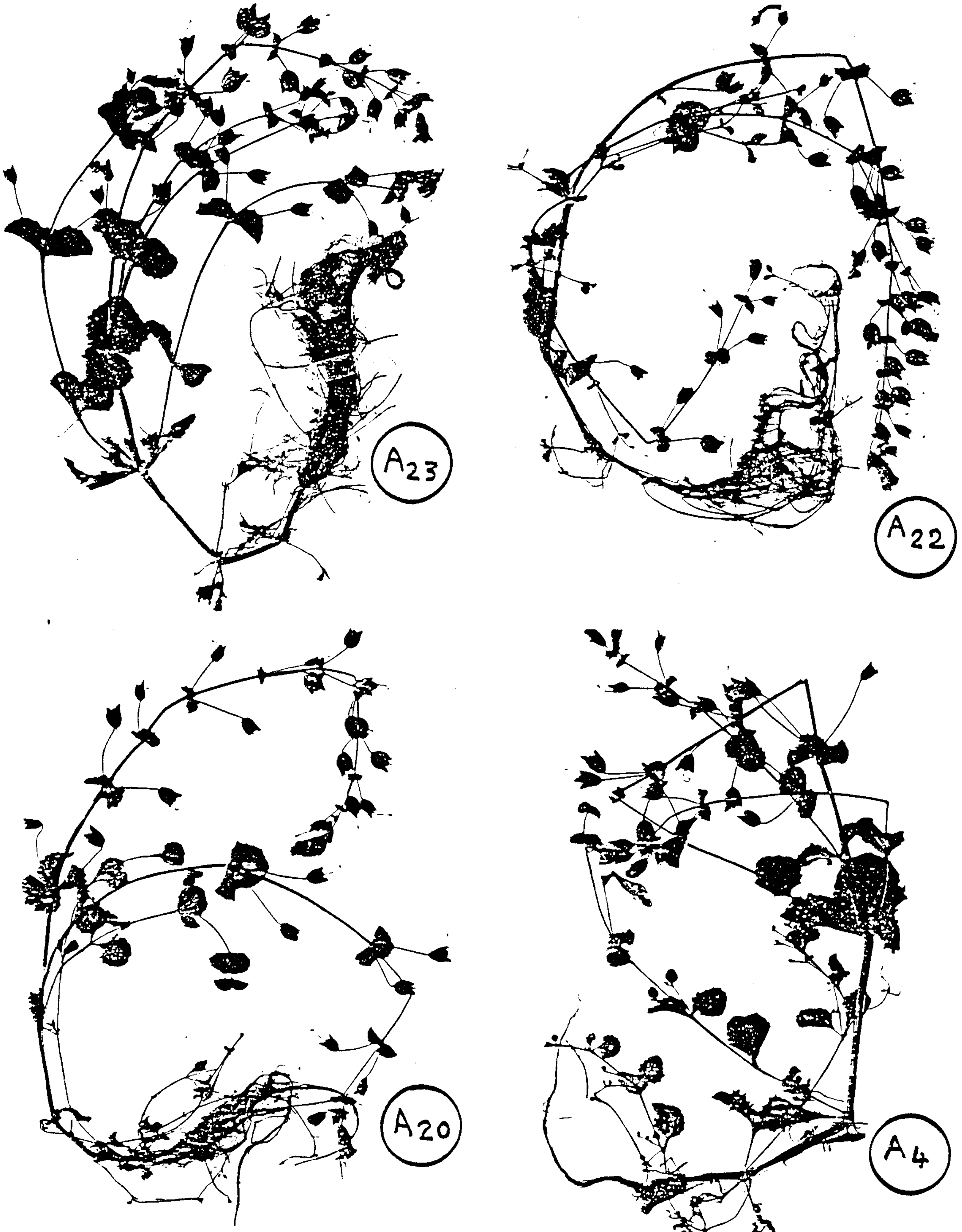

Figure 10 Xerox copies of four specimens of M. guttatus from plot A
(Circle diameter 5cm)

