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MINERALOGY AND GEOCHEMISTRY OF MINERALIZED AND BARREN FELSIC VOLCANIC PROFILES, PARKINSON PIT, MT MAGNET, WESTERN AUSTRALIA

K.M. Scott

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September 1998

(CSIRO Division of Exploration Geoscience Report 73R, 1989.
Second impression 1998)

CRC LEME is an unincorporated joint venture between The Australian National University, University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining, established and supported under the Australian Government's Cooperative Research Centres Program.

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Headquarters: CRC LEME c/o CSIRO Exploration and Mining, Private Bag, PO Wembley, Western Australia, 6014

RESEARCH ARISING FROM CSIRO/AMIRA REGOLITH GEOCHEMISTRY PROJECTS 1987-1993

In 1987, CSIRO commenced a series of multi-client research projects in regolith geology and geochemistry which were sponsored by companies in the Australian mining industry, through the Australian Mineral Industries Research Association Limited (AMIRA). The initial research program, "Exploration for concealed gold deposits, Yilgarn Block, Western Australia" (1987-1993) had the aim of developing improved geological, geochemical and geophysical methods for mineral exploration that would facilitate the location of blind, buried or deeply weathered gold deposits. The program included the following projects:

P240: Laterite geochemistry for detecting concealed mineral deposits (1987-1991). Leader: Dr R.E. Smith.
Its scope was development of methods for sampling and interpretation of multi-element laterite geochemistry data and application of multi-element techniques to gold and polymetallic mineral exploration in weathered terrain. The project emphasised viewing laterite geochemical dispersion patterns in their regolith-landform context at local and district scales. It was supported by 30 companies.

P241: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1987-1991). Leader: Dr C.R.M. Butt.
The project investigated the distribution of ore and indicator elements in the regolith. It included studies of the mineralogical and geochemical characteristics of weathered ore deposits and wall rocks, and the chemical controls on element dispersion and concentration during regolith evolution. This was to increase the effectiveness of geochemical exploration in weathered terrain through improved understanding of weathering processes. It was supported by 26 companies.

These projects represented "an opportunity for the mineral industry to participate in a multi-disciplinary program of geoscience research aimed at developing new geological, geochemical and geophysical methods for exploration in deeply weathered Archaean terrains". This initiative recognised the unique opportunities, created by exploration and open-cut mining, to conduct detailed studies of the weathered zone, with particular emphasis on the near-surface expression of gold mineralisation. The skills of existing and specially recruited research staff from the Floreat Park and North Ryde laboratories (of the then Divisions of Minerals and Geochemistry, and Mineral Physics and Mineralogy, subsequently Exploration Geoscience and later Exploration and Mining) were integrated to form a task force with expertise in geology, mineralogy, geochemistry and geophysics. Several staff participated in more than one project. Following completion of the original projects, two continuation projects were developed.

P240A: Geochemical exploration in complex lateritic environments of the Yilgarn Craton, Western Australia (1991-1993). Leaders: Drs R.E. Smith and R.R. Anand.
The approach of viewing geochemical dispersion within a well-controlled and well-understood regolith-landform and bedrock framework at detailed and district scales continued. In this extension, focus was particularly on areas of transported cover and on more complex lateritic environments typified by the Kalgoorlie regional study. This was supported by 17 companies.

P241A: Gold and associated elements in the regolith - dispersion processes and implications for exploration. Leader: Dr. C.R.M. Butt.
The significance of gold mobilisation under present-day conditions, particularly the important relationship with pedogenic carbonate, was investigated further. In addition, attention was focussed on the recognition of primary lithologies from their weathered equivalents. This project was supported by 14 companies.

Although the confidentiality periods of the research reports have expired, the last in December 1994, they have not been made public until now. Publishing the reports through the CRC LEME Report Series is seen as an appropriate means of doing this. By making available the results of the research and the authors' interpretations, it is hoped that the reports will provide source data for future research and be useful for teaching. CRC LEME acknowledges the Australian Mineral Industries Research Association and CSIRO Division of Exploration and Mining for authorisation to publish these reports. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian Mineral Industry.

