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ANNUAL REPORT  
EXPLORATION LICENCES 15/73 AND 2/70  
HATFIELD AND MACKINTOSH  
TASMANIA  
FOR 12 MONTHS ENDING JUNE 1, 1980.

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**OPEN FILE**

C.H. Young,  
Project Geologist, Tasmania.  
June 1980.

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Hydrothermal alteration zones of the Que River  
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Petrological and geochemical investigations.

*This was not  
meant to be  
included with  
this report*

*see p. 3.*

*H.*

SUMMARY

This report describes work conducted over the adjoining Hatfield and Mackintosh Licences, which enclose the Que River Mineral Leases, during the period June 2, 1979 to June 1, 1980. Reporting for the two licence areas was combined because the boundary between the two virtually bisects a single project area.

Research work is being conducted by the Federal Institute for Geosciences and Natural Resources of the Government of the Federal Republic of Germany. The research is part of a world wide programme from which it is hoped to evaluate parameters for a genetic approach to mineral exploration.

It is anticipated there will be a renewal of direct exploration activity following establishment of the Que River Mine and further to the research work by the Federal Institute, negotiations are in progress with the CSIRO (Minerals Research Laboratories) regarding the possibility of a research programme which could be instrumental in the discovery of further ore reserves.

INTRODUCTION

Hatfield River Exploration Licence 15/73 covers an area of 65 sq. km and was pegged on May 5, 1973 by Cominco Exploration Pty. Ltd. The E.L. was transferred from Cominco to Abminco N.L. early in 1978. The name Abminco N.L. was changed to Cleveland Tin Limited in early 1979 and then to Aberfoyle Exploration Pty. Ltd. in mid 1979. Work is managed by Aberfoyle Exploration Pty. Ltd.

Licence expiry date is June 26, 1980 and the licence may be renewed at six monthly intervals. E.L. 15/73 is partly over private land owned by Associated Forest Holdings Pty. Ltd. who also have a timber concession covering the entire area of the E.L.

Exploration Licence 2/70 Mackintosh River covers an area of 232 sq. km and was granted to Aberfoyle Tin N.L. in January 1970. The licence is now defined in two parts, the western being to the east of the Murchison Highway, the eastern to the immediate north-west of the Cradle Mountain-Lake St. Clair National Park. The E.L. was transferred from Aberfoyle to Abminco N.L. in early 1978. The name Abminco N.L. was changed to Cleveland Tin Limited in early 1979. Work is managed by Aberfoyle Exploration Pty. Ltd. The licence is subject of a joint venture between Aberfoyle Limited and Paringa Mining & Exploration Co. Ltd. Current equities are Paringa 10%, and Aberfoyle Limited 90%. The licence expires on June 30, 1980. It may be renewed at six monthly intervals.

In August 1979 the part of E.L. 2/70 described as Mackintosh East became managed by Geopeko - a division of Peko-Wallsend Operations Ltd. under a joint venture agreement. Geopeko report independently on E.L. 2/70 Mackintosh East.

#### RESEARCH PROGRAMMES

##### Federal Institute for Geosciences and Natural Resources

Research work commenced in July 1977 by the Federal Institute for Geosciences and Natural Resources of the Government of the Federal Republic of Germany, is continuing. The research is part of a world wide programme from which it is hoped to evaluate parameters for a genetic approach to mineral exploration.

The data is not made public by the Institute except to report to the Government of the Federal Republic of Germany.

Two separate reports were presented to Aberfoyle Exploration Pty. Ltd., namely;

1. Hydrothermal Alteration Zones of the Que River Volcanic Sulphide Deposit Outlined by Mineralogical Petrological and Geochemical Investigations by G. van den Boom and Gert Washausen (M.Sc.) Thesis. English translation by G. Washausen, edited by C.H. Young.

2. Untitled - Petrological notes on drill core samples from drill holes MC1, MC2, MC3 and H1 and H2 with accompanying trace element assay data.

The Director of Mines gave an understanding (May 28, 1979) that data contained in reports pertaining to samples from within the Que River Mineral leases will remain confidential until further notice.

Accordingly, the report on Hydrothermal Alteration Zones of the Que River Volcanic Sulphide Deposit is supplied to the Department of Mines under separate cover. *(included as App. B)*

The petrological notes by T. Finlow Bates refer to the Mt. Charter area in Hatfield licence E.L. 15/73 and are appended to this report. (See Appendix A).

CSIRO (Minerals Research Laboratories) Research Project

Negotiations are in progress with members of the CSIRO (Minerals Research Laboratories) regarding the possibility of a research programme which could be instrumental in the discovery of further ore reserves.

It is anticipated that an integrated programme involving geology, trace element and whole rock geochemistry, gossan and isotope studies be commenced, initially to explain the nature of the alteration halo around the Que River deposit (i.e. a detailed study and development of a model of the deposit itself) and then application of the model on a regional scale involving both the Mackintosh and Hatfield exploration licences.

CONCLUSION AND RECOMMENDATIONS

First derivative exploration of the attractive volcanic stratigraphy within the Hatfield and Mackintosh licences is now complete, that is detailed surface exploration using the techniques of geological mapping, soil geochemistry and I.P. geophysics, as well as airborne EM, and in part UTEM. No coincident first order soil geochemical, I.P. or EM targets of a magnitude similar to that at Que River were detected.

Further exploration for massive base metal sulphides is warranted and second derivative techniques involving geology, trace element and whole rock geochemistry are recommended, initially to explain the nature of the alteration halo around the Que River deposit and then to define drill targets.

FINANCEHATFIELD

Twelve months from July 4, 1979 to June 30, 1980

Geology	1,289
Geochemistry	354
Tenure	992
Sundries	24
	<hr/>
	\$2,659

Expenditure by the Federal Institute for Geosciences and Natural Resources is not reported here.

MACKINTOSH WEST

Twelve months from July 4, 1979 to June 30, 1980.

Geology	\$ 654
Geophysics	609
Geochemistry	203
Tenure	5,623
Sundries	<u>44</u>
	<u>\$7,133</u>

## Excluded are:

- 1) Expenditure on EL 2/70 EAST BLOCK where work is carried out by Geopeko under a proposed joint venture arrangement.
- 2) Expenditure by the Federal Institute for Geosciences and Natural Resources which has not been reported.

REFERENCE

Young, C.H. (1979) Annual Report Exploration Licences 15/73 and 2/70 Hatfield and Mackintosh, Tasmania.  
For the 12 Months ending June 1, 1979.

SIGNED: \_\_\_\_\_

*C.H. Young.*

C.H. Young,  
Project Geologist, Tasmania.

ENDORSED: \_\_\_\_\_

*K.R. Yates*

K.R. Yates,  
Manager - Outside Exploration.

APPENDIX A

Petrological Notes on Drill Core from  
Holes MC1, MC2, MC3, H1 and H2 and  
Trace Element Assay Data.

### Introduction

As a result of discussion held in February/March 1977 with people from Cominco a parcel of samples were supplied by Mr. Young from the Mount Charter district (SW of the Que River deposit). These samples are being examined first to assist the geochemical studies of Dr. G. van den Boom and also for comparison with the Que River material. As some delay is expected in getting the geochemical data from these samples these notes are given as an interim indication that work is proceeding.

### General points

Although the acid members of this suite of rocks are obviously almost totally mineralogically reconstituted I would equate them as a group more with the altered porphyritic lavas and tuffs in the hanging wall sequence (group B) at Que River rather than with the more pervasively<sup>IV</sup> affected footwall rocks (Group A) (Finlow-Bates 1977).

The andesitic samples are not dissimilar to the andesitic rocks described as more distal from the Que River deposit. However, with the possible exception of samples from MCI there is certainly in this suite no evidence of the reworked tuff features thought significant at Que as indicating the parallelism of tuffaceous activity and marine conditions. After seeing how closely the mineralization at Que River is bound to this sedimentation affected tuff and considering the indications that are appearing that some depth of water is needed to keep metals in solution (Hass, 1971, Ridge, 1973, Large 1977, Finlow-Bates and Large 1978) then I would say that some evidence of marine processes is a "plus" for the probability of ore occurring.

One point is clear with respect to interpretation of the chemistry in the acid rocks the chemistry now seen is virtually all of

hydrothermal origin and classification of original rock type on chemistry will probably be impossible.

Diamond Drill Hole MC 1 (samples 206238, 35 m; 206239, 37 m; 206240, 75 m; 206241, 129 m; 206242, 183.5 m)

All of these samples are strongly altered - mainly silicification and sericitization. In the sheet supplied by the Abminco field geologists rock names were also suggested. As with the Que River material (Finlow-Bates 1977) it is not possible to equate the field name unequivocally with the petrographic appearance. Having now seen the drill core from Que River personally I can only speculate that the hand specimen appearance more closely equates to the primary rock and the thin section story to the alteration. While I personally was (and am still) unable to accurately place the rock types unerringly in the classification erected by Mr.C. Young; and while I do still tend to the opinion that probably too many divisions have been established, the classification system is useful as an exploration tool for stratigraphic control. Therefore, only at the loosest level can we seek a correlation between the laboratory results and the field description and the two approaches are not a "test" of each other but supply different information. In general however, there is a better correlation between thin section and hand specimen than for the Que samples seen previously. The general petrographic features of the samples from MC 1 are as follows:

All samples are extremely strongly hydrothermally altered with variable amounts of sericite, quartz (often cherty) and pyrite as the products. There is some variation in the "folcation" exhibited by the samples and registered by the alignment of sericite. Sample 206238 is a relatively uniform rock lacking strong "folcation" composed mainly of irregular, dusty, small (0.1 mm) grains of quartz and abundant sericite with scattered larger (0.1 to 0.3 mm) subhedra of pyrite and a dusting of fine (0.01 mm) pyrite and altered iron oxides. Sample 206239 is similar to 206238 but contains some strongly foliated thin (0.3 to 0.7 mm) zones rich in strongly aligned flakes of sericite. Sample 206240 although more similar to sample 206238 is even more

obviously divided into sericite rich and quartz rich parts. Pyrite is more abundant in the sericite rich portions and some very pale green chlorite is present in the quartz rich parts. Within the sericitic zones also are a few "ghost" textures that are almost certainly relicts of feldspar. What appear to be quartz pseudomorphs after small (0.1 to 0.4 mm) laths of feldspar are more prominent in the foliated sericitic portions of sample 206241. In this sample also coarser-grained (0.1 to 0.6 mm) aggregates of fine (0.01 to 0.02 mm) pyrite are prominent in both quartz rich and sericite rich zones. Sample 206242 contains much "foliated" sericite in interconnecting zones that envelope patches of cherty quartz and other areas of coarser polycrystalline quartz. Within some of the cherty zones are small patches of sericite with a texture almost certainly following glass shard material and also crystals of feldspar?

On petrographic grounds one cannot contradict the hand specimen classification of 206238 and 206240 as lavas and the others as pyroclastics.

Diamond Drill Hole MC 2 (samples 206243, 50.5 m; 206244, 102.3 m; 206245, 147 m; 206246, 160 m; 206247, 183 m)

Of these samples only 206243 (and perhaps 206246) is obviously similar in general appearance to the material from D.D.M.C.I. What appear to be silicified (chert) and sericitized crystals of feldspar and polycrystalline aggregates of quartz enclosing pyrite are enveloped by abundant "foliated" masses of sericite. In sample 206244 what appear to be crystal phenocrysts in hand specimen are actually seen to be sericitized, pyritized and silicified rock fragments in thin section. The matrix between these "dusty" rock fragments consists of clearer polycrystalline quartz that contains individual grains and aggregates of euhedral pyrite and associated sphalerite. Also present within this polycrystalline quartz are minor patches of a titaniferous phase

(leucoxene-anatase?) in skeletal aggregates probably after ilmenite - perhaps the rock is more basic. Sample 206245 appears to be a proxylitized andesitic tuff lava (if we accept the chlorite alteration as an indication that the original rock was intermediate to basic). The rock consists of a jumble of variously carbonatized, chloritized and sericitized volcanic rock fragments cut by veins of carbonate. Sample 206246 is probably also a pyroclastic rock but containing glassy fragments as well as rock fragment material. The glass and rock fragments are now totally converted to sericite and the pseudomorphs sit in a very fine-grained cherty matrix containing some pyrite. The mica quartz composition may indicate more acid pyrite. A more intermediate composition seems likely for the parent rock of sample 206247. Rather large (0.5 - 1.00 mm) phenocrysts of carbonatized and sericitized phenocrysts sit in rock fragments that appear to be composed of a chloritized, silicified and sericitized matrix of small laths of feldspar and probably glass. I would be inclined to classify this sample as a tufflava.

Diamond Drill Hole MC 3 (samples 206248, 23.6 m; 206249, 53 m; 206250, 87 m; 206251, 143.5 m)

Sample 206248 is probably the most basic sample in the total suite. It seems to be a moderately strongly propylitized andesite. Weakly sericitized and saussiritized phenocrysts (up to 0.8 mm) of oligoclase-nadesine feldspar are set in a more strongly altered matrix. The matrix consists of a mass of secondary chlorite, sericite, epidote and pyrite in which relict textures of feldspar and possibly ferromagnesian minerals are visible. Vesicular structures within the rock are now filled with coarser-grained chlorite, epidote and quartz. Samples 206249, 50 and 51 are all more acidic and appear to be porphyritic lavas. In 206249 the feldspar grains (now totally attend to fine-grained quartz and sericite) are larger than in 206250 and 51. In the latter two

samples the feldspar phenocrysts are totally sericitized and are scattered through what appears to be basically a primary siliceous matrix. A few slightly "reabsorbed" quartz grains are also present in similar to those normally encountered in dacites.

Diamond Drill Hole DDMH 1 and H 2 (samples 206252, 60.5 m; 206253, 103.5 m)

Sample 206252 is a fine siltstone consisting of a very weakly foliated mass of sericite, quartz, chlorite, some fine pyrite and carbonaceous material. Secondary veinlets of pyrite with pressure fringes of chlorite and quartz cut the rock. Sample 206253 is sericitized, chloritized and silicified andesitic tuff lava or pyroclastic although the alteration is not as strong as in the acid samples of DDM's MC 1, 2, and 3. The rock consists of variably sized, often large (up to many millimetres) porphyritic andesitic rock fragments with partially altered feldspar phenocrysts separated by zones of polycrystalline fine-grained quartz containing some smaller feldspar crystals. The latter are also only slightly altered.