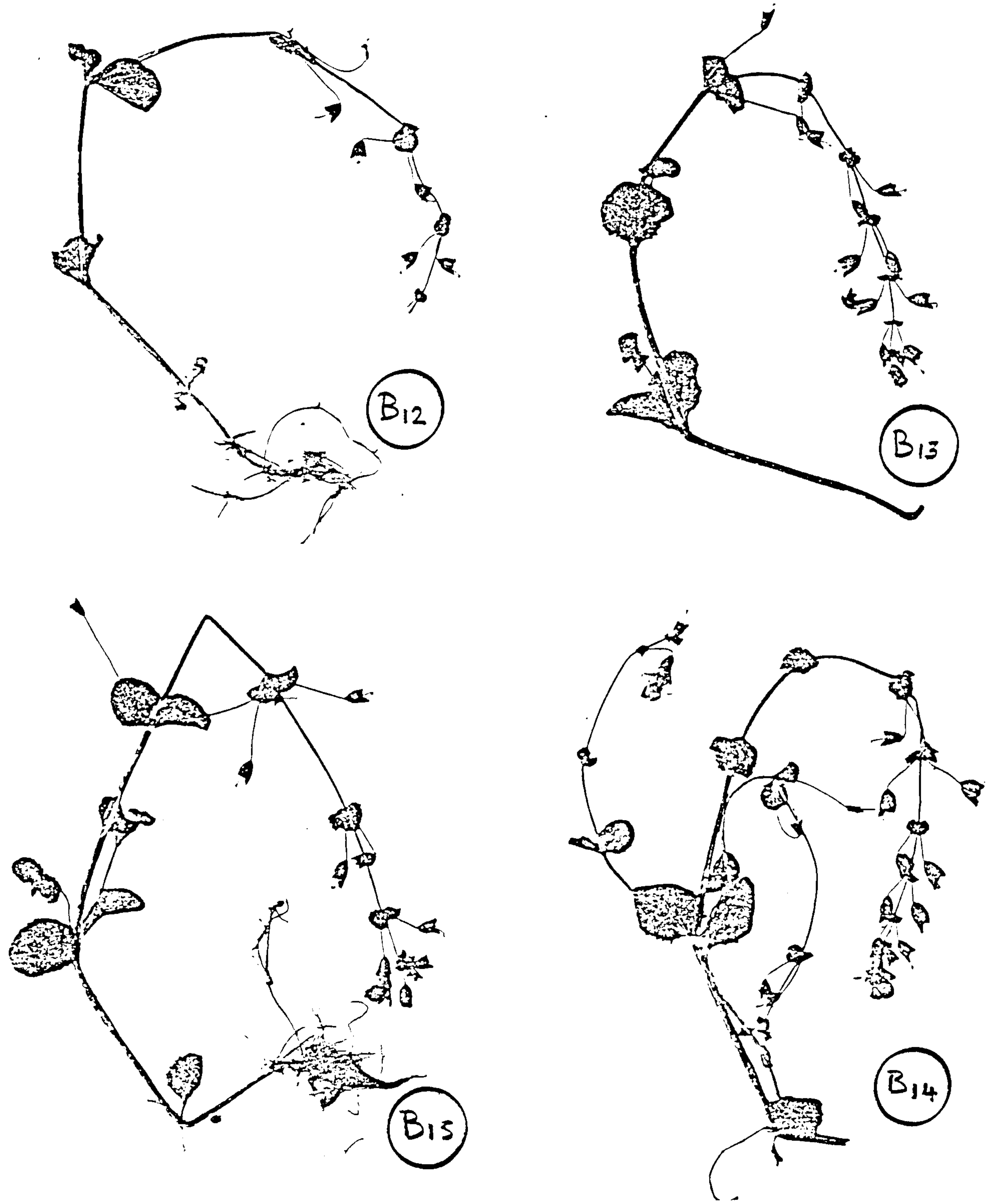

Figure 1 1Xerox copies of specimens of *M.guttatus* from plot B
(circle diameter 5cm)

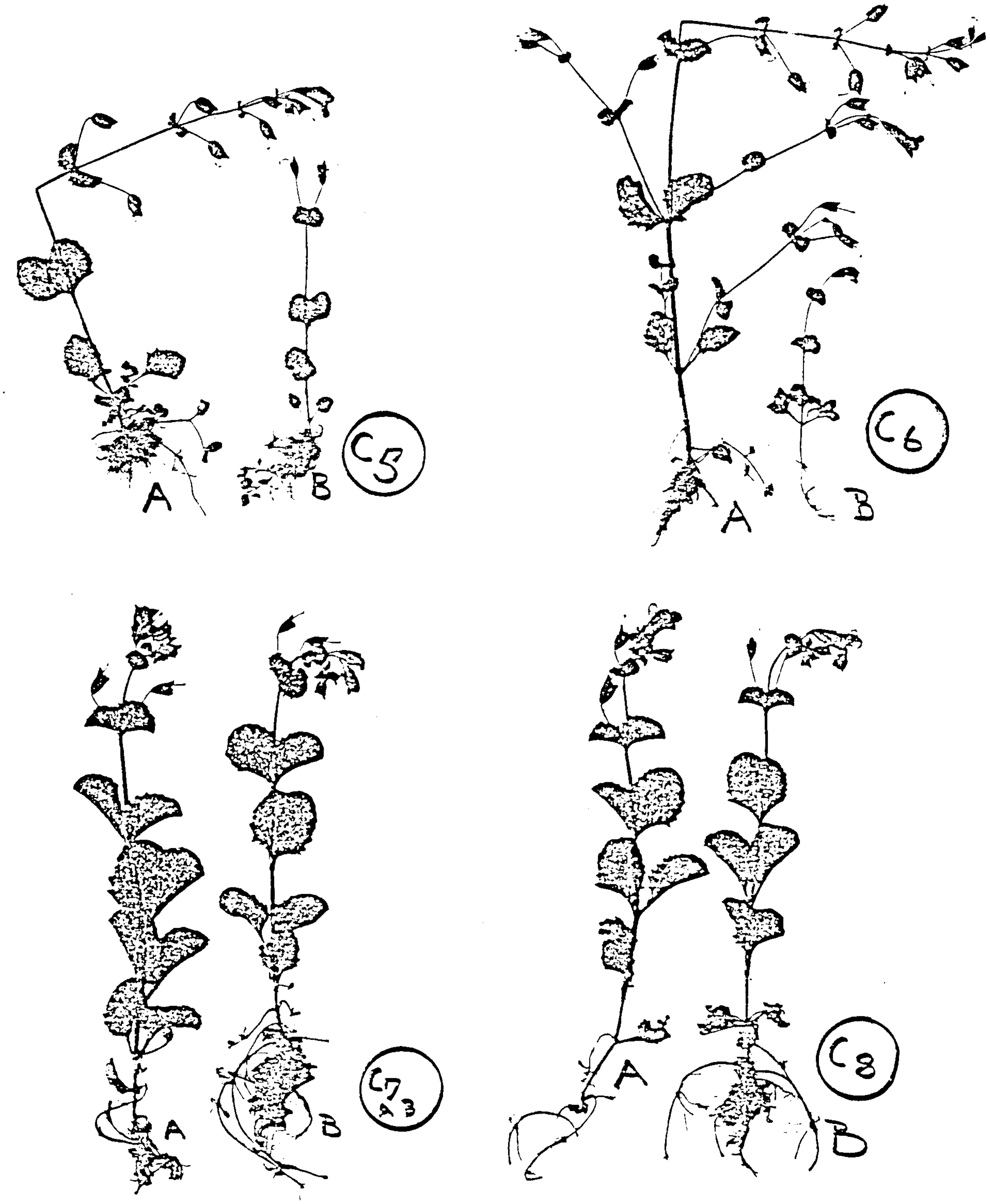

Figure 12 Xerox copies of specimens of *M. guttatus* from plot C (circle diameter 5 cm).