This report (CRC LEME Open File Report 17) is a Second impression (second printing) of CSIRO, Division of Exploration Geoscience Restricted Report 073R, first issued in 1989, which formed part of the CSIRO/AMIRA Project P241.

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PREFACE

The CSIRO-AMIRA project "Exploration for Concealed Gold Deposits, Yilgarn Block, Western Australia" has as its overall aim the development of improved geological, geochemical and geophysical methods for mineral exploration that will facilitate the location of blind, concealed or deeply weathered gold deposits.

This Report presents results of research conducted as part of Module 2 of this project (AMIRA Project 241). "Gold and Associated Elements in the Regolith - Dispersion Processes and Implications for Exploration".

The objectives of this module are:

i. To obtain a better understanding of the nature and genesis of lateritic and supergene gold deposits.

ii. To determine characteristics useful for exploration, espectially in areas of transported overburden for: a) further lateritic and supergene deposits, and b) primary mineralization - including that with no expression as appreciable secondary mineralization.

iii. To increase knowledge of the properties and genesis of the regolith.

iv. To provide data applicable for exploration for other commodities in and beneath the regolith.

In particular this report (a) documents geochemical and mineralogical features of profiles through barren and mineralized felsic volcanic rocks, (b) evaluates the usefulness of gold pathfinders found in a previous study, (c) suggests geochemical discriminants for distinguishing mafic from felsic rocks.

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SUMMARY

Study of profiles through felsic rocks below thin a soil in the southern portion of the Parkinson Pit at Mt Magnet shows zonation: goethite → muscovite/kaolinite → muscovite/kaolinite/goethite → albite/goethite → fresh rock. Calcrete may also be developed at the soil/rock interface. Bands of mafic rock within these profiles are similar mineralogically to adjacent felsic rocks but they do have greater Ti, Co, Cr, Ni, Sc and V contents than the felsic rocks.

The elements, Co, Cu, Ni, Sc, W and Zn which were found to be strongly associated with ferruginous rocks in mafic profiles are similarly associated in the felsic profiles. Of the pathfinders, Ag, As, Mo and Sb, associated with Au in mafic profiles, only As has been found useful in felsic rocks. However, in these rocks W and B also appear to be associated with Au.

1. INTRODUCTION

A previous study of the rocks within the Parkinson Pit at Mt Magnet (500 km NNE of Perth) concentrated on the weathered and altered basalts present within the northern and central parts of the pit (Scott, 1989a). Although the mineralogy of a more southern profile was considered in that report, this report presents both mineralogical and geochemical results from two additional profiles through felsic rocks from the southern highly mineralized portion of the pit.

2. SAMPLES AND ANALYTICAL METHODS

Fifty-two samples of weathered to fresh altered rock were selected from diamond drill holes NMS D7 (29 samples) and NMS D8 (23 samples), located about 60 m apart (Fig 1). The hole NMS D7 was drilled for 120 m with a declination of 60° to the west but NMS D8 was vertical for 71.5 m. Samples were selected to include representatives of each major visually distinctive zone within the profiles. Thus sampling frequency was irregular but averaged 3 to 4 m.

A representative portion of each sample was crushed to -75 μm in Mn-steel jaw crushers and a ring mill. The resultant powders were then analysed mineralogically by X-ray diffractometry as described by Scott (1989a). Using these results, 17 samples from NMS D7 and 13 from NMS D8 were selected for chemical analysis.

Major elements (except Na) were analysed by X-ray fluorescence spectrometry (XRF) using fused discs, with the minor elements, As, Ba, Pb and Zr also being analysed by this method using pressed powders. Sodium and the trace elements, Co, Cr, Cu, Ni, Sc, Sr, V, Y and Zn were determined by inductively coupled plasma emission spectrometry (ICP). The elements Ag, B, Bi, Ga, Ge, Mo, Sb, Sn, Tl and W were estimated semiquantitatively by optical emission spectroscopy. Gold values (determined by Metana Minerals N.L.) for the 1 m composite about the samples used in this study have been used to provide a better estimate of gold grades than the spot samples would have provided.

3. RESULTS

3.1 Mineralogy NMS D7 and NMS D8

As quartz and rutile have relatively constant abundances through the profiles, they are not discussed further in this section. The term "muscovite" is used to include both muscovite (*sensu stricto*) and illite throughout this report.