Diamond Drill Hole H 2 (samples 206254, 202 m; 206255, 153 m)

Sample 206254 is a weakly altered andesite or dacite consisting of feldspar laths and euhedra (0.3 to 0.8 mm) in a "dusty" matrix of feldspar, quartz, chlorite, minor sericite and some secondary leucoxene. Sample 206255 seems to be a more altered (carbonatized) version of sample 206253.

- Finlow-Bates, T. (1977): The Que River volcanogenic sulphide deposit. Petrological considerations. Report for the Federal Institute of Geosciences and Natural Resources - Hannover
- Finlow-Bates, T. and Large, D. (1978): Water depth as a major control on the formation of submarine exhalative ore deposits: Geol. Jb. D 30, p. 27 - 39
- Haas, J.L. (1971): The effect of salinity on the maximum thermal gradient of a hydrothermal system at hydrostatic pressure: Econ.Geol. 66, p. 551 - 556
- Large, R.R. (1977), Chemical evolution and zonation of massive sulphide deposits in volcanic terrains: Econ.Geol. 72, p. 549 - 572
- Ridge (1972): Volcanic exhalations and ore deposition in the vicinity of the sea floor: Mineral Deposita, 8, p. 332 - 348

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## TRACE ELEMENT ANALYSIS BY XRF

Hannover, den 9.2.1979

Einsender: Dr.Klau/Dr.Finlow-Bates

Probenart: Vulkanite

Konzentrationsangaben in ppm

Hole No.	Depth	Sample No.	Ba	Ce	Co	Cr	Cu	La	Nb	Ni	Pb	Rb	Sc	Sr	Th	V	Y	Zn	Zr	Geological Log
MC1	35 m	206238	859	121	53	11	60	132	7	19	61	158	20	0	23	145	23	135	135	Porphyritic dacite
	37 m	206239	1168	64	60	18	32	97	0	21	61	150	13	11	22	129	22	81	122	Porphyritic dacite pyroclastic
	75 m	206240	1042	149	48	9	25	145	10	19	276	154	15	0	22	126	21	98	122	Porphyritic dacite
	129 m	206241	10298	20	47	8	86	111	11	21	288	200	20	99	30	134	18	621	153	Streaky pyroclast
	182.5 m	206242	2906	85	40	16	39	112	10	23	3	247	25	36	31	170	29	168	182	Streaky pyroclast
MC2	50.5 m	206243	3362	61	32	16	71	94	13	24	10	250	23	54	33	119	33	555	250	Porphyritic dacite
	102.3 m	206244	14331	30	53	0	52	156	10	26	249	131	17	198	20	128	17	1837	115	Porphyritic dacite
	147 m	206245	1376	146	27	17	108	203	3	21	0	71	20	83	24	138	27	331	131	Altered andesite?
	160 m	206246	1248	118	45	12	19	142	19	32	0	110	12	15	18	34	33	13	181	Porphyritic dacite pyroclastic
	183 m	206247	1042	154	26	2	0	155	22	21	0	178	15	100	31	18	49	77	257	Altered andesite?
MC3	23.6 m	206248	2017	208	29	14	9	234	6	20	56	43	25	694	20	164	35	200	190	Weathered andesite pyroclastic
	53 m	206249	5266	216	21	29	28	266	6	29	75	180	12	45	20	55	32	398	154	Porphyritic dacite pyroclastic
	87 m	206250	6082	79	49	14	25	144	28	24	256	153	11	21	26	62	12	141	147	Porphyritic dacite
	143.5 m	206251	3732	131	32	6	0	176	18	21	0	176	11	18	22	70	15	51	175	Porphyritic dacite

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TRACE ELEMENT ANALYSIS BY XRF Continued...

Hole No.	Depth	Sample No.	Ba	Ce	Co	Cr	Cu	La	Nb	Ni	Pb	Rb	Sc	Sr	Th	V	Y	Zn	Zr	Geological Log
H1	60.5 m	206252	955	82	47	160	137	111	9	160	48	103	19	7	15	150	30	183	117	Pyritic black shale (Que River Slates)
	103.5 m	206253	1601	197	44	22	110	222	5	31	0	95	22	550	13	178	30	73	140	Andesitic pyroclastic
H2	202 m	206254	2304	153	65	10	18	171	6	22	70	79	18	460	30	128	24	2684	123	Andesite
	153 m	206255	2240	138	25	3	135	165	9	21	842	28	20	508	20	174	26	1775	125	Andesitic pyroclastic

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APPENDIX B

FEDERAL INSTITUTE FOR GEOSCIENCES  
AND NATURAL RESOURCES (BGR)

HYDROTHERMAL ALTERATION ZONES OF THE QUE RIVER  
VOLCANIC SULPHIDE DEPOSIT OUTLINED BY MINERALOGICAL  
PETROLOGICAL AND GEOCHEMICAL INVESTIGATIONS.

By

G. van den Boom and  
Gert Washausen (M.Sc.) Thesis.

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Abstract

X-ray, microscope and geochemical investigations were carried out in order to define hydrothermal alteration zones which might be used to outline (limit) possible ore in the exploration area of the Que River deposit, Tasmania. Australia.

The evaluation of X-ray investigations suggests it is possible to define ore (Zn, Pb, Cu) by using the following hydrothermal indicator minerals:

The sulphates gypsum ( $\text{Ca SO}_4 \cdot 2 \text{H}_2\text{O}$ ) or anhydrite ( $\text{Ca SO}_4$ ) and alunite ( $\text{KA l}_3(\{\text{OH}\}_6/\{\text{SO}_4\}_2)$ ) or jarosite ( $\text{Fe}^{3+}$  substituting  $\text{Al}^{3+}$  in the alunite formula) as typical minerals. These sulphates are likely to result from a hydrothermal alteration solution of acid character high  $\text{SO}_4^{2-}$  concentration and thus proximity to volcanic centres.

These minerals appear in all rock sequences within the deposit area (andesites, dacites, rhyolites). In the alteration zone, surrounding the deposit area, the characteristic feature is the appearance of the carbonates: Calcite ( $\text{Ca CO}_3$ ), dolomite ( $\{\text{Ca, Mg}\} \{\text{CO}_3\}$ ), siderite ( $\text{Fe CO}_3$ ) and magnesite ( $\text{Mg CO}_3$ ).

The sulphates and carbonates - identified as traces or minor constituents by means of x-ray diffraction - are part of a rock sequence which has undergone a very low grade greenschist metamorphism. Chloritisation is common to the whole exploration area.

Thin section investigation based on the zonation found by means of x-ray diffraction confirms the minerals typical for the zones, and indicates a possible new zone between the two zones previously noted: In the contact area between the sulphate and the carbonate zone K-feldspar recrystallisation and zeolithisation (mostly natrolite) is found in a few samples. The small number of these samples does not allow an "interzone" to be defined.

Univariate geochemical statistics of the elements Zn and Pb as deposit formers and the elements Sr and Na with a negative halo in the deposit area and the main alteration area, support in most parts, the results of the mineralogical investigations.

Thus by using a combination of x-ray, microscope and geochemical techniques there is a high probability of finding prospective areas.

### Introduction

The opportunity for the present work on the volcanogenic sulphide Zn-Pb-Cu deposit at Que River, Tasmania, Australia came as part of the research programme "stratiform deposits" of the B.G.R. Hannover.

The term volcanogenic deposit applies to massive sulphide ore bodies with an obvious connection between their formation and volcanic processes. They are stratabound and appear mainly in the acid parts of volcanic differentiation series. These deposits are found in Precambrian (Canada) up to Tertiary (Japan) volcanics. Though in all these cases we are dealing with the same type of deposit there are a series of variations to be found.

The investigations on the Que River deposit should lead to definition of characteristics typical for Paleozoic deposits.

There is much known on the parameters of stratabound volcanogenic sulphide deposits. E.g. D. Sangster (1972) resumes the following metallogenetic factors of the Canadian ore deposits:

1. The volcanics must be part of a calc-alkaline suite.

2. The volcanism must be submarine.
3. Exploration is limited to the most acid parts of the volcanic sequence (dacites and rhyodacites) which as final differentiation products indicate the end of volcanism. This final stage is described by S.I. Naboko (1963) as the post-caldera period, linked to the strongest hydrothermal activities.
4. Coarse pyroclastics or agglomerate indicate the possible presence of sulphide ores.
5. Sulphide constituents of the agglomerates indicate the orebody is in the same stratigraphic horizon or overlying the pyroclastics.
6. In so called "distal" occurrences, that is ore bodies not in direct vicinity of volcanic centres, the coarse pyroclastics are substituted by submarine lavas and tuffs of rhyolitic-dacitic composition. These may actually be metamorphosed.
7. A connection to the "banded iron formation" (sulphide-carbonate-silicate-oxide facies) is regarded as proven.

The metallogenetic factors, found in a lot of Canadian deposits, are in most parts applicable to Australian Paleozoic occurrences, although the separation of the rock units is not as obvious as in the Canadian green stone belts, the same differentiation sequences are still to be found. I.B. Lambert (1978) resumes the rock types of the Woodlawn occurrence, SE New South Wales as follows.

1. Felsic volcanics
2. Fine grained sediments (e.g. tuffite)
3. Chlorite schists
4. Basic intrusives and tuffs

These rock types are compared to the island arc types of the Miocene volcanic belt in the NE of Japan, to which the Kuroko deposits are related. Despite the expected big differences between Precambrian, Paleozoic and Tertiary massive ore deposits, there is a commonness of super-regional and time-bound parameters. According to I.B. Lambert (1978) the following parallels are to be found in all three deposit areas (provinces):

1. The ore bodies are bound to calcalkaline submarine volcanics.
2. The occurrences are grouped regionally and are linked to volcanic centres.
3. There is a close correlation to the acid parts of the volcanics.
4. Massive as well as stringer ores are to be found. The massive ore occurs stratabound and often shows banding.

Besides these parallels there are a lot of differences to be noted. These might be explained by different grades of metamorphism and strong chemical variations during the evolution of lithosphere, hydrosphere and atmosphere.

According to S.I. Naboko (1963) further differences might be explained by the interaction of the ore bearing solutions with the surrounding rocks. These interactions - which causes a continuous variation of the cations in solution, as well as their concentration - cause a strong change of pH values, accompanied by a loss of volcanic gas of the solution during migration. The change from a low pH at the generation of the solution to a neutral to high pH on contact with the surface is also due to the cooling (condensation and dilution of the solution). The change of pH is responsible for the creation of different alteration zones.

Hydrothermal alteration created a clay-rich zone around the Japanese Kuroko deposits which changes to an outer zeolite-rich zone. The clay-rich zone was enlarged during the operation of hydrothermal activities.

Comparable zonations were found by I.B. Lambert (1978) by detailed geochemical investigations on core materials of the Woodlawn deposit. Here - likewise on the Kuroko deposits Lambert proved a relative increase of Mg, Fe, Sr and a relative decrease of Ca and Na in the wall rocks.

In a vertical build up around the Woodlawn deposit 4 zones are distinguished extending from zone 1 in the deposit area, over zone 2 in the hanging wall towards zone 4. Zone 3 is a special case of alteration, a long distance from the orebody.

The zone 1 alteration is comparable to the strongly silicified stockwork-zone, clay rich lenses and chert intersections of the Kuroko deposits. The influence of the ore bearing solutions on the alteration here is obvious. In contrast to the Kuroko occurrences there is no Ba enrichment in a baryte zone to be found.

Zone 2, over and underlying the orebody is parallelised by Lambert with the sericite-chlorite zone of Kuroko. The involvement of a possible low-metal solution during the creation of this zone is most likely. This is confirmed by Naboko (1963) by investigations on recent hydrothermal solutions of active volcanics: After the precipitation of the ore a propylitic, feldspar - zeolite, and argillitic zonation is generated by a NaCl-rich hydrothermal solution which is enriched with  $\text{SO}_4^{2-}$ ,  $\text{H}_2\text{S}$  and  $\text{CO}_2$ . In the case of the Woodlawn deposit such a low-metal-content solution "soaked" a volcano-sedimentary sequence (Lambert 1978).

The third zone, defined by Lambert for the Woodlawn complex, contains the central volcanic part. Here terrestrial alteration and weathering are predominant. Now and then zones of intrusive alteration are to be found, which are limited to small localities indicating the migration tracks of the hydrothermal solution.

Zone 4 here is the metamorphic equivalent of a clay-zone and is to be compared to the zeolite-zone in the Kuroko occurrences. Only minor chemical changes are to be found in this zone which might be explained by total reactions of the circulation solution within the sediments.

The subject of this work is to evaluate how many of the so far mentioned general metallogenic factors and details are reproduced in the Que River Deposit, Tasmania.

### Regional Geology

The orebodies of the stratabound Que River (Zn, Pb, Cu) deposit occur within the Cambrian Mount Read Volcanics. Thus Que River may correlate with neighbouring deposits of the same type: The sulphide deposits of the Rosebery and Hercules mines (Zn, Pb, Cu). The ore in these deposits is associated with lavas and pyroclastics. These rocks have undergone a low grade green-schist-metamorphism, which is likely to be of the same age as the ore formation - Middle Cambrian.

Ore formation should be regarded as connected to the Mount Read Volcanism, which caused by exhalative processes a low temperature ore precipitation within the volcanics.

The Mount Read volcanics are situated in the Dundas Trough. This trough as well as the distribution of the Mount Read Volcanics are sketched in (Plate Abb. 1).

The eastern and central parts of the Dundas Trough are filled with partly fossiliferous sediments of Upper Proterozoic to Upper Cambrian age and with volcanics of the same age.

The western part of the former geosyncline in direct contact to the Mount Read Volcanics has not been the subject of intense study.

The eastern and central parts of the Mount Read Volcanics are overlain by Ordovician to Middle Devonian sediments. The northern parts

030

are overlain by Tertiary basalts and in part by Quaternary glacial overburden.