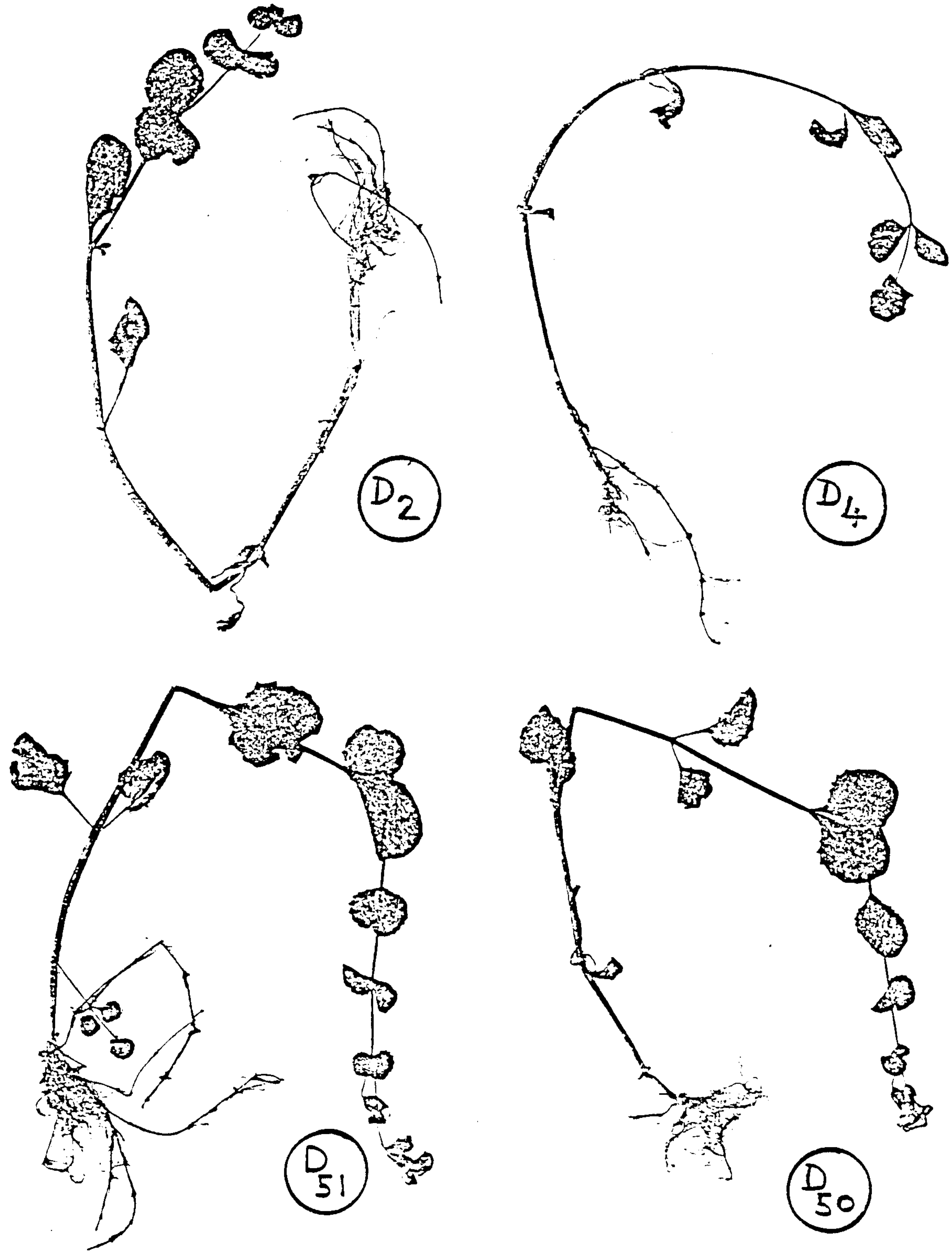

Figure 13 Xerox copies of specimens of M. guttatus from Plot D (circle diameter 5cm).

thick stems and big leaves. This is a good example of morphological vatiation discussed by other writers. The specimens from Plot D (Figure 13) are poor from the plot itself(probably due to lack of sufficient light Figure 8) but strong and healthy further down the outflow channel where conditions are more favourable (D50 & D51 Figure 13). Although these observations are made from four plots only we conclude that easily recognisable morphological features do exist in specimens of M.guttatus within the plots but they are not directly associated with the silver content of the waters. Further research at other springs in the area is required to establish the validity of this conclusion and that in the preceeding paragraph.

General Conclusion M.guttatus in Northern B.C. appears to be an indicator of warm springs with alkaline to neutral pH. The presence of silver in the spring waters appears not to affect the growth,or form of the plant in this area.

b)M.guttatus as a biogeochemical indicator plant for silver in Northeastern B.C.

In all 11 samples of foliage and roots of M. guttatus were processed and analysed usung the ICP technique described above. In this discussion we assume that all the chemical data is correct as plotted on Table 2.