Six mineralogically distinct zones were recognized in NMS D7 (Fig 2):

(i) The uppermost goethite/kaolinite zone (0.4 to 3.3 m) consists of yellow brown weathered felsic volcanics with the uppermost sample actually an indurated soil containing grey lithic fragments. The samples are characterized by low mica contents, abundant goethite and kaolinite. The soil sample has plagioclase (albite) due to its relatively fresh lithic fragment content. Minor talc is also present in the soil.

(ii) The muscovite/kaolinite zone (5.5 to 24 m) is composed of white friable rock. Besides muscovite and kaolinite, smectitic clay is present but Fe oxides are generally only present in trace amounts.

(iii) Goethite is however quite abundant in the underlying muscovite/kaolinite/goethite zone (27.7 to 58.5 m). Rocks of this zone are white to purple and brown in colour and although friable often have brown Fe-rich bands through them. Goethite increases in abundance toward the base of this zone. Apart from the dominating minerals which define this zone, smectitic clay, chlorite/vermiculite ± hematite also occur.

(iv) Partially weathered material of the albite/goethite zone (62.5 to 75.5 m) is buff to pink-grey in colour. It is often schistose with brown Fe oxides along fractures. Black Mn oxides may also be present. Kaolinite occurs in the uppermost samples of this zone but smectitic clay and disseminated dolomite in the lower part. Chlorite is developed throughout this zone.

(v) Fresh grey felsic volcanics characterized by assembluges of albite, dolomite and pyrite occur between 79.9 and 93.1 m. Veins of quartz are present but both pyrite and dolomite are disseminated. Chlorite and muscovite are also present in this zone but Fe oxides are absent.

(vi) Green-grey mafic volcanics with disseminated pyrite and white dolomite bands occur at the base of the hole (103.8 - 115.3 m). These rocks are characterized by more chlorite and less muscovite than the overlying felsic volcanics but the mineral phases present are similar to those in the zone above (Fig 2).

Six mineralogical zones were also recognized in NMS D8 (Fig 3):

(i) The soil zone (0.2 m) contains lithic fragments and black ferruginous pisoliths. Mineralogically it is dominated by goethite and kaolinite (as in NMS D7) but it also contains muscovite, tourmaline, talc and smectitic clay.

(ii) Calcite as calcrete occurs between 0.6 and 1.3 m. It cements soil and lithic fragments near the surface and white kaolinitic saprolite at 1.3 m. Goethite and chlorite occur in the soil sample with muscovite, kaolinite and smectites in both samples.

(iii) The muscovite/kaolinite zone (3.2 to 24.5 m) consists of white friable saprolite with patches of fuchsite and minor goethitic staining. Minor smectite and vermiculite are also present.

(iv) The white rocks of the underlying muscovite/kaolinite/Fe oxide zone (26.5 to 44.9 m) are more competent than those of the zone above and red to brown ferruginous staining is more abundant. Apart from the more abundant goethite and hematite in this zone, it is mineralogically similar to the zone above.

(v) Partially weathered albite/goethitic zone (49.6 to 56.6 m) rocks are buff coloured with red to yellow ferruginous areas. Black Mn oxides are also present as veins. Kaolinite and smectitic clay are not as abundant as in the zones above and chlorite/vermiculite and plagioclase are present.

(vi) Fresh grey felsic volcanics with disseminated pyrite and dolomite occurs from 58.9 to 69.0 m (albite/dolomite/pyrite zone). Chlorite is consistently developed in this zone (Fig 3) and is actually more abundant than muscovite.

3.2 Geochemistry NMS D7 and NMS D8

Detailed chemical analyses are presented in Tables 1 and 2 with averages from the zones delineated above in Tables 3 and 4 respectively.