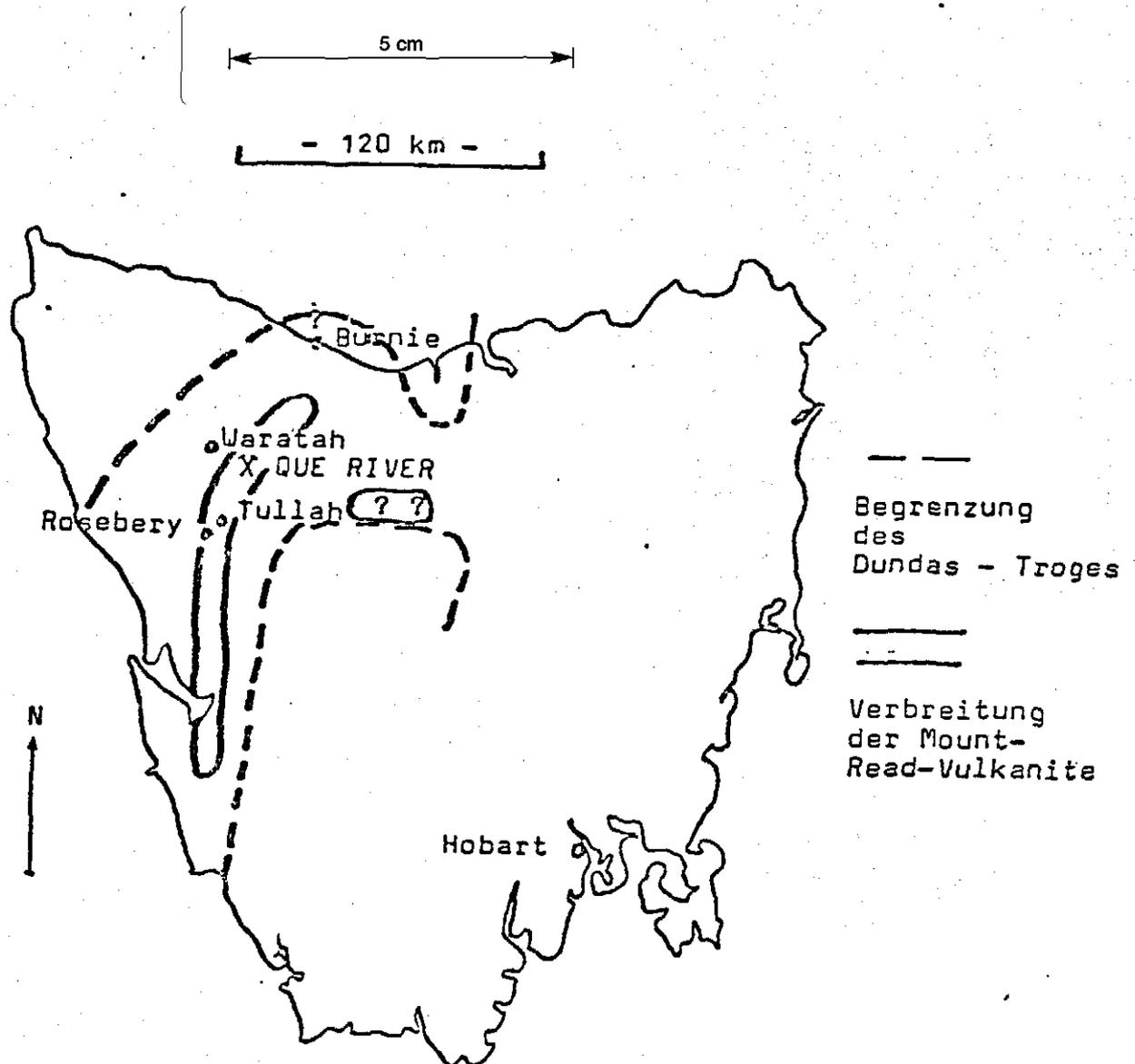


Abb. 1: Obersichtskarte von Tasmanien

(Angaben übernommen von M. Solomon, *Geology of Tasmania*, S. 467, 1963)

031

Geology of the Area Investigated

The Que River deposit was found in 1973 by means of geophysical investigation and is the property of Aberfoyle Limited 90% and Paringa Mining & Exploration Company Limited 10%.

Que River is situated at 145.8°E and 41.5°S.

From Wynyard (airport) the area is accessible by the Murchison Highway.

Mapping in the Que River area revealed a W dipping series of andesitic agglomerates, lava-breccias and vuggy lavas with a doleritic intrusive. These rock sequences are typical for the Mount Read Volcanics.

The predominantly andesitic material is overlain by fossiliferous middle Cambrian black shale. This Que River shale occurs 0.5 km E of the Murchison Highway and overlies the andesites with a concordant W dip.

In the area about 1 km E of the deposit the andesites are underlain by a greywacke-shale-volcanic series with a steep W dip. According to recent opinions this series is connected to the Farrell group (Tullah).

Interbedding the Que River shale, or overlying this, there is a sequence of dacitic to rhyolitic pyroclastics, in which there are quartz crystals up to 5 mm in size. These N-S trending rocks of dacitic to rhyolitic composition are accompanied by lenticular ore bodies with the same bearing and vertical dip.

032

The Que River deposit, 2.5 km E of Murchison Highway and S of the Que River, consists of lenticular ore bodies of 8 m average thickness. These lenses with a maximum thickness of 30 m are divided into Zn-Pb rich and Cu rich types which are separated by an approximate 125 m thick body of pyritic pyroclastics. The ore lenses have not been intersected by drilling below 260 m.

The whole volcanic complex is sheared, as are the ore lenses. The shear zones, filled with clay material may make mining difficult. Besides the above mentioned shears, which are not confirmed by geophysical methods, one major fault zone (Plate Abb. 3) was proved by magnetics.

Rugged relief, partly glacial overburden, deep weathering and thick rainforest vegetation make sampling and other exploration activities difficult. As outcrop is only about 1% of the whole area, the geological summary in (Plate Abb. 3) has to be regarded as interpolation of the known data from drilling, costeaning and road profiles.

033

Plate Abb. 2  
Outcrop pattern.

A sub-aerial genesis of the whole volcanic complex is indicated by tuffs, whilst the pyritic rocks and massive sulphide ore bodies give hints of a submarine genesis of the deposit. A temporal sequence for the genesis of the deposit is also indicated by the occurrence of two different ore lens types in two separate horizons.

The following cycle of the volcanism is very likely: Extrusion of dacitic lavas, now found as breccias in contact with the Cu rich ore.

Plate Abb. 3 Surface geology (simplified).

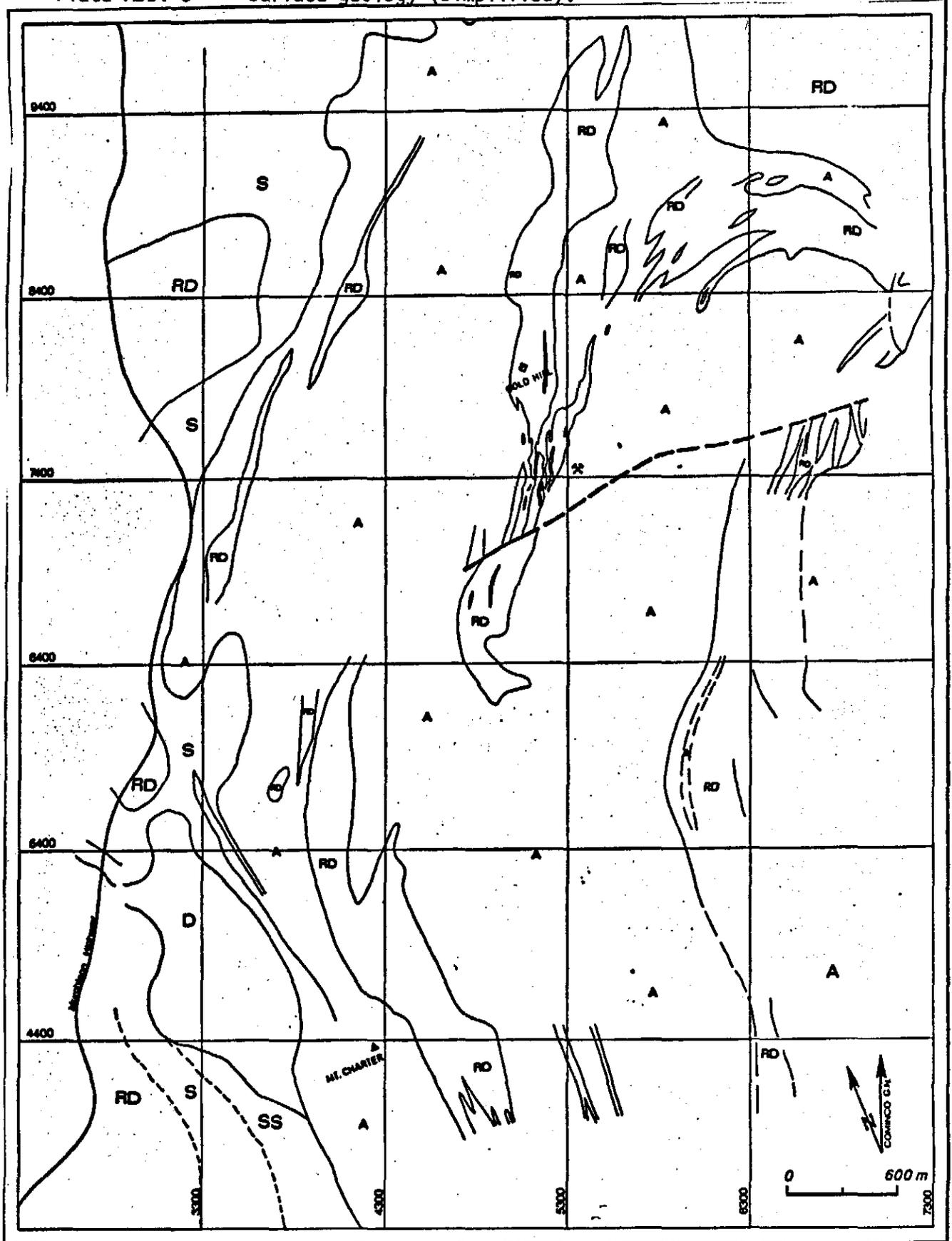


Abb. 3 : Vereinfachte Oberflächengeologie im Prospektionsgebiet QUE RIVER , Tasmanien , Australien . Geologie : COMINCU EXPL.PTY.LTD. , 1976 .

- |  |                        |                        |            |
|--|------------------------|------------------------|------------|
|  | geol. Kontakt          | Kambrium :             | Jura ? :   |
|  | geol. Kontakt vermutet | A : Andesite           | D : Diabas |
|  | Störung                | RD : Rhyolithe , Dazit |            |
|  | Straße                 | S : Que-River-Schiefer |            |
|  | Erzvorkommen QUE RIVER | SS : Sandstein         |            |

In a phase of relative volcanic inactivity ore precipitation within shaly to tuffitic materials took place.

These were later overlain by andesitic to dacitic volcanics, as pyroclastics or fine grained lavas. After that dacitic tuffs and tuff agglomerates were deposited, indicating a new climax of volcanic activity. In these heavily altered rocks appear the Zn-Pb rich ore bodies.

The whole deposit shows a typical zonation:

The basal part is formed by silicified rhyolites with disseminated pyrite. This base is overlain by the Cu rich parts of the deposit. Here massive pyrite is found. The overlying mineral sequence is dominated by galena and sphalerite. The end of ore bearing mineralisation is indicated by quartz rich mineral paragenesis with a high Fe content.

Plate Abb.4: Silicified host rock and disseminated pyrite  
at the ore base.

### Material Investigated

In the 30 km<sup>2</sup> exploration area of Que River, 187 surface rock samples were collected. The sampling was carried out in winter of 1977 by members of B.G.R., Hannover and Aberfoyle staff members. Most of the samples were taken from the dacitic to rhyolitic rock sequences or from andesites in close contact to the former mentioned series.

Plate Abb. 5 shows the distribution of sample sites.

### Sample Treatment and Methods of Investigations

The rock samples were crushed and ground in an agate mill to <75µm (-200 mesh) in the laboratories of the B.G.R. One chip sample of each sample was kept for thin-section investigation.

Part of the powder was used for XRF in the B.G.R. The following 27 elements were analysed.

Main Elements: SiO<sub>2</sub>, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, MgO,  
CaO, Na<sub>2</sub>O, K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>.

Trace Elements: Ba, Ce, Co, Cr, Cu, La, Mn,  
Nb, Ni, Pb, Rb, Sc, Sr, Th,  
V, Y, Zn, Zr.