Ag,Pb,Zn,Cu,B

This group of elements might reasonably be assumed to be associated with mineralization in the Zap Claims area. The silver pattern in the foliage samples is almost ideal. With the highest values at the springs in Plot A (2.1 ppm)and Plot B(3.7 ppm). In these plots the silver content decreased within a few metres from the source which indicates that if M. guttatus is used for prospecting samples should be collected at the spring itself. Lower values were found downstream from Plot B in Plot C and much lower values in Plot D the control plot. The silver in roots paralleled the pattern in the foliage but tended to be less sensitive to changes in conditions within the plots. The higher values in the roots are probably due to silver in the plant tissue and not in the mineral matter in roots. Some idea of the difficulty in separating mineral matter from the matted rotts can be obtained from examination of the mat of roots on plant A23 (Figure 10).

In general the foliage values for lead(Table 2) mimic the pattern for silver except lead values are higher than expected in CFBB,DFBB and DFBC(Table 2). Lead is often accumulated in the roots of plants and this is the case with M. guttatus(Table 2). An unexplained observation is why the highest lead was found not in Plot B as expected but in Plot A. Otherwise the pattern for lead in roots mimics that for silver in foliage.

	PLOT A		PLOT B				PLOT C		PLOT D		
	AFBA	AFBB	BFBA	BFBB	BFBC	BFBD	CFBA	CFBB	DFBA	DFBB	DFBC
FOLIAGE											
Ag	2.1	1.6	3.7	1.1	.64	.66	.22	.82	.04	.14	.12
Pb	17.0	9.4	2.8	1.5	.87	.35	1.00	3.10	.29	3.20	1.90
Zn	136	99	90	66	55	55	68	73	67	63	68
Cu	26	18	9.9	8.9	8.2	10.0	6.2	7.1	15	14	13
B	46	32	35	34	34	38	45	42	38	57	38
Mg	3800	3200	4200	2500	3100	2800	3100	3800	2800	3200	3300
Ca	15900	13000	13000	13000	12000	11000	12000	12000	21000	26000	24000
Al	100	100	100	100	100	100	100	100	100	100	200
Fe	300	300	190	240	210	180	200	100	200	200	120
Mn	56	34	6.7	3.5	1.2	1.7	23	27	1.9	2.2	6.2
P	2500	2600	3800	3600	2900	2900	2900	2200	2100	2100	1900
Ni	1.8	1.0	1.1	0.5	0.9	0.7	0.5	0.3	1.2	1.1	1.2
Bi	1.1	1.4	1.6	1.4	1.0	1.0	1.1	1.1	1.5	1.2	1.6
Ba	400	300	200	100	100	100	100	200	300	300	300
ROOTS											
Ag	28.7	59.5	29.7	25.7	21.7	21.0	20.7	10.8	2.7	.56	.46
Pb	600	944	131	152	183	101	63	35	5.2	3.8	2.5
Zn	1026	966	484	491	915	700	381	367	312	393	297
Cu	48	48	33	29	30	16	6.2	4.8	13	13	10
B	15	12	9.6	1.3	12	19	16	14	13	18	11
Mg	160000	180000	13000	9400	7100	5700	3200	2900	3400	3200	2700
Ca	400000	450000	31000	26000	24000	16000	7800	6000	58000	9100	7900
Al	1400	2700	2500	2300	1800	800	300	200	100	200	100
Fe	4900	9000	5100	5100	3700	1900	900	400	200	200	120
Mn	751	1203	133	136	123	65	47	22	3.0	1.9	-
P	1400	1200	1400	1600	2000	1900	1800	1600	2000	1400	1200
Ni	4.5	8.7	7.1	9.9	7.1	3.2	1.4	1.0	2.3	3.1	1.6
Bi	3.5	4.6	2.6	2.7	1.9	1.4	1.3	1.0	2.0	2.4	2.2
Ba	300	300	200	200	200	200	100	100	100	100	100

Table 2 Geochemical Data for M. guttatus foliage and roots (PPM oven dry weight elements determined simultaniously by an ICP technique .)

The zinc in foliage ranges from 55 to 70 ppm in all but three samples AFBA,AFBB and BFBA (Table 2).where the increase is nearly twofold. In roots the background zinc content is some 300-350 ppm with higher values by a factor of three in Plot A andx1.5 and x3.0 in Plot B.

Copper values range from a high of 26 ppm to a low of 6.2 in foliage and a high of 48 and a low of 4.8 in roots(Table 2). In general the copper was higher in roots than in foliage and highest in Plot A and lowest in Plot C. As expected with a micronutrient boron was higher in the foliage than in the roots(Table 2). Boron appears to be an element not related to mineralization because it varies without a pattern in M. guttatus foliage and roots.

Mg,Ca,Al,Fe,Mn

In the foliage levels of magnesium and calcium are relatively uniform in all plots except that high magnesium and calcium were found in roots of plants growing at springs suggesting some secondary precipitates of these elements near the origin of springs. This effect was not found in the foliage samples(Table 2). Aluminium was low in the plants but relatively high in the samples from plots A and B. Iron was slightly higher in Plot A foliage and this trend was also observed in the roots from plots A,B and C compared with the control plot D. Manganese values provided an interesting pattern in both foliage and roots. In foliage low values were found in Plots A and C and very low values in plots B and D suggesting a manganese deficiency in the plants. In the roots manganese was lowest in plot D and next lowest in Plot C.(Table 2).