3.2.1 NMS D7 The rock and soil of the uppermost goethite/kaolinite zone are characterized by high Al, Cr, Ni, Pb, Sb, Sn, V, W and Zr contents and low Si, K and Ba contents. Rocks of the muscovite/kaolinite zone have high Si and K contents and low chalcophile element contents, especially Fe, Co, Ni and Pb. The underlying muscovite/kaolinite/goethite zone again has high K but it also has high Fe, As, Au, B, Cu and Zn. In fact the Au contents of these rocks represent rich ore. Albite/goethite zone rocks have high Na, Mn, As, Au and Zn. Fresh felsic volcanics (albite/dolomite/pyrite zone) have high Mg, Ca, Na, S, Ag, Au and Sr and low Ti, Co, Cr, Sc, V, Y and Zr contents. Fresh mafic volcanics from the base of the hole have higher Fe, Mg, Ca and lower Si than the felsic rocks. Their S and sometimes their Au contents are also significant (Tables 1 and 3).

3.2.2 NMS D8 Goethitic soil from the top of this hole has high Fe, Ti, Cr, Cu, Ga, Ge, Ni, Sc, V, W, Y and Zr contents and low K, Ag, Ba and Sr contents. The calcrete has high Mg, Ca, Ba and low Fe, As, Co, Cu, Sc and W. Underlying muscovite/kaolinite-rich assemblages are rich in Si but depleted in Fe, As, Co, Cu and W like the calcrete above. The muscovite/kaolinite/Fe oxide zone has more Fe and Mn than the zone above and more associated trace elements especially As, Cu, Mo, Ni, Pb and Sb. Boron is particularly high in this zone and the partially weathered zone below. Albite/goethite zone (partially weathered) rocks have high Fe, Mn, Au, Co, Mo, Ni, Pb and Zn contents but low Cr, Sb and Sc contents. Fresh dolomitic and pyritic felsic volcanics from the base of the hole have high Mg, Ca, Na, S and Sr contents but low B, Cr, Sb, Sc, V and W relative to rocks higher in the profile.

Gold contents >0.5g/t occur in all the zones except the calcrete and muscovite/kaolinite zones with the partially weathered rocks of the albite/goethite zone having the highest values (Table 4).

4. DISCUSSION

4.1 Rock identification and its implications

Geochemical study of the fresh rocks from the base of NMS D7 indicates that basic rocks have higher Fe, Mg, Ca, Ti, Mn, Co, Cr, Ni, Sc and V but lower Si, K, Ba and Zr contents than the more felsic rocks (Table 3). When the compositions of the weathered rocks in the two holes are examined, samples 108334, 108337, 108339 and 108341 from NMS D7 and 108356 in NMS D8 all have $TiO_2 > 0.6\%$, $Cr > 200$ ppm, $Co > 30$ ppm, $Sc > 30$ ppm, $V > 170$ ppm and generally $Ni > 100$ ppm, i.e. higher abundances of these elements than other weathered rocks suggesting that these rocks may be mafic rather than felsic. Furthermore Ti/Zr ratios for these rocks are greater than 40 (usually > 60) suggesting that they are basaltic, using the criteria of Hallberg (1984).

The occurrence of such mafic rocks in the predominantly felsic sequence in the southern portion of the Parkinson Pit does not affect the mineralogical variations recognized but does mean that variations in the abundances of the elements Ti, Cr, Sc, V, Co and Ni may be due to lithological differences. Thus these elements cannot be used to derive information about Au occurrences.

Some of these mafic-associated elements are high in the soils, possibly reflecting a mafic-derived component in the soils (see below).

4.2 Soil/calcrete overburden

The uppermost samples from both holes are soils and are characterized by abundant goethite and kaolinite (Figs 2 and 3). The elements Fe, Au, Cr, Cu, Ga, (Ge), Ni, Pb, Sb, Sc (Sn), V, W and Zr are high in these soils with the mafic-associated elements Cr, Ni and V, attaining their maximum abundance there. Barium and Sr contents are low, reflecting low mica content relative to the underlying rocks.

The abundance of the mafic-associated elements, the presence of talc (Section 3.1), the poor development of mica and the presence of albite in the soil from NMS D7 (Fig 2) suggest an introduced component within the soils. Although the high abundance of mafic-associated elements could reflect a contribution from mafic rocks, the low Ti/Zr contents of the soils (Tables 1 and 2) suggest that the contribution from felsic rocks is dominant.