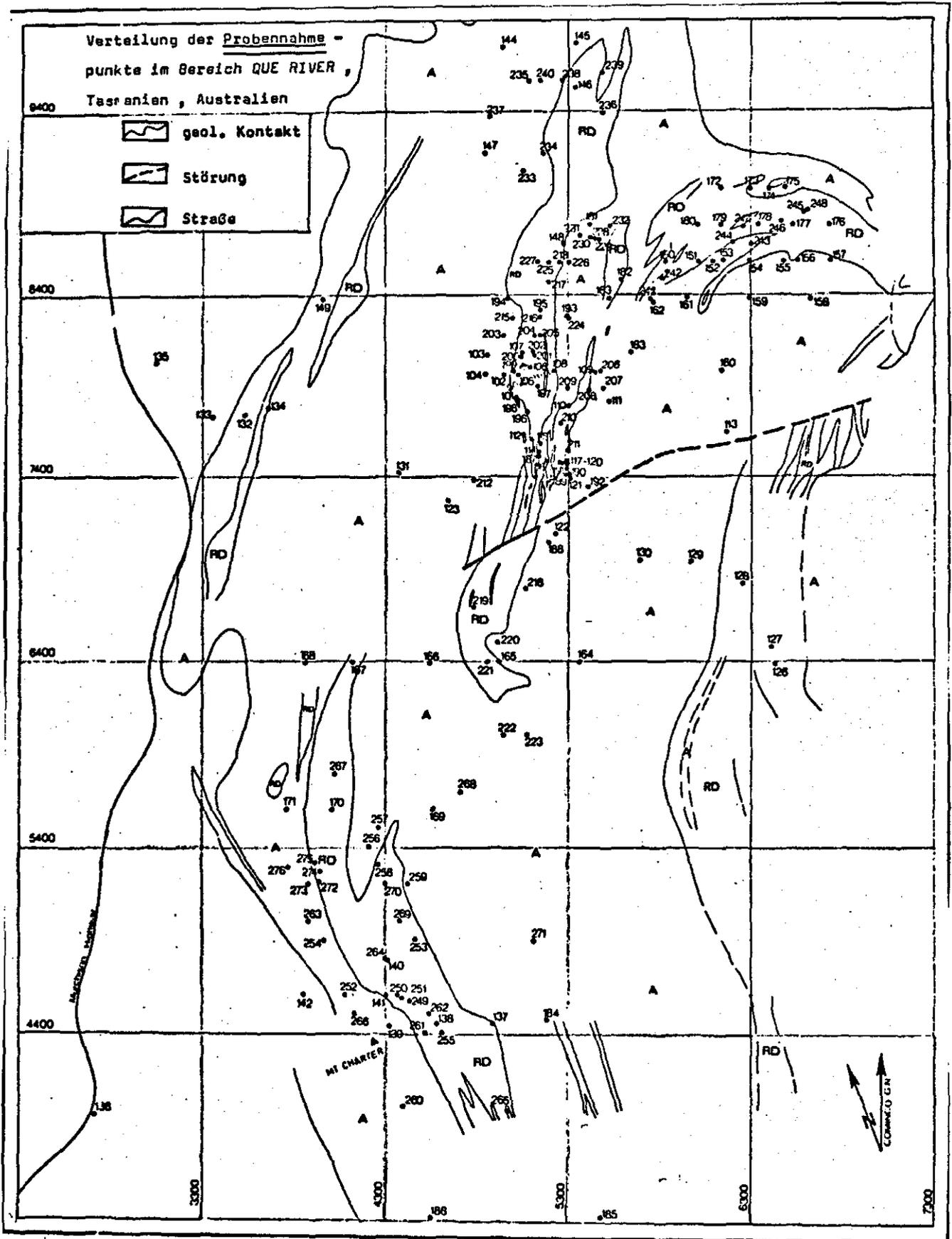
The data used in the present work is listed in annex 1.

Initially the powders were used for x-ray analysis at the Mineralogical Institute of the University of Hannover. These analyses were carried out by Scintollometer-Diffractometer and Guinier investigation, using Cu-K $\alpha$  radiation.

Out of 92 rock slabs, 46 thin sections were prepared at the B.G.R. and the same amount in the Mineralogical Institute of the University of Hannover. Microscope investigation on these thin sections was carried out at the Mineralogical Institute of the University of Hannover, using a Zeiss polarizing microscope.

The statistical evaluation of the geochemical data was carried out at the B.G.R. and is reported in "Pattern Recognition Applied to Geochemical Exploration Data in the Area of Que River, Tasmania, Australia". This unpublished report of G van der Boom and S. Rehder of January 1979 was used in the present work as source for geochemical discussion.

Plate Abb. 5: Sample Sites.



Probennpunkt 143 ist wegen seiner Lage bei 10500 N und 5760 E hier nicht verzeichnet .

Geologie : COMINCO EXPL.PTY.LTD. , 1976

A : Andesite RD : Rhyolithe , Dazite

Petrography

Field geologist observations permit a separation of the rocks within the exploration area into two main series, andesites and dacites to rhyolites.

These series may be sub-divided as follows. The main part of the rocks in the exploration area is formed by andesite lavas and andesitic pyroclastics. Pyrite and other sulphides are to be found here, either disseminated or in aggregates. The pyroclastics are partly carbonatised and generally show chloritisation. The groundmass shows feldspar porphyroblasts up to 2 mm, these form aggregates up to 5 mm diameter being filled with glass, chalcedony and/or carbonates. These rock sequences may be regarded as flow breccias.

The former mentioned pyroclastics are substituted in parts by streaky andesitic pyroclastics which are characterised by flattened pumice. Microscope investigation clearly show areas of devitrification, accompanied by chlorite, carbonate and in part illite. Feldspars up to 1 mm in size are partly sericitised, carbonatised and albitised.

In the ore zone pyritic andesitic-dacitic pyroclastic units of various thickness are found. Heavily chloritised fragments of porphyritic andesite are found in a dacitic matrix. Here pyrite, quartz, sericite, carbonate and chlorite are the main constituents. Occasionally green illite-hydromuscovite-aggregates may be found in close contact with the ore lenses.

Dacite-lavas in parts show flow regulated feldspar phenocryst and vugs. These rocks occur interbedded with the former mentioned ore-series. As they do not show any mineralisation they seem to have been impermeable to the ore bearing solutions, this is also indicated by the precipitation of nearly all ore lenses in the direct vicinity of these dacite-lavas. Carbonatisation and sericitisation of feldspars are fairly widespread and advanced. Strong devitrification is indicated by quartz recrystallisation in veinlets. The pyrite content is about 1% of the rock, as fracture filling it might increase up to 5%.

Dacitic materials with tuff and lava components show extrusive as well as pyroclastic elements. Some fragments of porphyritic dacite, partly flow banded are found in a matrix of comparable composition. These rocks might be interpreted as flow brecciated lava or as a lava with tuff agglomerate "impurities".

Dacitic pyroclastics occur together with dacites or substitute for them. They are characterised by dacite fragments in a matrix of tuffaceous dacite. This tuff is pyrite-quartz-sericite rich.

Irregularly distributed porphyritic dacite is to be found in the ore zone, showing intrusive and flow characteristics. This compact rock with abundant feldspar porphyroblasts shows silicification, carbonatisation, and sericitisation. Feldspar porphyroblasts up to 3 mm in size, formerly flow distributed, show sericitisation. Euhedral and anhedral quartz porphyroblasts show up in the devitrified quartz feldspar groundmass.

In shear zones and fault fissures Cu-rich mineralisation is noted.

Porphyritic dacitic pyroclastics appear in the ore zone, porphyritic dacites are found as fragments up to 20 cm. Sorting of the fragments is visible in parts and the fragments may be partly rounded. A sequence of tuffs and agglomerates might be indicated. The groundmass consists of quartz, sericite and carbonate with a large amount of pyrite.

In the immediate contact to the ore bodies reworked dacite tuffs, indicated by polymictic rounded fragments are to be found. Fragment sizes are up to 5 cm but average 5 mm. These rounded fragments are porphyritic dacites, sericitised trachytes and cherts. Irregular quartz aggregates indicate devitrification. The matrix is formed by secondary quartz, sericite, carbonate and pyrite.

A shaly dacite tuff which is heavily argillitised has to be regarded as definite host rock to the ore lenses. The sericite rich matrix outlines former feldspar crystals surrounded by devitrified areas. This rock has to be regarded as an indication of ore precipitation within a pumice zone, collapsed former pumice structures are still evident.

### Results of X-Ray Investigations

Evaluation of diffractometer and Guinier investigations permits a separation of the mineral paragenesis into three main groups. The three main groups are likely to be shown for dacitic as well as andesitic rocks with identical secondary minerals. The different amounts of the primary minerals within the single rock units, especially the differences in the contents of K-feldspar, pyroxene or amphibole are to be regarded as secondary during the search for zone-typical alteration minerals.

A typical mineral paragenesis for the ore zone was defined:

Main Minerals of the ore zone paragenesis are quartz, muscovite, plagioclase (An 20-30, derived from the difference in  $2\theta$  of the  $131$  and  $1\bar{3}1$  reflexes), and K-feldspar, these partly occur with the plagioclases and partly substitute them. Pyrite is abundant in this zone and is partly accompanied by thuringite.

Typical Minerals of this paragenesis, which make a limitation of the zone possible, are the sulphates gypsum or anhydrite and alunite or jarosite. These minerals not only enable the identification of the ore deposit group, they also suggest the nature of the alteration solution, which hydrothermally altered the area and caused the ore precipitation. Alunite ( $KAl_3((OH)_6/(SO_4)_2)$ ) and jarosite (in jarosite the  $Al^{3+}$  of the alunite is partly substituted by  $Fe^{3+}$ ) are according to W.E. Troger (1969) to be regarded as hydrothermal alteration products of alkali-feldspars in acid to intermediate volcanics if these have undergone a sulfateric alteration.

The regional distribution of the mineral assemblage described above is shown as Zone 1, in Plate Abb. 6.

The former mentioned sulphate-Zone (Zone 1) is enclosed (surrounded) by Zone 2, which may be described with the following mineral assemblages.

Main Minerals are quartz, muscovite, plagioclase (An 20-30, partly pure Ab), Mg rich chlorites (defined by intensity and position of the second base reflex) and K-feldspar, minor constituents of this paragenesis are pyrite, montmorillonite, illite and/or talc.

Typical Minerals of this assemblage are the carbonates which may be a minor constituent up to the main mineral. In the majority of the samples calcite and/or dolomite and/or ankerite are predominant. In some of the samples siderite or magnesite was found.

It should be noted that some samples of Zone 2, taken in close proximity to Zone 1 show besides carbonate traces of natrolite. The small number of these samples doesn't justify the definition of a new zone.

The regional distribution of the carbonate zone is shown as Zone 2 in Plate Abb. 6.

The third main group seemingly hasn't undergone major hydrothermal changes, besides chloritisation as a hint of hydrothermal alteration the primary minerals in the rock units are still identifiable. These as Zone 3 defined rocks-surround Zone 1 and 2 and may be described with the following mineral assemblage:

Quartz plagioclase and K-feldspar are the main components.

Mg-chlorites as well as pyrites are only of minor importance and both are not abundant. Depending on the rock type kaersutite and hypersthene, as well as other members of the amphibole and pyroxene groups were identified by x-ray. This indicates a relatively unaltered zone. As a sheet silicate muscovite appears beside the previously mentioned Mg-chlorite.

The separation of the exploration area into the former mentioned zones is based on the evaluation of the x-ray-data of 166 surface samples.

Table of zone typical minerals:

Zone 1:

Gypsum / anhydrite / alunite / jarosite / (Fe-chlorite)

Zone 2:

Calcite / dolomite / ankerite / siderite / magnesite /  
(Mg-Fe-chlorite)

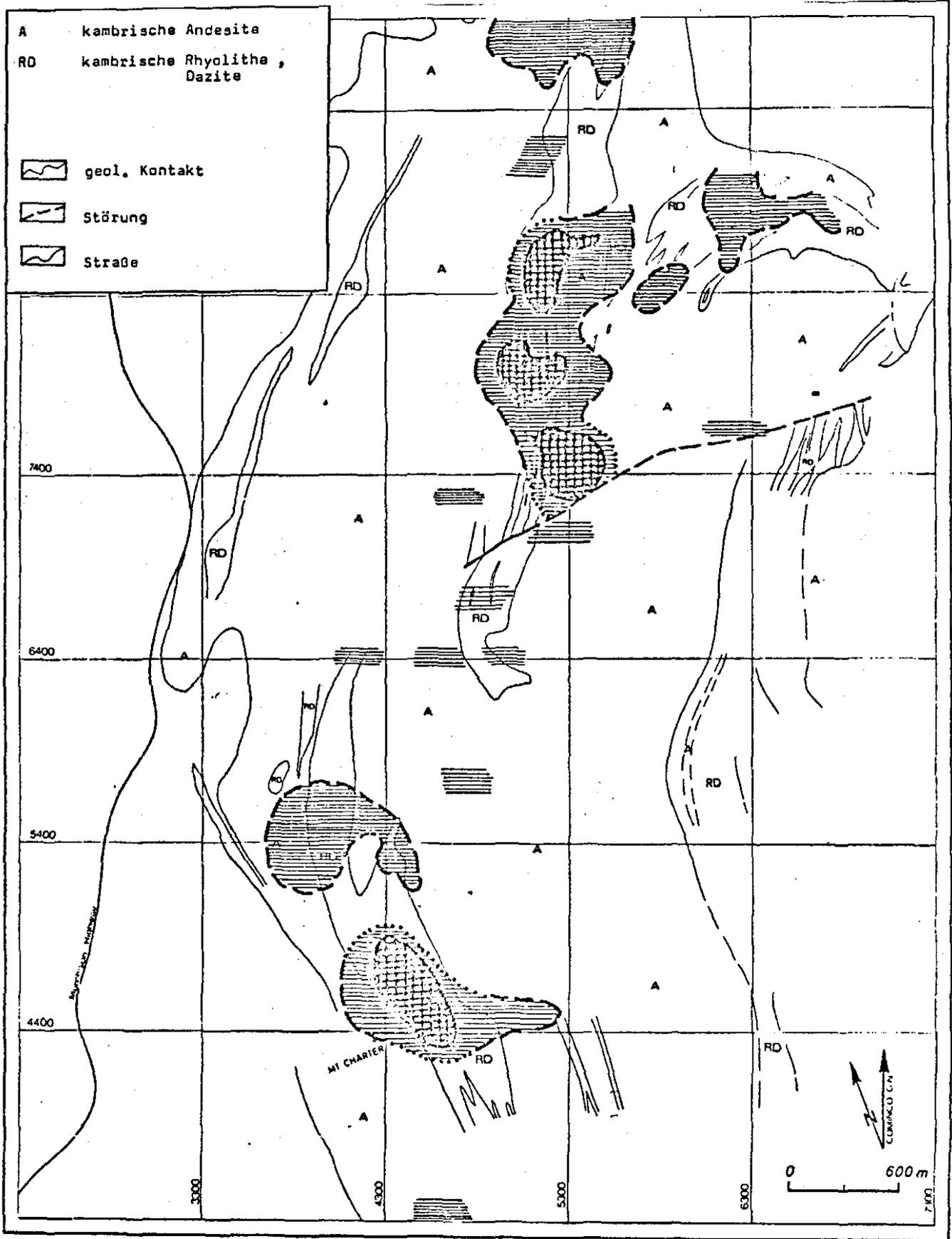
Zone 3:

Primary minerals e.g. kaersutite / hypersthene  
(small amounts of secondary Mg-chlorite)

A possible new Zone between Zone 1 and Zone 2:

Natrolite besides the above mentioned indicator minerals of Zone 2

Plate Abb. 6: Regional distribution of the alteration zones.