P,Ni,Bi,Ba

Phosphorus was higher in the foliage than in the root material (Table 2) but no trend in the data were apparent. Nickel was an example of a non-nutrient trace element which appeared not to be related to mineralization. Bismuth was a surprise because there was no pattern in the plant material, the level was slightly higher in samples of roots from Plot A.(Table 2). Barium has a similar pattern to bismuth and is not considered to be significant from the viewpoint of prospecting on the basis of plant material.

General Conclusion

It seems clear that M.guttatus foliage(or roots) could be used for exploration for silver in the Zap claims area. Roots could also be used for prospecting for lead,zinc and copper and for some unexplained reason manganese also followed the same pattern. For biogeochemical prospecting the samples of M.guttatus should be collected as near to the origin of a spring as practical wil one,or two other samples at 10 m intervals downstream if this is practical. We also conclude that nickel,bismuth and barium should also be determined in root material.

THE RELATIVE EFFECTIVENESS OF PLANTS COMPARED WITH WATERS AND STREAM SEDIMENT FOR PROSPECTING IN THE FOUR PLOTS

The collection of water samples and five samples of stream sediment from each of the four plots enabled a comparison of the relative effectiveness of the different media for prospecting in the Zap Claims area to be drawn.

Water Samples

The ICP data for direct analysis of waters is listed on Table 3. It should be stressed that the water samples were run without a preconcentration step and,consequently,represent a first approximation only.

As expected in an area of neutral to high pH the dominant cations in the waters were calcium and magnesium. The acidified waters provided a useful check on the performance of the method and provided slightly lower values for these elements compared with the natural waters. In general the calcium was found to be slightly lower and the magnesium slightly higher in the control plot waters compared with those from the other plots. This might be looked into as a diagnostic tool for springs in the area. Barium values were similar in the two water samples collected from each site with slightly lower values from Plot D samples. Manganese was uniformly low in all the samples which might be predicted from the data for *M.guttatus* on Table 2. Copper values were higher in the acidified samples from Plot A and B,otherwise the levels were similar in all plots. The antimony values were a surprise and suggest that this element may have a regional high in the area.

Conclusion

The direct analysis of waters without preconcentration provided relatively little information of interest in exploration in samples from the Zap claims area. With respect to the major elements the Ca/Mg ratio might be used as a diagnostic tool for the discovery of springs which were mineralised. Otherwise the elements listed provide little information especially as the elements of major interest -silver,lead,bismuth and tungsten- were not determined by this technique.

Stream Sediment Samples

The plot approach provided an excellent opportunity to examine in detail the performance of the stream sediment prospecting method at each of the four springs. The ICP data for the steaam sediments is plotted on Table 4. When

	PLOT A		PLOT B		PLOT C		PLOT D	
	AFWA	AFWB	BFWA	BFWB	CFWA	CFWB	DFWA	DFWB
Ca	25.9	32.2	27.9	32.0	27.7	32.0	34.4	39.2
Mg	16.2	19.9	17.5	19.4	17.3	19.6	12.9	14.2
Ba	.193	.201	.151	.152	.154	.140	.103	.092
Mn	.004	.003	.004	.004	.004	.003	.002	.003
Zn	.042	.008	.022	.011	.012	.008	.012	.003
Cu	.011	.005	.014	.005	.005	.005	.005	.003
Sb	.042	.037	.096	.044	.059	.042	.047	.064

Table 3 Geochemical Data for water samples (PPM WA samples acidified ,WB samples not acidified, both series of water samples filtered in the field. All elements determined simultaniously by an ICP technique)

Sample		Ag ppm	Pb ppm	Zn ppm	As ppm	Cu ppm	Mo ppm	Cd ppm	Bi ppm	W ppm	Co ppm	Ni ppm	V ppm	Th ppm	B ppm	Ti %	P %	Fe %	Mg %	Ca %	Al %
Plot A	AFCA	52.5	565	589	54	28	.18	2.0	12	-	1.5	5.2	6.8	.92	2.7	.01	.01	.517	6.4	17	.19
	AFCB	55.2	335	795	92	33	.25	2.5	11	-	2.8	7.2	8.5	.76	3.4	.01	.03	.759	5.4	14	.27
	AFCC	55.9	924	779	34	38	.06	2.3	12	-	1.8	5.9	7.5	1.3	3.5	.01	.01	.707	6.0	16	.24
	AFCD	3.0	34	115	20	17	.33	2.1	5	.28	9.3	27	26	1.8	3.4	.04	.06	1.380	3.3	7.5	.77
	AFCE	22.9	131	307	29	14	.61	1.6	5	-	8.2	29	22	2.3	6.2	.05	.07	1.280	2.8	5.8	.55
Plot B	BFCA	156	210	266	24	23	.84	2.1	5	.25	10.0	32	26	1.8	4.8	.05	.06	1.560	2.9	8.2	.62
	BFCB	142	290	264	29	38	.90	2.3	6	-	9.5	30	26	1.5	7.1	.04	.07	1.530	2.8	8.6	.64
	BFCC	119	216	255	25	20	1.10	1.8	4	-	9.2	33	29	2.1	3.5	.06	.07	1.650	2.5	5.7	.66
	BFCD	95	204	310	23	15	1.10	1.4	4	-	9.3	34	29	2.0	3.6	.06	.07	1.640	2.4	4.9	.63
	BFCE	94	220	310	24	15	1.30	1.7	3	-	9.5	34	29	2.0	3.5	.06	.07	1.650	2.5	5.0	.63
Plot C	CFCA	27.5	135	274	35	6	-	.50	2	-	3.9	15	14	1.6	1.5	.04	.10	.72	1.3	2.7	.38
	CFCB	32.8	142	272	23	5	-	.53	2	-	4.2	15	14	1.8	1.4	.05	.09	.71	1.1	2.9	.40
	CFCC	24.7	142	258	27	5	.26	.33	2	-	4.3	15	15	2.1	1.2	.05	.09	.72	1.2	2.1	.40
	CFCD	30.8	135	[illegible]	26	5	-	.58	2	-	4.4	15	15	1.7	1.1	.04	.08	.74	1.2	3.7	.39
	CFCE	27.6	165	338	20	6	.12	.87	2	.02	4.5	17	15	2.7	1.9	.05	.08	.74	1.3	4.5	.41
Plot D	DFCA	3.49	12	122	13	19	.04	.14	9.7	3.8	1.0	2.6	1.9	.62	1.2	-	-	.08	.47	40	.08
	DFCB	.22	1	126	11	21	.13	.14	8.9	3.7	.7	2.6	1.7	.65	3.7	-	.01	.05	.30	29	.10
	DFCC	.21	2	114	11	14	-	.01	8.4	3.3	.6	2.1	1.1	.32	9.7	-	-	.03	.34	34	.06
	DFCD	.19	1	120	10	21	.10	.13	7.8	3.4	.5	2.2	.9	.49	2.6	-	-	.02	.27	35	.07
	DFCD	.22	2	130	12	17	-	.12	9.0	3.4	.5	2.6	1.2	.58	4.4	-	-	.02	.28	39	.07