Surficial enrichment of Au is often found in ferruginous lateritic caps in the Yilgarn Block (Butt, 1988) and its presence in soil at Mt Magnet may reflect incorporation of such material into the soil. The presence of elevated amounts of As, Cu, Mo, Pb, Sb, Sn and W in these samples is also consistent with this interpretation (cf. Lawrance, 1988).

The calcrete horizon in NMS D8 is only weakly developed so that although it results in increased Ca, Mg and Sr contents in the calcite zone, soils and rocks in which it is present are not otherwise different from their non-calcareous equivalents above or below (Table 2, Fig 3). There is no association of Au with calcrete (cf. Scott, 1989b).

4.3 Geochemical variations through the felsic rock profiles

Below the soil and calcrete the profiles through NMS D7 and NMS D8 are similar except for the persistence of the goethite/kaolinite zone into saprolite in NMS D7. The zone is rich in As, Cr, Cu, Ni, Sb, V and W relative to the underlying rocks (Table 3). These elements are expected to be mainly present in goethite as found previously in the Parkinson Pit but Cr ~ 1200 ppm is present in rutile and Cu and Cr contents ~ 200 ppm are present in the kaolinite (Scott, 1990).

White muscovite/kaolinite zone rocks are present over a vertical interval of about 20 m. These minerals so dominate the zone that it contains little else. Thus the K and Ba contents of this zone are high and Fe and chalcophile elements low (Tables 3 and 4). Hence even though the Ti content of this zone is similar to that in the zone above (Table 3), the Cr content of the rutile here is only ~ 300 ppm (Scott, 1990). However despite the absence of chalcophile elements, some thin intervals of Au mineralization are present in this zone (Figs 2 and 3).

The underlying muscovite/kaolinite/Fe oxide zone has greater chalcophile element contents (in particular As, Cu, Mo, Ni, Pb, Sb and Zn) than its less ferruginous equivalents above. The presence of manganese oxides, particularly cryptomelane, in this zone may account for the stabilization of some of the Co, Cu, Ni, Pb and Zn (Scott, 1990). Sources of the Mn are not easily identified but weathering carbonates. particularly Mn-rich siderite as found in fresh mafic rocks from NMS D4 (Scott, 1990), may represent potential sources. The occurrence of Mn in this interval where mafic rocks are also present (Section 4.1) may thus be significant.

Gold is well developed in this zone, especially in NMS D7 (Table 3, Fig 2). Although Ag, As, Mo and Sb were found to be associated with Au in weathered material in the northern part of the Parkinson Pit (Scott, 1989a) these associations (with the exception of As) are not obvious here. Perhaps the elevated B in this zone reflects the strong association of this mineralization with quartz-tourmaline-pyrite veins. Tungsten also appears to be associated with the gold in this interval.

Partially weathered felsic volcanics characterized by the presence of albite and goethite but lower kaolinite than the rocks above, are consistently mineralized in both NMS D7 and NMS D8 (Figs 2 and 3). The presence of B and W with Au in this zone and the poor development of Ag, As, Mo and Sb relative to the mineralized zones in oxidised mafic rocks (Scott, 1989a) may also suggest that this ore is related to quartz-tourmaline-pyrite veins.

Fresh felsic volcanics consist of assemblages of albite, muscovite, dolomite and pyrite with some chlorite (Figs 2 and 3). The lack of B with Au in these rocks suggests that the Au is associated with pyrite rather than quartz-tourmaline-pyrite veins (Table 1). Silver is also present in the highly mineralized sample but at least some of the silver is likely to be present in tetrahedrite which is also present as inclusions in pyrite (Scott, 1989b). Of other potential pathfinders only W is present. The rutile, muscovite and chlorite of these rocks all have low Cr contents. Dolomite in these rocks is ankeritic (Scott, 1990).

4.4 Comparison of weathered felsic and mafic rocks

Comparison of of zonation through mafic rocks (as in NMS D4, Scott, 1989a) with that in NMS D7 and NMS D8 reveals a greater abundance of kaolinite in the felsic rocks. Furthermore the presence of calcrete above such rocks in NMS D8 indicates that calcrete development is not controlled by lithological factors (cf. Scott, 1989a). Despite differences in the abundance of kaolinite, broad changes in profiles through mafic and felsic rocks are similar i.e. ferruginous rocks → lighter coloured rocks → ferruginous rocks above partially weathered rocks. Although Na- and Ca-substitution in the micas is significant in the mafic rocks, especially in the poorly mineralized profile (Scott, 1989a), such substitution is quite minor in the felsic rocks (Scott, 1990).