Sulfatzone : Zone 1

Karbonatzone : Zone 2

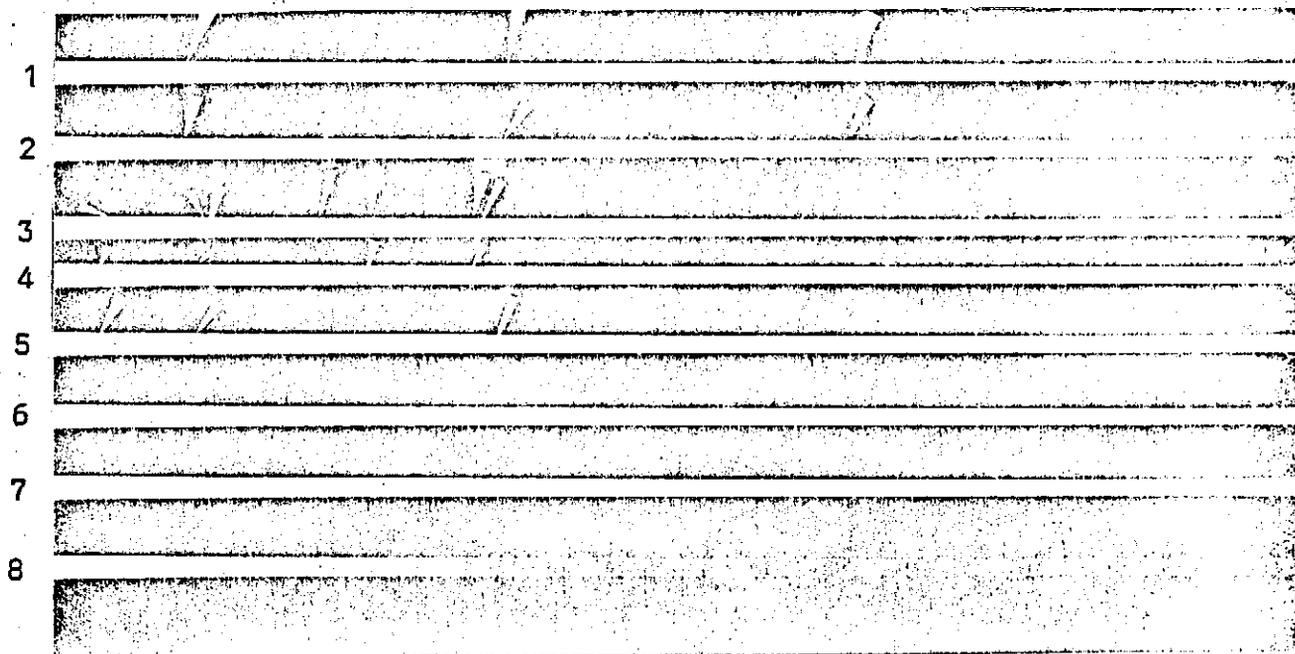
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Geologie : COMINCO EXPL.PTY.LTD.,

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Plate Abb. 7 Contact copy of a Selection of Representative  
Guinier shots



Typical x-ray reflexes of Zone 1 typical minerals pic 1. (sample 118) and pic 2 (sample 217) pic 3 (sample 198) x-ray reflexes of samples from contact Zone 1/Zone 2.

Pic 4 (sample 111) and 5 (sample 201)

show x-ray reflexes of typical mineral assemblages of Zone 2.

X-ray reflexes of mineral assemblages of Zone 3 are shown in pic 6 (sample 221) and pic 7 (sample 260).

Pic 8 is a reference with quartz reflexes.

Dashes ( / ) indicate chosen, characteristic reflexes of typical minerals

pic 1 & 2 gypsum + pyrite

pic 3 Mg-chlorite, natrolite, dolomite

pic 4 Mg-chlorite + ankerite

pic 5 Mg-chlorite + magnesite

### Results of Microscopic Investigations

The evaluation of 90 thin sections based on the zonation established by the results of x-ray diffraction (Plate Abb. 6) permits the following characterisation of the typical zonation features.

#### Dacitic Material in Zone 1

For the dacite lavas, porphyritic dacites, porphyritic dacite pyroclastics and shaly dacite tuffs of this zone an almost complete devitrification must be mentioned, indicated by the appearance of euhedral and anhedral secondary quartz in veinlets and fissures, also in former vugs or as filling in the areas of leached super crystals: Plate Abb. 8a quartz recrystallisation accompanied by precipitation of pyrite at the same time. In most cases pyrite is of euhedral shape and shows pressure shadows in contact zones (Plate Abb. 8b). The pressure shadows often are made up by light coloured mica, however the total mineralogy of the shadows is not likely to be resolved by means of optical methods. Former super crystals of feldspars, amphiboles and pyroxenes are often leached completely and even so often substituted by secondary quartz and pyrite. Flow orientated plagioclase (An 20-30) show various stages of sericitisation. Now and then completely sericitised feldspars with a pyrite skeleton may be seen. The sulphates alunite and jarosite are mainly microcrystalline and appear in the vicinity of former feldspar crystals. Whereas gypsum, besides appearing in analogous positions also may be found as filling of cracks and fissures (Plate Abb. 8c, 8d). Samples from the contact to Zone 2 show in the vicinity of former vugs K-feldspar recrystallisation. Besides the quartz content which is too high for dacitic material and thus indicates silicification, the appearance of sericitic, light coloured mica and pyrite

(up to 5 mm in diameter) as main minerals is typical. The devitrified fine grained quartz-feldspar groundmass (on the average about 30%) shows as accessories epidote, zircon, apatite now and then FeOOH-phases. With some samples the occurrence of Fe-rich opt(-) chlorites with anomalous blue interference colour should be mentioned.

#### Andesitic Material in Zone 1

Besides the characteristics mentioned for dacitic material a higher content of Fe-rich chlorite is noted in the andesitic pyroclasts. The appearance of hornblende veinlets is fairly widespread. As most of the samples were derived from the contact to Zone 2 a smaller amount of devitrification and a partial carbonatisation of the feldspars is observed. Nevertheless the formation of sulphates in the areas of former feldspars is still the dominant feature.

In the immediate ore deposit zone there are heavily silicified rocks with a high pyrite content and FeOOH-phases, weathering products of the pyrite. Other minerals are rarely seen in such samples. The groundmass shows, besides a large amount of glass, hornblende porphyroblasts, sericite, apatite and zircon.

#### Dacitic Material in Zone 2

Dacite lavas and dacitic tuffs appear in this zone along with dacitic pyroclastics. They show carbonates as filling of fissures and carbonatised feldspars. Apart from silicification caused by devitrification indicated by anhedral secondary quartz, heavy chloritisation is characteristic for this assemblage. The chlorite amounts to 50% for many of the samples

049

mainly the Mg-rich variety which is shown by anomalous brown birefringence colours and their positive optical character. In smaller amounts the optically negative and anomalous blue Fe-chlorites are still present. Depending on the "overprinting" of the rocks by chlorites the optical identification of other minerals often is not very likely. Super crystals of plagioclase in most cases are completely sericitised or chloritised and partly skelitised by pyrite (Plate Abb. 8e).

The pyrite is often strongly affected and shows changes towards FeOOH-phases, these often sketch out pumice textures in tuffs and pyroclastics. In samples from near the contact to Zone 1 zeolites sometimes appear in fissures or vugs. In most cases they are natrolites in fissures. Sometimes cubic and prismatic zeolites of the Phillipsite-Harmotom group appear in former vugs or areas of leached supercrystals. If zeolites appear in contact with plagioclase they often show albitisation besides carbonatisation. Secondary K-feldspar in part associated with the zeolites, appears as vug filling accompanied by secondary quartz (Plate Abb. 8f). K-feldspar of the first generation often is identified as sanidine showing the typical hourglass structure. Sometimes up to 5 mm in size, hematite and lepidocrocite crystals appear in the fine grained quartz-feldspar-matrix. Accessories in this groundmass are apatite, augite, glass, zircon and FeOOH-phases.

#### Andesitic Material in Zone 2

Compared to the neighbouring dacitic material the mostly pyroclastic samples show less devitrification.

Supercrystals of feldspars are often completely carbonatised, partly exhibiting albitisation (Plate Abb. 8g). In tuffaceous materials the feldspars are often linked together with veins of carbonates or quartz pyrite. Sericitisation and chloritisation have, compared to the dacitic materials, progressed further. Pyrite is in most cases anhedral and shows changes to FeOOH-phases. Zeolitisation is neither found in feldspar areas nor in areas of leached former crystals, but now and then they may be found as vug fillings with secondary quartz and euhedral apatite (Plates Abb. 8h, 8i). Possible identification of the former super crystals now leached is given by their shape. Often these areas remain holes or are only partly filled by secondary quartz. Residues of kaersutites are now and then preserved in carbonate rich surroundings. Augite residues are bedded in chlorite. Besides these amphibole, respectively pyroxene residues, the accessories are apatite, zircon, disseminated pyrite and FeOOH-phases.

#### Dacitic Materials in Zone 3

Dacite lavas, dacitic pyroclastics and tuff agglomerates appear here. Silicification going along with devitrification and chloritisation are the main features. Finely disseminated pyrite with strong weathering (alteration) changes are only minor constituents (Plate Abb. 8l). Sericitisation and only small amounts of carbonatisation of plagioclase are to be found, microcline accompanies this assemblage. In most parts the primary materials like pyroxenes, augites and kaersutites as members of the amphibole family remained unchanged, in parts chloritised in the rim zones. In these reaction rims hematite may be found (Plate Abb. 8k).

The secondary minerals like chlorite, hematite, quartz and sericite in these rims might be in part due to weathering. Glass, epidote, zircon and apatite are the main accessories.

#### Andesitic Material in Zone 3

Chloritisation is the main feature within the andesitic pyroclastics of this area, whilst silicification according to the small amount of devitrification is scarcely to be found. Sericitisation is a little more prevalent in the feldspar components, whereas carbonatisation was noticed only in a few samples taken in contact to Zone 2. Likewise to the dacite sample, the primary (original) mineralogy is scarcely affected and preserved with minimal changes. The amount of glass in most samples is higher than 50%.

#### Petrological Calculations

With the element concentrations found by RFA a norm calculation acc. to Nockolds (1954) was carried out for the different rock sequences.

Calculation of three phase co-ordinates in the system  $\text{Fe}_2\text{O}_3 - \text{MgO} - \text{K}_2\text{O}$  permitted the statistical check on element enrichments, referring to the norm distribution for andesites, dacites and rhyolites established by Nockolds. After this data treatment a comparison of the MgO and  $\text{K}_2\text{O}$  surplus in its regional distribution correlated very good with the distribution of the other alteration indicators. Plate Abb. 9 shows areas with MgO surplus, Plate Abb. 10 contains the regional distribution of  $\text{K}_2\text{O}$  surplus.

AKF and ACF diagrams were not calculated, due to the fact that the Fe contents of the individual samples was determined as  $Fe_2O_3$ .

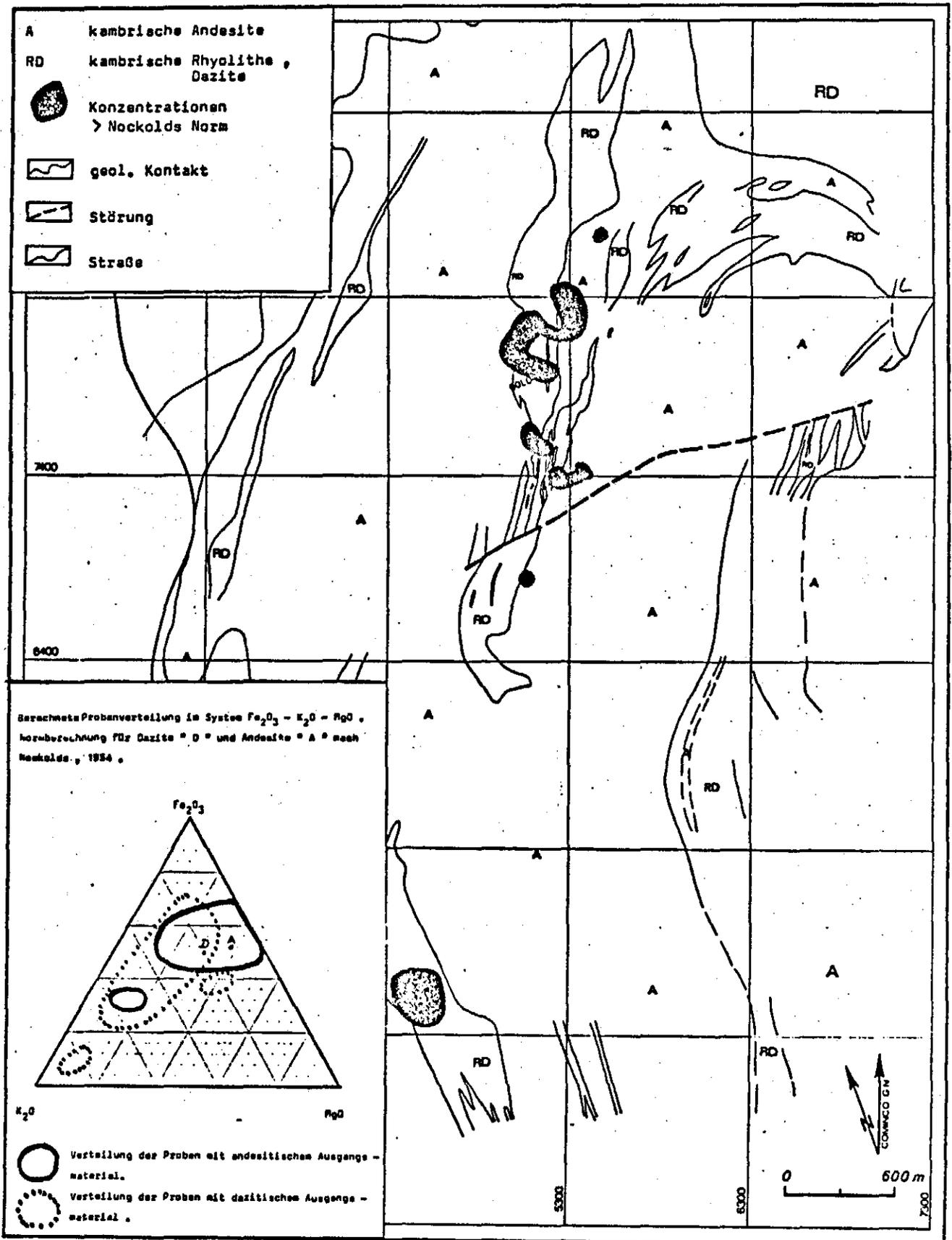
Calculations of Barth's Standard cell could only be used for the following qualitative interpretations depending on the inhomogeneity within the rock series.