Table 4 Geochemical Data for Stream Sediment Samples taken at two metre intervals across the plots
Note the ..FCA sample is taken at the spring and the others down from it.

it is remembered that the data on Table 4 and Table 5 was obtained in 40 minutes some idea of the potential of the ICP method is obtained. On the negative side some of the element data sets appear suspect. For example the very high Ca values for the sediments of Plot D. If these are true values then one might expect that some general interferances might occur-for example in the data for La(Table 5). However from the viewpoint of this study we assume that the geochemical data for the sediments is correct.

In general the pattern for the elements determined in the foliage and roots of M.guttatus (Table 2) is similar to that listed on Tables 4&5. In particular the patterns for the nutrient element manganese are similar in the roots and the sediments in which they grow.

Plot & Sample	Mn ppm	La ppm	Ba %
AFCA	602	3.5	.01
AFCB	1099	4.8	.02
AFCC	1003	5.1	.02
AFCD	179	10.0	.04
AFCE	168	9.9	.03
BFCA	335	9.9	.04
BFCB	331	10.0	.04
BFCC	216	11.0	.04
BFCD	207	10.0	.03
BFCE	207	11.0	.03
CFCA	110	11.0	.02
CFCB	142	11.0	.02
CFCC	144	11.0	.02
CFCD	167	9.5	.02
CFCE	120	8.7	.02
DFCA	27	.52	.02
DFCB	13.	.17	.02
DFCC	85	.07	.02
DFCD	10	-	.02
DFCE	9	.13	.02

Table 5 Geochemical Data for Stream Sediment Samples : Manganese,Lanthanum and Barium

Ag Pb Zn Cu As Bi Cd Mo W

The Ag pattern in the sediments shows a decreasing gradient pattern away from the source. The pattern is,in general very similar to that found in the roots and foliage of M.guttatus (Table 2). Clearly stream sediments are a reliable prospecting tool in this area.

Pb and Zn show a similar pattern in sedimets of plots A B and C (Table 4). In Plot D the decrease in Pb is much more dramatic than for Zn. Combined with the data for Ag these patterns suggest that the source is mineralization with Ag-Pb-Zn minerals. As expected Cd has a similar pattern these three elements but As,Cu and Mo appear to be unrelated to it. Bi and W also have a distinct and interesting pattern with high Bi in Plots A and D and high W in Plot D.The replication of the sediment sampling brings these patterns out very well.

Fe Mn Ni Co V

The increase in Fe in sediment of Plot A is interesting.This pattern is evidenced by Ni Co and V but not manganese which appears to reach a maximum around 5m from the spring and then decrease rapidly. A similar, but less well developed trend is found for these elements in Plot B. All these elements are relatively low in Plot D. As in the case of the previous group the replicated stream sediment sampling provides details of the abundance behaviour of these elements in the different plots.

B Ba La Th

These elements were all determined in the sediment material. Boron patterns are interesting because they are slightly enhanced in Plots A,B and D near springs and three times lower in Plot C on the outflow channel from the spring in Plot B. Although Ba data is listed in percent it indicates that the element is slightly enhanced in plots A and B compared with polts C and D. Lanthanum is an element which might be expected to have a uniform level of concentration in the rocks of the area. This is found in Plots B and C. In Plot A the data is variable but suggests a pattern similar to that for manganese. In Plot D this element is in low concentration. The values vary little from plot to plot. In plot A a positive gradient away from the spring is indicated with the opposite in plot B. The Th is surprisingly uniform in Plots C and D with a consistantly lower level in Plot D.

Ca Mg Al P Ti

Patterns for these elements in sediments are listed as percent and provide a background to the trace element data listed above. The very high indicated Ca in Plot D has been discussed already. Lowest Mg was found in Plot D which may be significant. P,Ti and Al are all low in Plot D compared with the other plots. The relatively high Al in Plot B may be significant.

General Conclusion

From the viewpoint of geochemical prospecting the stream sediment was superior to using <u>M.guttatus</u> or waters. Using the ICP technique more elements were determined in the sediments especially some of the rare ones such as Bi and W which are important in exploration. The replicated at 2m intervals in all four plots provided an insight to the behaviour of individual elements immediatly after passing out of the spring. Some elements decreased some increased and still others remained at the same level of concentration. It was concluded that this procedure be adopted for other springs in the Zap claims area as an aid to prospecting.