The elements Co, Cu, Ni, Sc, W and Zn which were found to be associated with ferruginous rocks in mafic profiles (Scott, 1989a) are similarly associated in the felsic profiles. In both types of profile however some of these elements are actually more strongly associated with Mn oxides than Fe oxides (Scott, 1990). The elements, Ag, As, Mo and Sb which appeared to be good pathfinders for Au in the weathered mafic rocks (Scott, 1989a) are not strongly associated with Au in the weathered felsic rocks, perhaps because the Au association with tourmaline veins is more dominant in these rocks (see above).

5. CONCLUSIONS

The weathered profile in the southern portion of the Parkinson Pit consists of a thin soil (with a transported component) above felsic rocks. Zones in the rock change from goethite/kaolinite → muscovite/kaolinite → muscovite/kaolinite/goethite → albite/goethite → fresh felsic volcanics. A calcrete horizon may also be present at the boundary between soil and rock.

The elements Co, Cu, Ni, Sc, W and Zn are strongly associated with ferruginous rocks. Some of these elements are actually stabilized by adsorption onto and/or incorporation into Mn oxides in the interval up to 20 m above fresh rocks. Potential pathfinder elements (Ag, As, Mo and Sb) identified in mafic profiles do not appear to be useful in the felsic profiles, except perhaps for As. However W and B do appear to be associated with Au in the lowest two ferruginous zones.

6. ACKNOWLEDGEMENTS

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Table 1. Chemical composition of samples, NMS D7 (major components, wt %; minors, ppm)

	108321	108323	108325	108328	108329	108331	108333	108334	108337	108338	108339	108341	108343	108344	108345	108347	108348
Depth (m)	0.4	3.3	10.5	18.9	24.0	31.2	38.7	44.2	53.1	58.5	62.5	69.6	75.5	79.9	85.5	103.8	112.5
SiO_2	58.2	48.7	69.8	70.6	70.1	65.0	69.7	54.5	53.6	66.3	59.6	57.7	68.1	76.2	60.3	46.6	40.3
Al_2O_3	18.2	27.0	19.1	18.4	17.6	17.3	17.2	17.3	19.0	15.6	17.8	19.1	15.4	10.8	13.8	13.2	11.3
Fe_2O_3	6.49	8.02	0.74	0.75	1.84	7.41	3.30	16.9	13.8	7.43	9.14	8.11	4.53	2.60	3.37	9.42	7.52
MgO	2.40	0.20	0.36	0.42	0.33	0.37	0.24	0.46	0.51	0.59	1.20	1.60	1.13	1.47	2.48	6.28	5.19
CaO	0.13	<0.04	<0.04	0.17	<0.04	<0.04	<0.04	<0.04	0.09	0.09	0.12	0.11	0.75	1.55	4.89	7.23	14.5
Na_2O	0.45	0.19	0.18	0.24	0.17	0.16	0.16	0.14	0.17	0.21	1.77	2.32	4.10	0.37	2.82	1.13	0.96
K_2O	0.70	0.11	4.42	3.42	3.68	3.62	3.17	3.39	3.85	3.03	2.92	3.66	1.93	3.07	2.63	1.99	1.98
TiO_2	0.46	0.44	0.44	0.42	0.41	0.41	0.42	0.78	0.88	0.42	0.62	0.80	0.37	0.26	0.34	0.63	0.44
P_2O_5	<0.1																→
MnO	<0.04						→	0.21	0.17	0.15	0.44	0.09	<0.04	0.04	0.06	0.15	0.21
SO_3	<0.1												→	2.17	0.85	<0.1	2.48
Ag	0.2	1	0.3	0.5	0.5	0.5	0.8	0.8	1	1	0.8	0.3	0.3	3	0.8	0.6	2
As	41	160	13	18	35	270	89	140	220	84	120	140	62	34	38	10	46
Au	0.90	0.06	0.04	0.05	0.57	2.66	4.09	27.0	0.53	1.22	2.60	2.36	0.96	28.0	1.07	0.01	2.08
B	150	150	200	80	150	350	150	200	200	250	150	200	50	80	150	60	100
Ba	280	14	630	580	650	610	560	600	630	520	610	740	420	660	570	410	300
Co	16	37	<5	<5	<5	6	6	110	46	24	40	38	10	7	10	37	30
Cr	960	500	93	84	130	120	96	370	400	150	220	360	42	38	37	260	410
Cu	78	130	<5	15	59	150	62	120	180	97	60	40	61	28	21	100	46
Ga	30	15	40	30	40	35	30	30	30	35	30	40	15	20	20	15	15
Ge	3	2	4	3	3	2	2	3	3	3	3	3	3	4	2	2	1
Mo	4	2	0.3	0.3	6	10	3	3	2	4	4	4	2	4	1	0.3	2
Ni	180	360	<20	<20	28	59	66	210	170	96	150	93	34	29	36	150	160
Pb	36	93	<5	9	8	35	11	9	12	31	26	13	32	20	11	<5	<5
Sb	100	1000	30	30	80	60	<30	<30	<30	80	40	30	40	40	<30	<30	<30
Sc	<5	42	6	15	13	12	13	45	39	14	30	32	<5	<5	<5	23	17
Sn	4	4	2	2	2	1	2	2	2	1	2	3	1	2	1	3	3
Sr	51	10	32	30	36	41	32	38	41	47	150	150	230	180	350	170	130
V	140	400	82	96	110	130	110	320	290	130	170	200	68	73	57	190	180
W	40	40	10	10	30	30	20	10	30	40	30	30	30	30	20	10	10
Y	11	9	6	7	8	6	6	16	14	7	12	10	7	4	6	9	8
Zn	36	13	9	12	21	28	28	260	140	130	140	110	91	36	38	73	46
Zr	120	200	110	110	120	120	120	79	85	90	92	78	110	78	100	45	39
Ti/Zr	23	13	25	23	21	21	21	58	62	28	40	62	20	21	20	84	69