By comparing the individual samples after normalisation with Nockolds norm data the original rock compositions, in most cases could be reconstructed. Thus for the samples with the field name "dacite" a strong tendency towards rhyodacite should be noted down. The norm data of the samples shown in comparison to the norm data for dacites after Nockolds (1954) lower Fe and Mg contents and higher K contents. This tendency is compatible to the norm data for rhyodacites according to Nockolds.

After calculating average composition of the investigated rock samples for the corresponding andesites, dacites and rhyodacites from the normed data, the following picture of hydrothermal changes in the different rock units was revealed:

In the ore zone an increase of silica, ferromagnesian and aluminum content was noted. K values show all over the exploration area, a tendency to be high, thus implying a K supply. Na and Ca show all over the exploration area a tendency of loss.

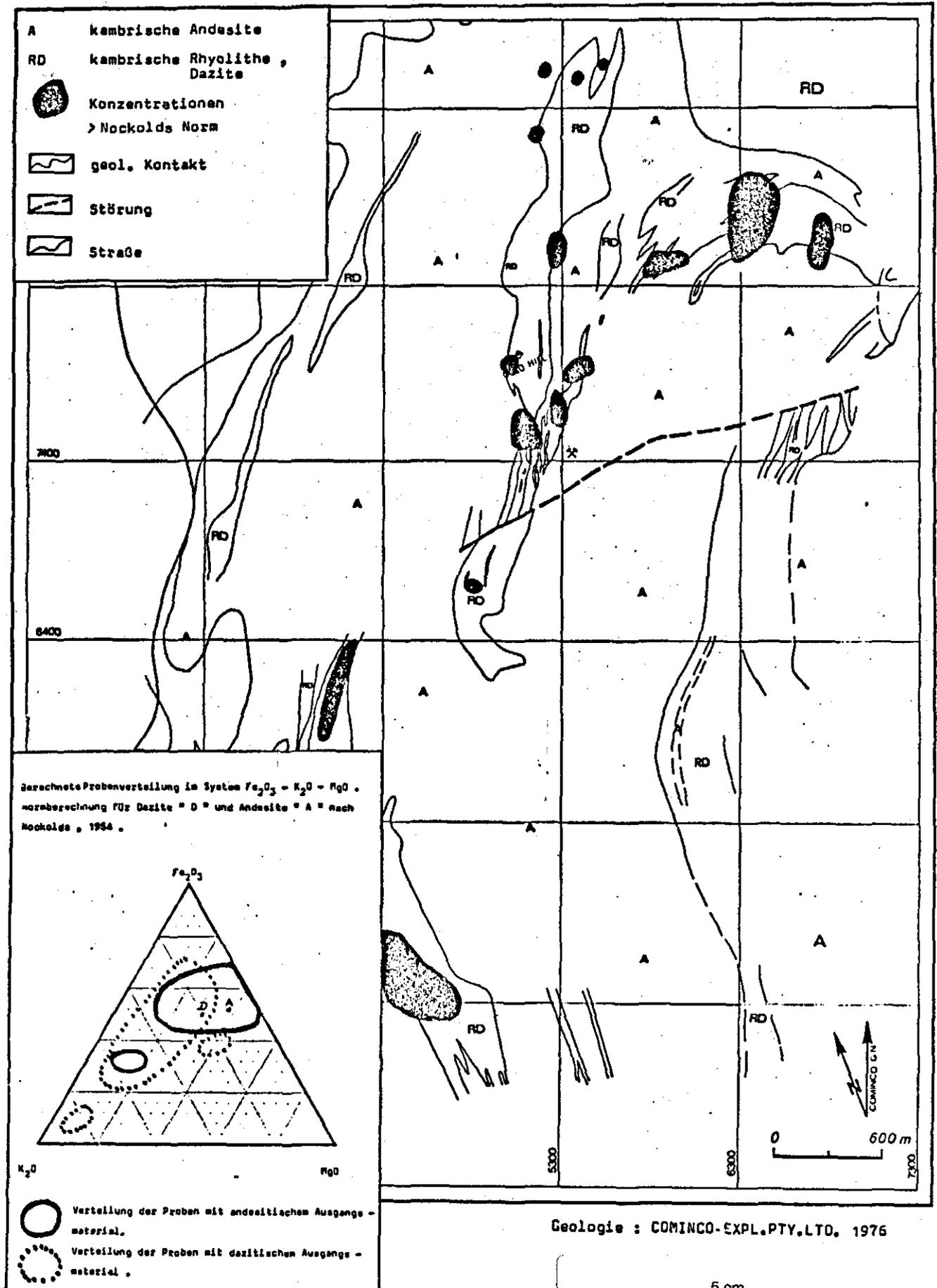
Plate Abb. 9 Regional Distribution of MgO surplus



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Plate Abb. 10 Regional Distribution of  $K_2O$  surplus



### Geochemical Results

Univariate statistical evaluation.

The elements important for finding an ore deposit and for limiting the prospective area, as well as the indicator elements for hydrothermal alteration are discussed in the following chapter and their distribution is shown on the corresponding maps, (refer app. 1 and 2).

For geochemical investigation a large number of samples are necessary to keep possible errors during statistical analysis fairly small. The univariate statistics used here are based for all elements on 174 samples.

Element concentration builds up various (at most two) populations: One population shows the distribution of the normal background values of one certain rock-type. The second population has often a casual and/or regional connection with the ore horizon. According to Lepeltier (1969) a histogram, where sample frequency is plotted against element concentration, shows mixed populations by gaps or more inflexion points within the distribution curves (app. 2). The so called threshold value for the single elements is shown by a gap in the frequency curve.

Variance is a measurement for the influence of one element on the development of a positive or negative anomaly.

The standard deviation used here shows the distribution of the single values around the average value of the distribution curve.

Pb Distribution

Statistical parameters in this case are:

Smallest value	:	1 ppm
Highest value	:	9487 ppm
Geom. mean	:	25.8 ppm
Standard dev.	:	969.103
Variance	:	939 E 3

The high variance is indicative of the big influence the element has on exploration. The statistical evaluation shows for the Pb - histogram (app 2) a threshold value of 150 ppm. The areas with anomalous Pb content are shown in Plate Abb. 11.

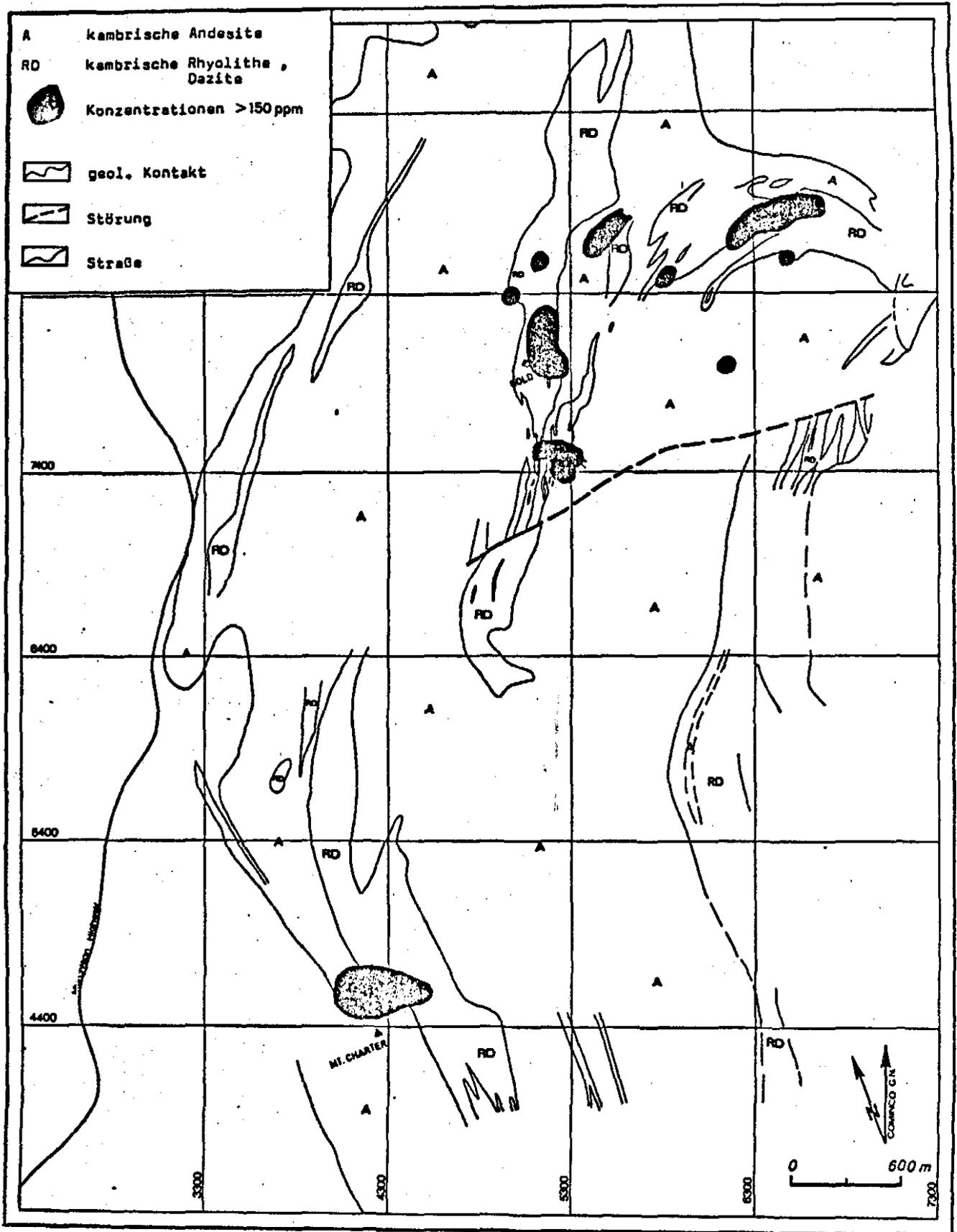
Zn Distribution

Statistical parameters from the analyses:

Smallest value	:	1 ppm
Highest value	:	12557 ppm
Geom. Mean	:	61.6 ppm
Standard Dev.	:	1372.447
Variance	:	1880 E 3

The exploration value of this element again is shown by the high variance. The Zn histogram (app 2) gives a threshold at 200 ppm. The regional distribution of the 40% of samples with higher a Zn value is shown in Plate Abb. 12.

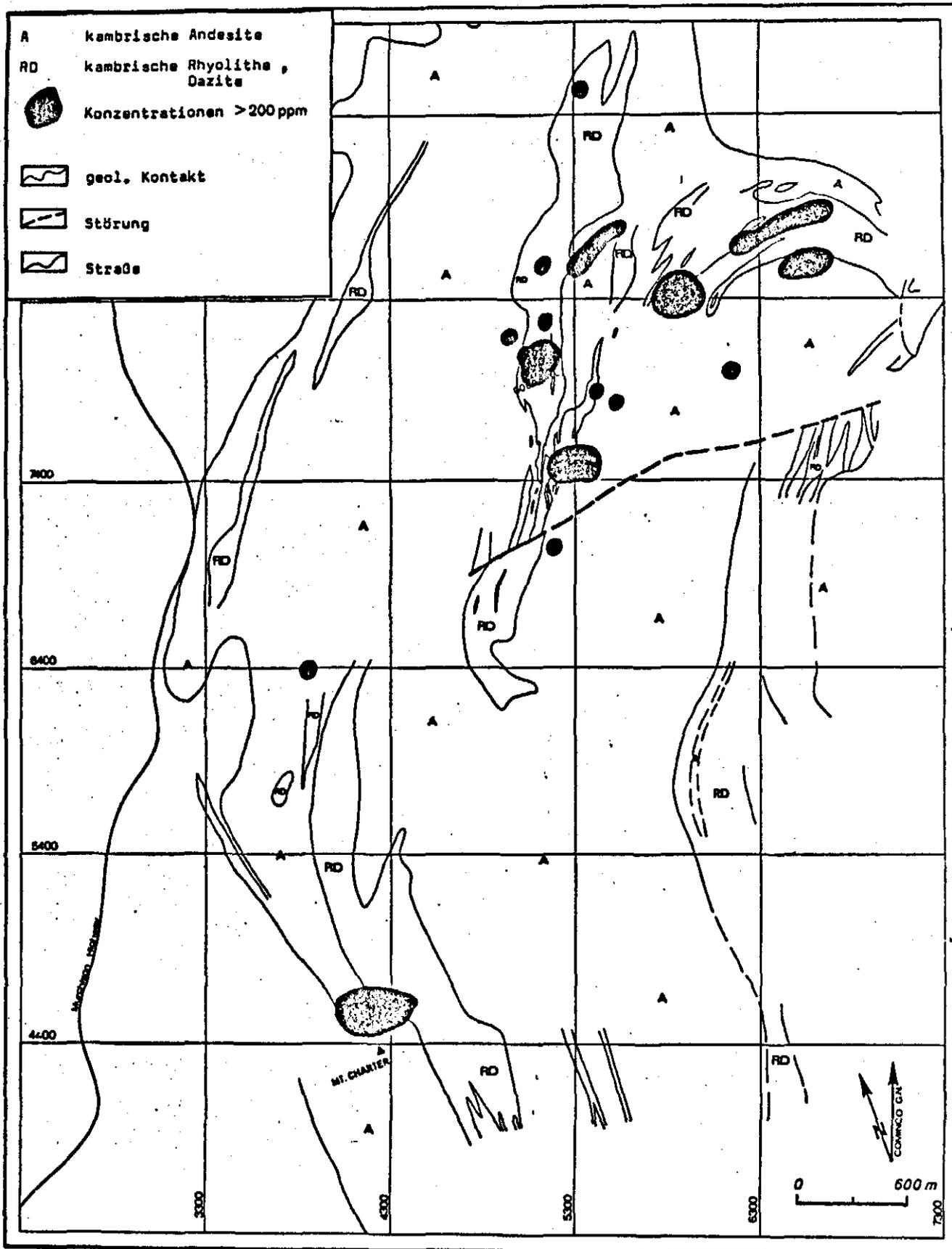
Plate Abb. 11 Geochemical Distribution of Pb Primary dispersion.