SUMMARY CONCLUSIONS AND RECCOMENDATIONS

The small scale research project described in this report has provided significant information regarding the three objectives listed on page 1. In general the information gained on the plant M.guttatus has focussed attention on its use in the prospecting process and the supporting data for spring waters and stream sediment has indicated the relative effectiveness of the three prospecting methods within the confines of the four plots studied. The project has also demonstrated the effectiveness of the ICP multielement approach to chemical analysis which is very suitable for a preliminary investigation of this type.

As a result of the investigation at the four plots the following conclusions were drawn :-

1)M.guttatus is not a specific indicator plant for silver although in the Zap Claims area its presence is associated with waters of high pH (6-7.5) warm springs (temperature 8° - 16°C)

2)This preliminary investigation confirmed the well known fact that the form of M.guttatus is variable even at the same sample point (Figure 12,p.18) Our investigation did not indicate that the growth form of the plant was directly related to silver mineralization in the springs.

3)M.guttatus foliage could have been used as a biogeochemical indicator plant in the Zap claims area where high silver(and other elements-Zn and Pb)were found in the stream sediment and in the plants. However from the viewpoint of practical prospecting stream sediment material was shown to be more reliable than the plants and to involve more anomalous elements than the foliage of M.guttatus.

4)M.guttatus root samples could also have been used as a biogeochemical indicator. They appear to be more effective than the foliage but less so than the stream sediment material.

5)Direct chemical analysis of waters by the ICP method used in this research (after filtering and with,or without,the addition of nitric acid to samples in the field).was inferior to either M.guttatus or stream sediment as a prospecting media in this area. (Note if preconcentration of the waters was carried out prior to analysis by ICP this statement might require modification). Calcium/Magnesium ratios in waters might provide useful leads in th area.

6)Stream sediment sampling at 2m intervals for 10m from spring origins is reccomended as the most effective and reliable method of geochemical prospecting at springs in the Zap Claims area. Using the scan ICP method Ag Pb Zn Cu As Bi Cd Mo W Fe Mn Ni Co V B Ba La Th and major elements Ca Mg Al P and Ti can be determined simultaniously in stream sediment material from the Zap Claims area. Although the major element data is semi-quantitative due to the extraction technique used it does provide general information pertinent to prospecting in the area.

It is reccomended that in future prospecting based on springs in the area the following guidelines should be observed :-

A)Stream sediments should be collected at 2M intervals for 10m at all springs the sediment material should be analysed for many elements by an ICP technique such as that described here.

B)The presence,or absence,of M.guttatus at springs should be noted and if practical a herbarium collection of the plants should be made with representatives from all springs.

C)Temperature and pH measurements should be made at all springs and filtered waters should be collected for determination of Ca/Mg ratios in them.

D)The colour of the waters as sampled should also be noted.This may be important in acid springs draining areas rich in organic matter.

In general it is reccomended that M.guttatus be studied further in the area in order to verify the preliminary findings of this report or to modify them if experience warrents this to be done.

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APPENDIX A

Information on the ICP instrumentation (Jarrell-Ash)

Jarrell-Ash Plasma AtomComp Direct-Reading Spectrometer System

What can you expect from a Plasma AtomComp?

Outstanding analytical performance plus speed, economy, and versatility — features that assure your lab efficient operation and dependable analyses.

Analytical performance:

- Sensitivity to parts per billion.
- Precision to < 1% RSD (relative standard deviation) for most elements at the 10 ppm concentration level.
- Stability to ± 2% or better for 3 hours and longer for most elements at the 10 ppm concentration level.
- Virtually no chemical interferences.
- Automatic correction for interelement interferences.
- Linearity over entire concentration range for all elements (curve, below left).

Speed:

- Completely automated operation gives you printed results for a 61-element analysis in less than 1 minute.
- No operator preparation of individual channels or manual switching between channels. Choose the program you want and all necessary element channels are ready for operation.
- Simple, quick standardization with up to six standards, a blank, and keyboard commands.

Economy:

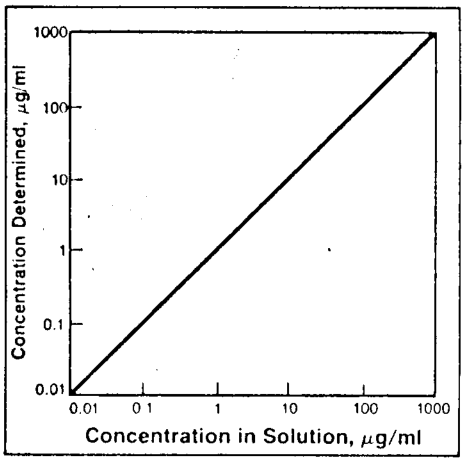
- Rapid sample processing increases load capability, decreases personnel needs . . . saves time and money.
- Inexpensive and easily available standards. Because the system analyzes aqueous solutions, you can make your own standards.

Versatility:

- Analyzes over a dynamic concentration range greater than 100,000 in a single sample with no change in operating parameters or operator intervention.
- Sequential analysis of widely different concentrations from same calibration.
- Results printed out in ppm, ppb, % concentration, etc. You may have different elements in same sample printed out in different units.
- Excellent results for both water and many organic samples . . . even most acids above 25% strength.

Consider these accessories:

- Automatic background correction . . . single or multiple point.
- Variety of optional software packages are invaluable for handling large amounts of analytical data.
- Variable wavelength channel . . . especially useful when analyzing unknowns or for wavelength scanning.
- Autosampler compatibility for quick sample throughput.
- Multiple-source capability. ICAP/spark and ICAP/arc source combinations extend the AtomComp's utility to other sample forms and applications.