Table 2. Chemical composition of samples, NMS D8 (major components, wt %; minors, ppm)

	108350	108352	108353	108355	108356	108359	108361	108364	108366	108367	108369	108371	108372
Depth (m)	0.2	1.3	3.2	8.2	12.0	24.5	32.2	38.5	44.9	49.6	56.6	62.0	69.0
SiO_2	52.2	67.0	71.8	78.4	65.4	71.0	70.4	61.7	54.7	57.5	52.3	64.7	64.9
Al_2O_3	16.1	16.9	17.5	13.7	21.1	18.1	15.7	18.3	17.0	17.2	13.8	13.6	13.1
Fe_2O_3	19.0	0.71	0.55	0.57	0.96	1.05	4.98	9.96	15.0	12.8	20.9	3.37	3.04
MgO	0.51	1.20	0.35	<0.1	0.13	0.13	0.15	0.19	0.27	0.32	0.27	1.63	1.78
CaO	0.12	2.46	<0.04 →	→	→	→	→	→	→	0.16	0.15	3.12	3.82
Na_2O	0.43	0.49	0.56	0.41	0.48	0.36	0.28	0.24	0.34	0.43	1.31	2.10	2.10
K_2O	1.02	3.37	2.99	2.82	3.15	3.29	3.13	2.72	2.45	2.93	2.99	2.82	2.76
TiO_2	0.81	0.38	0.39	0.32	0.87	0.43	0.39	0.44	0.37	0.42	0.33	0.34	0.32
P_2O_5	<0.1 →	→	→	→	→	→	→	→	0.21	0.12	<0.1	<0.1	<0.1
MnO	0.10	<0.04 →	→	→	→	→	→	0.17	1.00	0.81	1.83	0.06	0.05
SO_3	0.12	<0.1 →	→	→	→	→	→	→	→	→	→	2.53	1.12
Ag	0.1	0.6	1	0.6	1.5	1	0.8	0.6	0.5	0.4	0.5	1	1
As	100	12	12	12	17	26	120	490	210	110	110	67	51
Au	0.53	0.11	0.02	0.03	0.06	0.20	0.22	1.15	0.34	1.00	1.24	0.63	0.60
B	150	200	100	200	150	200	200	400	80	300	150	60	60
Ba	380	770	520	530	660	560	500	480	540	580	650	540	480
Co	28	<5 →	→	→	→	→	10	14	68	48	84	12	9
Cr	470	58	69	51	310	60	66	94	57	26	24	37	35
Cu	96	7	5	<5	10	33	63	120	83	25	18	19	15
Ga	40	30	30	20	30	30	30	30	30	40	30	20	20
Ge	4	2	2	2	2	1	2	1	1	3	2	2	1
Mo	5	1	1	1	3	1	3	3	20	5	10	2	2
Ni	110	<20 →	→	→	→	→	→	56	440	100	110	36	28
Pb	28	5	<5	6	24	8	24	50	49	21	70	12	12
Sb	40	30	30	30	50	30	100	80	100	<30	<30	<30	<30
Sc	20	5	11	13	38	<5	<5	14	24	10	<5	8	<5
Sn	4	4	3	2	2	1	2	1	1	1	1	1	2
Sr	48	140	74	63	77	77	79	81	130	110	170	200	200
V	330	73	73	53	220	75	77	130	120	79	72	52	52
W	40	10	10	10	10	10	30	30	60	30	30	10	10
Y	13	4	4	3	10	6	5	7	13	12	11	6	6
Zn	64	6	<5	5	7	14	16	45	160	160	150	37	33
Zr	200	86	89	78	75	120	120	140	240	120	110	100	93
Ti/Zr	25	27	26	24	69	22	19	19	9	21	18	20	20