Geologie : COMINCO EXPL.PTY.LTO. , 1976

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Plate Abb. 12 Geochemical Distribution of Zn Primary Dispersion.



Geologie : COMINCO EXPL.PTY.LTD. , 1976

5 cm

After these two elements with a positive halo in and around the deposit area, elements with a negative halo, proving hydrothermal alteration, should be regarded. In case of hydrothermal alteration and during creation of alteration zones, high mobile elements show a negative halo in the area of the strongest hydrothermal changes. With regard to stratabound deposits, which are originated by hydrothermal solutions, the ore bearing area should be in close contact to the leached areas or be identical.

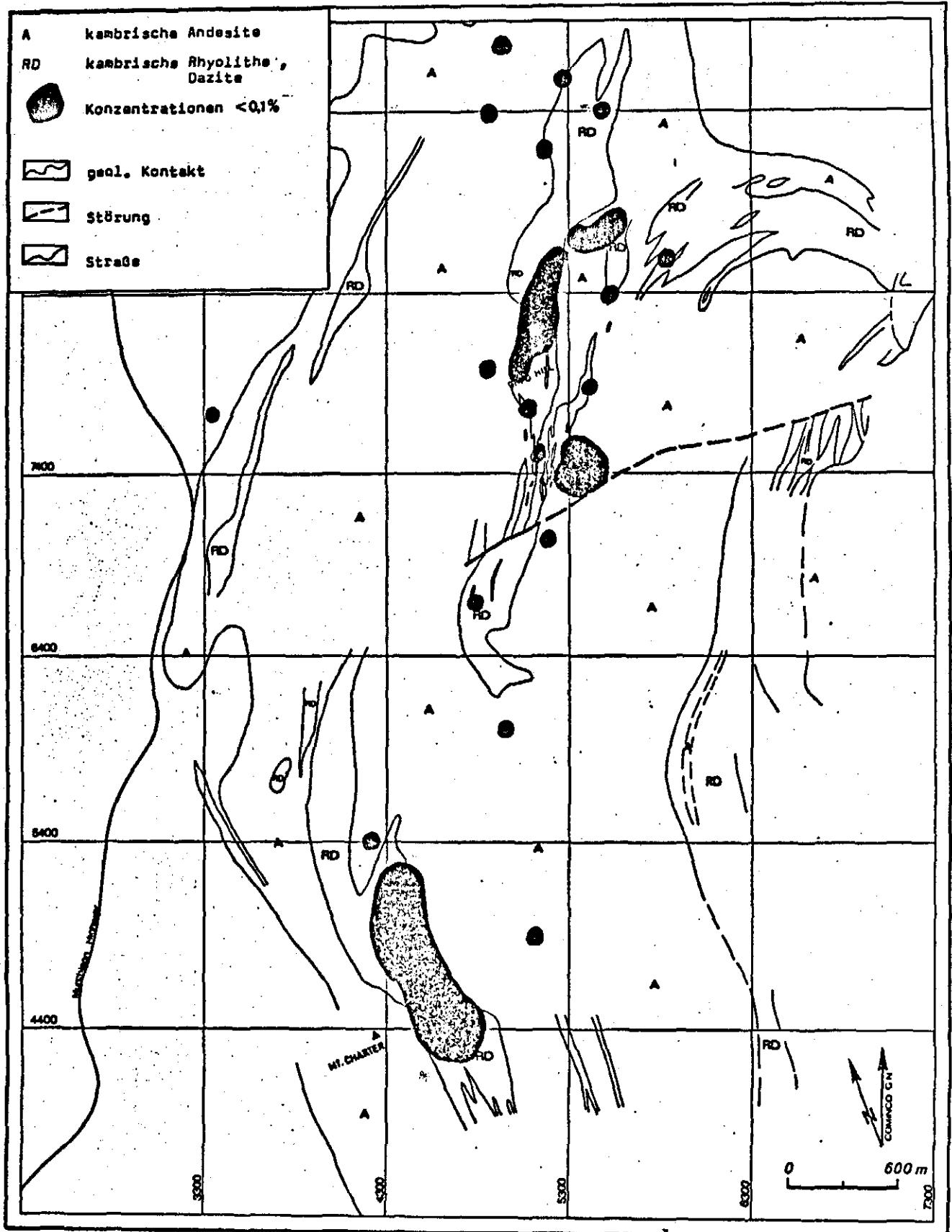
#### Na<sub>2</sub>O Distribution

Statistical parameters for the Na<sub>2</sub>O contents:

Smallest value	:	.01 %
Highest value	:	5.58 %
Geom. mean	:	.29 %
Standard dev.	:	1.343
Variance	:	1.8

The threshold for the negative halo is derived for Na<sub>2</sub>O from the histogram (app 2) as 0.1%. Plate Abb: 13 shows the regional distribution of the values below 0.1%, showing the alteration centres.

Plate Abb. 13 Geochemical distribution of Na<sub>2</sub>O primary distribution



Geologie : COMINCO EXPL.PTY.LTD. , 1976

5 cm

Sr Distribution

Smallest value	:	1 ppm
Highest value	:	797 ppm
Geom. mean	:	37 ppm
Standard dev.	:	184.085
Variance	:	339 E 2

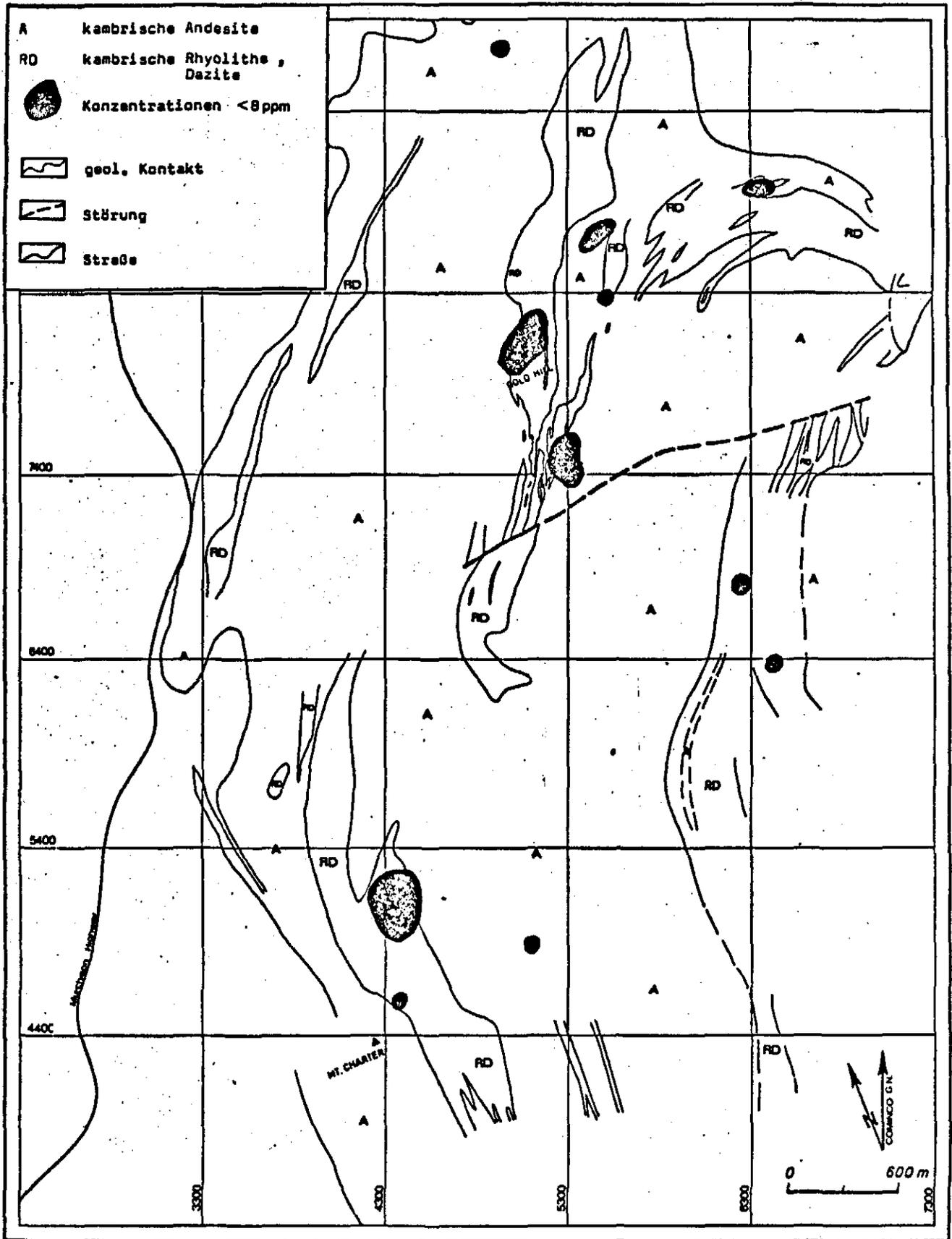
The threshold for the negative halo of Sr is shown in the corresponding histogram in (app 2) to be 8 ppm. The primary dispersion of the Sr values below this limit is presented in Plate Abb. 14.

Distribution of the Single Elements.

There is a distribution of Pb values >200 ppm in the area investigated in the area of Mount Charter, Gold Hill and in the area NE of the ore zone. As this criteria is also valid for the known deposit area the identification of primary dispersion within the above mentioned areas might be regarded as an indicator for a possible ore bearing horizon.

These anomalies, probably indicating another deposit, are in most cases accompanied by negative halves of the elements Sr <8 ppm and Na ( $\text{Na}_2\text{O}$  <0.1%).

Plate Abb.14 Geochemical Distribution of Sr primary Dispersion



Geologie : COMINCO EXPL.PTY.LTD. , 1976

5 cm

### Evaluation and Discussion

The general metallogenetic factors of a volcanogenic deposit mentioned in the introduction, (D. Sangster 1972) are also applicable to the Que River deposit, Tasmania, Australia. The association of the orebody with calc-alkaline, submarine volcanics mentioned for the Woodlawn deposit by I.B. Lambert (1978) is similar to regional geology of the Que River deposit. The deposit appears in the calc-alkaline to alkaline series of the Cambrian Mount Read volcanics, to which they are related in time and space.

A submarine origin is indicated by the appearance of pyritic rock sequences in the surroundings of the massive sulphide ore bodies and by the sulphide themselves. Proof for an origin in reducing environment is the appearance of siderite.

The sampling was carried out by members of the BGR and Aberfoyle staff, mainly in the areas of the most acid parts of the volcanic differentiation sequence. The outcropping rock units in the area of the known deposit of Que River are made up of dacitic to rhyolitic pyrite bearing pyroclastics or agglomerates. The same rock units also accompany the possible zones of mineralisation according to own investigations.

A regional cluster of possible mineralised areas in the dacitic rock sequences of the exploration area was revealed during the investigations carried out.

The characteristic of massive sulphide ores and so called stringer ores in the known deposit may be compared to the mineralisation complex at Woodlawn (I.B. Lambert, 1978).

In the Que River deposit a baryte ore zone, defined by T. Sato (1974) for the Kuroko deposits, is lacking. Comparable observations were made by I.B. Lambert (1978) in the Woodlawn deposit.

The known and possible mineralised zones of Que River are linked to the occurrence of alteration sulphate minerals. The origin of the sulphides alunite/jarosite and gypsum may be (according to W.E. Tröger, 1969) derived from the interaction of hydrothermal sulfateric alteration solutions with the surrounding rocks. Mainly the hydrothermal alteration of feldspars indicates the occurrence of the sulphate minerals. According to S.I. Naboko (1963) investigations on recent hydrothermal solutions of active volcanoes has shown the occurrence of alunite has to be regarded as indicative of the activities of acid sulphate-chloride or sulphate-bearing hydrothermal solutions. These solutions, which are generated by vadose waters and condensation of volcanic steam mostly show only a little metal-ion-concentration. The heating up of the solutions is based on their contact to volcanic heat as well as transport of this heat by volcanogenic gases. These volcanogenic gases, in most cases are  $\text{CO}_2$  and  $\text{H}_2\text{S}$  and during the generation of the hydrothermal solution are in solution. During the migration of the solution these gases partly move out of the fluid phase and migrate separately.

The loss of gases and the interaction of the solution with the surrounding rocks leads to a change of the pH-value. This change ranges from ultra-acid (partly negative pH-values, Naboko, 1963) at the origin of the solution to neutral or weakly basic pH-values when reaching the surface (pH 6 to pH 9, Naboko 1963).

The cooling of the solution during  $H_2O$  steam condensation leads to a dilution of the solution, which also effects the pH-value.

A further result of the higher  $H_2O$  content is the oxidation of volcanogenic  $H_2S$  to  $H_2SO_4$ . This formation of sulphuric acid, together with the strong temperature drop close to the surface, evokes the formation of the sulphate minerals alunite, jarosite and gypsum. Therefore the sulphates within the mineralised areas of the Que River prospect have a close connection with the main areas of hydrothermal alteration (Zone 1). The formation of (acc. to Troger 1969) alunite, jarosite and gypsum in situ due to weathering is not very probable for the Que River deposit, because the sulphates appear only in discrete, distinct and limited areas. Alunite and jarosite are mainly found in the area of altered feldspars. The lack resp. of complete sericitisation and/or chloritisation and/or carbonatisation of the feldspars indicates the influence of alteration.

According to S.I. Naboko (1963) it is possible that the same hydrothermal solution, producing sulphates close to the surface, is responsible for sulphate ore precipitation in the underlying areas.

By loss of  $CO_2$  in connection with alkaline enrichment - by interaction with the surrounding rocks - the hydrothermal solution may start the expansion of an alteration zone which is characterised by K-feldspar recrystallisation and zeolitisation. In the present paper microscopic investigation has revealed K-feldspar recrystallisation in some samples from the contact of Zone 1 to Zone 2. These are accompanied by zeolites, - mostly natrolite - which was proved by x-ray diffraction and microscopic investigation. The small number of samples with this mineral combination was sufficient to justify a definite zeolite-K-feldspar zone.