Curve illustrates the linearity — characteristic of Plasma AtomComp analyses — for six representative elements (Al, Cd, Cr, Mo, Pd, and Pt) over a 0.02-1000µg/ml concentration range. For Al, Cr, and Mo, linearity extends even further (below graph to 0.001).

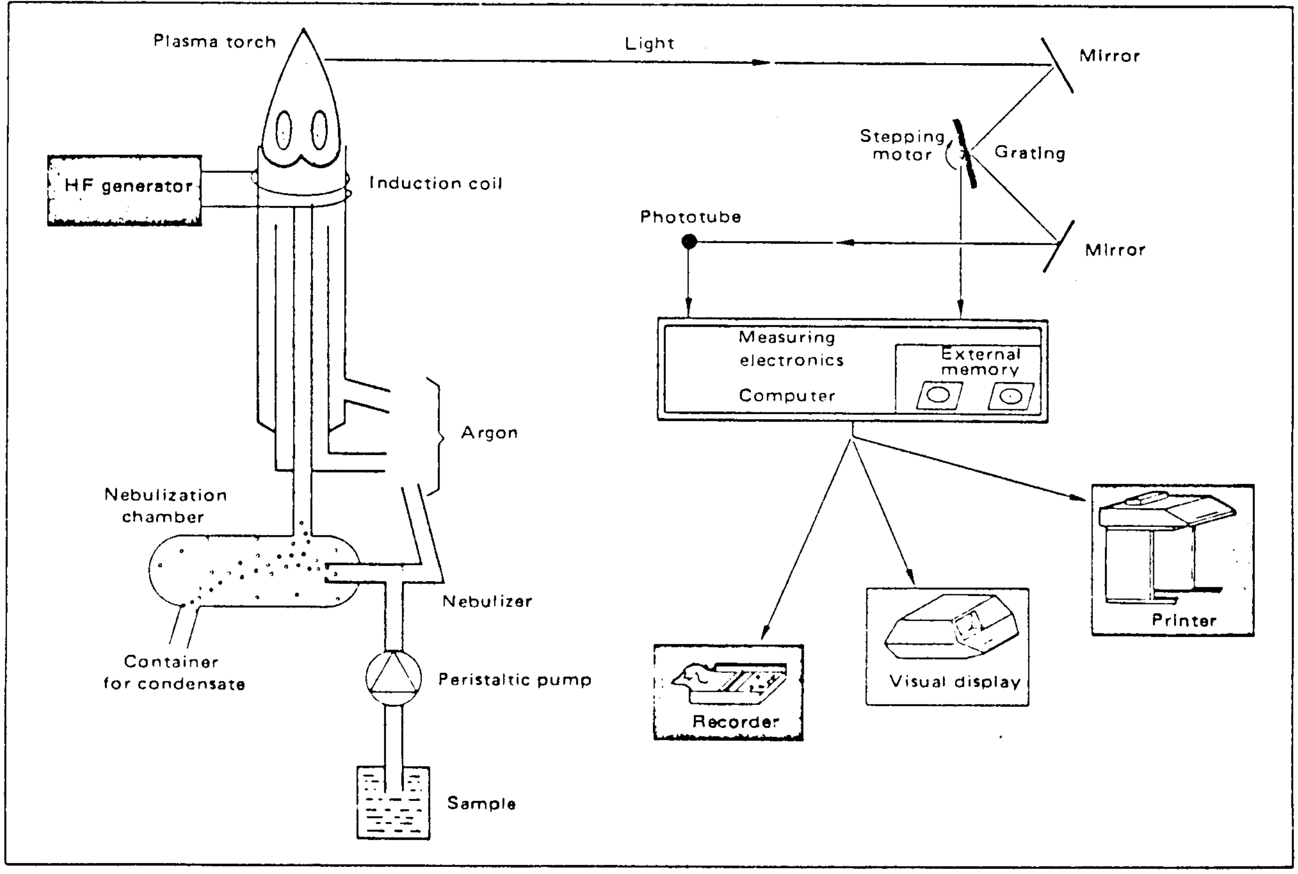
Detection Limits in Water[1]

Element	µg/l (ppb)	Element	µg/l (ppb)	Element	µg/l (ppb)	Element	µg/l (ppb)
Ag	3	Eu	2	Nb	20	Si	5
Al	25	Fe	5	Nd	10	Sm	10
As	50	Ga	20	Ni	10	Sn	30
Au	4	Gd	10	Os	50	Sr	1
B	4	Ge	100	P	60	Ta	20
Ba	1	Hg	30	Pb	25	Te	60
Be	1	In	40	Pd	40	Th	30
Bi	30	Ir	20	Pr	20	Ti	2
Ca[2]	10	K	300	Pt	30	Tl	50
Cd	2	La	2	Re	10	U	100
Ce	30	Li	4	Rh	10	V	1
Co	3	Mg[2]	20	Ru	50	W	50
Cr	5	Mn	1	Sb	50	Y	1
Cu	2	Mo	5	Sc	1	Zn	4
Dy	3	Na	10	Se	50	Zr	3

[1] *Twice the standard deviation of the blank.*

[2] *Data are for normal analytical line, not the most sensitive line.*

Note: These values represent Jarrell-Ash production quality control specifications and are ***guaranteed.*** *Detection limits are being improved continually. Check with your Jarrell-Ash representative for the most up-to-date values.*



Layout diagram for an ICP sytem and laboratory