The assemblage chlorite + pyrite + sulphate + quartz ± carbonate, characterising Zone 1, as well as the assemblage chlorite + carbonate + pyrite + hydro-mica + quartz of Zone 2 are according to Naboko the result of a continuous pH-value change.

The development of a clay rich zone around the Woodlawn deposit, stated by I.B. Lambert (1978) and comparable to the Kuroko alteration, is also proved in case of the Que River deposit by the appearance of illite and chlorite in zones 1 and 2. In Zone 2 besides the above mentioned sheet silicates the presence of montmorillonite and talc is noted.

The enrichment in Si, Fe, Mg and K in the wallrocks derived from calculations of Barth's Standard Cell for Que River samples matches with the geochemical results of Lambert for the Woodlawn and Kuroko deposits. This statement is also valid for the depletion of the wallrock in Ca and Na.

The zonation of the alteration, caused by chemical variations in the alteration (fluid) solution, is proved by the actual results of the x-ray and microscope investigations.

The appearance of the mineralogically defined Zone 1 in the areas of Mount Charter, Gold Hill, NE Que River and in the area of the known ore deposit, matches with the regional distribution of the elements Pb, Zn, Na. The regional distribution of Sr also shows limits of alteration Zone 1.

The occurrence of Pb and Zn anomalies in the areas of the mineralogically defined Zone 2 (8200N - 9000N, 5600E - 6800E, Plate Abb. 6) may be evaluated as indication of a deeper seated sulphide mineralisation, which caused by the alteration zonation still shows a carbonate overlay (overburden). The pyritic dacitic pyroclastics in these areas also point out the possibility of a mineralised zone in the underlying rock (D. Sangster 1972).

The distribution of the negative halo of Na- a guide to the strong interaction of hydrothermal solutions - supports the mineralogical definition of Zone 1. There seems to be a hint of a strict limitation of this zone to the migration areas of the hydrothermal solutions. The different distribution of the Na negative halo, compared with Zone 1, especially in the area N and E of Mount Charter might be explained by removal of this mobile element by weathering.

The negative halos of the element Sr are regionally identical with those areas, in which mineralogical investigations have revealed the lack of complete sericitisation and/or carbonatisation of the feldspar constituents of the rock. The Sr distribution especially in the mineralogically defined Zone 2 is an important indicator of hydrothermal alteration.

The regional distribution of MgO and  $K_2O$  surplus - derived from norm calculation according to Nockolds (1954) appear as well in the mineralogically defined zones 1 and 2. They do not coincide with a special mineral assemblage. Their mineralogical expression is the higher amount of x-ray proved Mg-chlorite or magnesite and microscopically found K-feldspar regrowth.

A third alteration zone, surrounding Zones 1 and 2 shows only chloritisation of the rocks involved. This zone mainly deals with andesitic rocks without prospective value.

The typical criteria for the hydrothermal alteration within the exploration area of Que River, Tasmania, Australia which could find application as possible exploration parameters on other paleozoic stratabound ore deposits in acid volcanics may be derived from the following list:

1. Mineralogical investigations show a three fold alteration zonation.
2. Zone 1 (ore body area) is indicated by sulphate minerals and massive appearance of pyrite.
3. The following Zone 2 is characterised by strong carbonatisation and chloritisation. Widely spread is disseminated pyrite.
4. In the outer Zone 3 mainly chloritisation as proof of hydrothermal alteration is to be found.
5. Zones 1 and 2 are part of a clay-rich alteration area, which might surround possibly mineralised areas.
6. The mineralogically deferred Zone 1 is most likely congruent with the regional distribution of Pb and Zn anomalies.
7. Besides that Zone 1 is also generally matched by a negative Na-halo.

8. The enrichment of the elements Si, Fe, Mg and K and the depletion of Ca and Na is typical for the altered wallrocks of the ore (mineralisation) zones.

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APPENDIX 1Elementkonzentrationen

Probennr.	Pb (ppm)	Zn (ppm)	Sr (ppm)	Na <sub>2</sub> O (Gew.%)
101	83	5	9	0.17
102	19	1	32	0.57
103	17	105	77	2.78
104	13	138	8	0.10
105	145	1	17	0.13
106	853	4827	12	0.16
107	127	45	1	0.07
108	628	57	9	0.16
109	23	23	129	1.43
110	25	51	201	0.87
111	58	411	250	1.12
112	4	140	51	1.11
113	71	60	10	0.16
114	190	1	15	0.28
115	22	128	40	0.22
117	27	549	32	1.09
118	1278	3730	1	0.34
119	3732	3063	160	2.14
120	419	686	1	0.01
121	40	59	1	0.06
122	23	626	504	1.74
123	25	74	268	2.11
124	28	407	643	4.17
125	33	587	574	2.60
126	21	4	5	0.22
127	53	1	16	0.06
128	19	32	5	0.03
129	20	80	311	1.05
130	16	108	410	2.68
131	1	131	115	2.11
132	19	63	93	0.33
133	83	20	26	0.11
134	1	34	71	0.57
135	96	175	145	3.58
136	12	35	112	4.89
137	5	16	115	1.86
138	19	1	28	0.14
139	23	66	655	2.72
140	63	67	41	0.01
141	1158	351	188	0.59

APPENDIX 1 fortges.

Probennr.	Pb (ppm)	Zn (ppm)	Sr (ppm)	Na <sub>2</sub> O (Gew.%)
142	19	65	19	0.01
143	34	315	6	0.01
144	19	114	3	0.01
145	36	85	110	1.89
146	427	809	52	1.30
147	4	41	249	2.91
148	26	3	17	0.59
149	37	77	557	4.57
150	1	4	10	0.15
151	3	17	28	0.41
152	15	110	110	2.98
153	3	31	89	1.82
154	69	170	57	1.49
155	5101	8651	351	3.89
156	68	310	12	0.73
157	1	7	4	0.17
158	7	54	322	2.54
159	16	85	460	2.88
160	301	663	433	1.92
161	41	486	797	5.55
162	16	232	62	1.60
163	18	127	2	0.05
164	9	168	448	2.46
165	24	61	139	1.70
166	30	82	351	2.62
167	1	10	9	0.36
168	16	470	9	0.60
169	64	106	324	2.15
170	1	51	92	4.23
171	4	52	709	3.01
172	15	93	66	1.70
173	1	1	2	0.17
174	4	15	4	0.31
175	3	129	10	0.48
176	20	50	56	0.62
177	1	7	48	3.09
178	440	573	130	2.09
179	7	24	91	1.97
180	2	1	47	0.53
181	10	185	714	5.58

## APPENDIX I fortges.

Probennr.	Pb (ppm)	Zn (ppm)	Sr (ppm)	Na <sub>2</sub> O (Gew.%)
182	4	126	32	2.21
183	1	6	16	0.21
184	56	180	607	2.21
185	1	94	274	4.05
186	1	36	54	4.06
187	14	78	17	0.04
188	4	38	10	0.07
189	8	9	1	0.01
190	21	2	6	0.01
191	260	5	1	0.01
192	187	89	24	0.01
193	17	76	65	1.08
194	157	122	57	1.61
195	53	155	26	0.01
196	3	160	17	0.10
197	73	4	37	0.18
198	244	73	37	0.98
199	119	48	13	0.04
200	1470	464	1	0.01
201	694	567	1	0.01
202	857	250	1	0.01
203	44	370	67	0.46
204	408	110	1	0.01
205	91	152	13	0.01
206	1	23	78	2.47
207	35	92	179	0.80
208	113	787	412	0.08
209	13	60	261	3.85
210	1	24	72	2.59
211	127	21	6	0.01
212	1	71	51	0.32
213	120	7	9	0.01
215	1	124	514	3.44
216	676	253	1	0.01
217	57	12	35	0.03
218	216	206	441	1.35
219	77	70	10	0.01
220	1	87	353	3.32
221	16	10	152	2.69
222	1	20	12	0.01

## APPENDIX 1 fortges.

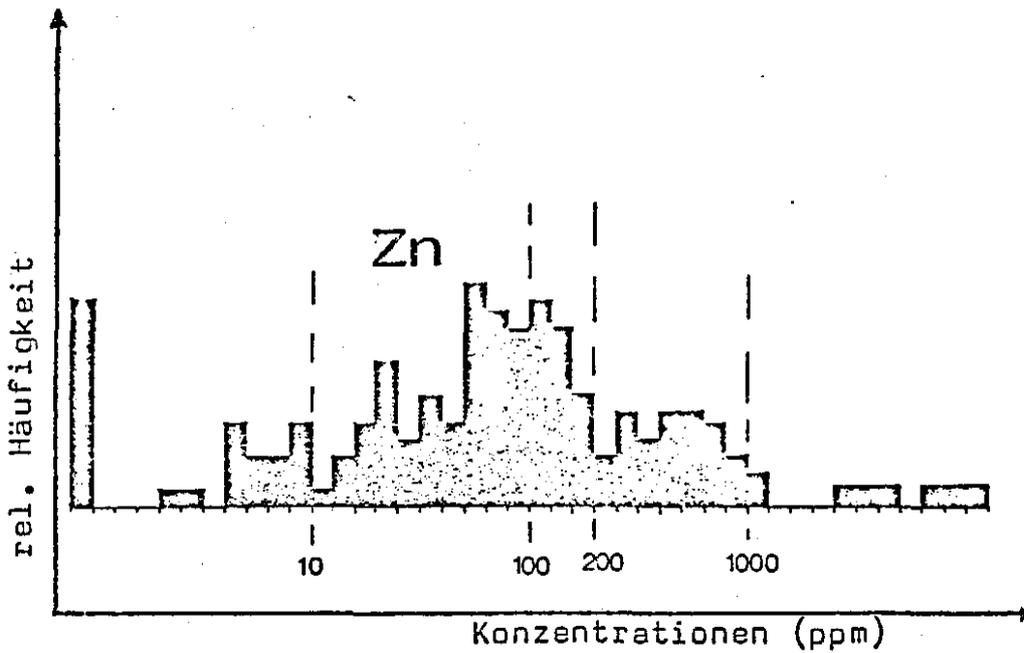
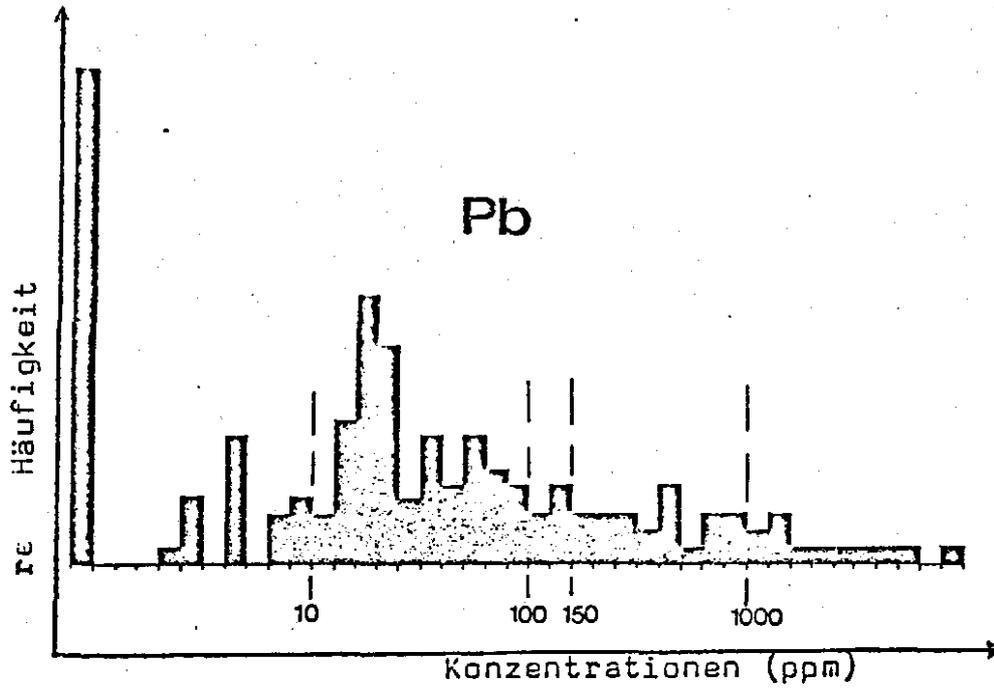
Probennr.	Pb (ppm)	Zn (ppm)	Sr (ppm)	Na <sub>2</sub> O (Gew.%)
223	1	70	91	1.42
224	18	813	68	1.24
225	63	13	11	0.01
226	10	296	92	1.72
227	959	362	171	2.79
228	2415	80	1	0.01
229	1481	101	1	0.01
230	24	511	276	1.84
231	1	129	10	0.01
232	226	406	1	0.01
233	1	54	1	0.38
234	5	16	7	0.05
235	1	118	85	1.75
236	17	51	1	0.01
237	24	20	23	0.06
238	14	56	30	0.09
239	1	31	76	1.77
240	12	21	23	0.74
241	98	167	122	0.57
242	420	734	110	1.63
243	1	1	22	0.69
244	1677	1125	170	1.12
245	334	683	148	3.25
246	316	821	157	0.22
247	1249	75	91	1.10
248	4053	7751	203	1.38
249	197	18	23	0.06
250	9487	12557	224	1.36
251	366	36	6	0.01
252	684	276	696	2.22
253	14	8	19	0.01
254	1	31	67	0.34
255	1	8	11	0.01
256	37	87	30	0.01
257	1	114	312	2.32
258	39	137	574	3.52
259	1	149	1	0.01
260	1	36	72	0.85
261	1	1	17	0.04
262	7	6	21	0.01

APPENDIX 1 fortges.

Probennr.	Pb (ppm)	Zn (ppm)	Sr (ppm)	Na <sub>2</sub> O (Gew.%)
263	12	281	30	0.15
264	129	26	22	0.01
265	15	51	151	3.35
266	2600	1123	572	3.29
267	1	16	119	1.10
268	37	50	418	1.43
269	1	1	2	0.01
270	20	107	2	0.01
271	14	1	4	0.01
272	18	1	31	0.01
273	47	6	25	0.01
274	1	15	8	0.01
275	43	1	47	0.03
276	63	375	613	3.85

APPENDIX 2

Histogramme



APPENDIX 2 fortges.