Table 3. Average composition of zones, NMS D7 (major components, wt %; minors, ppm)

Zone	Goethite/kaol	Musc/kaol	Musc/kaol/goe	Albite/goe	Albite/dol/py	Albite/chl/dol
	Soil/rock	Felsic Rock				Mafic Rock
Depth (m)	0.4-3.3	10.5-24.0	31.2-58.5	62.5-75.5	79.9-85.5	103.8-112.5
SiO_2	53.5	70.2	61.8	61.8	68.3	43.5
Al_2O_3	22.6	18.4	17.3	16.8	12.3	12.3
Fe_2O_3	7.26	1.11	9.77	7.26	2.99	8.47
MgO	1.30	0.37	0.43	1.31	1.98	5.74
CaO	0.08	0.07	0.05	0.33	3.22	10.9
Na_2O	0.32	0.20	0.17	2.73	1.60	1.05
K_2O	0.41	3.84	3.41	2.84	2.85	1.99
TiO_2	0.45	0.42	(0.58)	(0.60)	0.30	0.54
MnO	<0.04	<0.04	0.11	0.18	0.05	0.18
SO_3	<0.1	<0.1	<0.1	<0.1	1.51	1.24
Ag	0.6	0.4	0.8	0.5	1.9	1.3
As	100	22	160	110	36	28
Au	0.48	0.22	7.10	1.97	14.9	1.05
B	150	140	230	130	120	80
Ba	150	620	580	590	620	360
Co	27	<5	(38)	(29)	9	34
Cr	730	100	(230)	(210)	38	340
Cu	100	26	120	54	25	73
Ga	28	37	32	28	20	15
Ge	3	3	3	3	3	2
Mo	3	2	4	3	3	1
Ni	270	16	(120)	(92)	33	160
Pb	65	7	20	24	16	<5
Sb	550	47	37	37	<30	<30
Sc	22	11	(25)	(21)	<5	20
Sn	4	2	2	2	2	3
Sr	31	33	40	180	270	150
V	270	96	(200)	(150)	65	190
W	40	17	26	30	25	10
Y	10	7	10	10	5	9
Zn	25	14	120	110	37	60
Zr	160	110	100	93	89	42

NOTE: Values in parentheses affected by mafic rocks in zone

Table 4. Average composition of zones, NMS D8 (major components, wt %; minors, ppm)

Zone	Goethite	Calcite	Musc/kaol	Musc/kaol/Fe oxide	Albite/goe	Albite/dol/py
	Soil	Calcrete	Felsic rock			
Depth (m)	0.2	1.3	3.2-24.5	32.2-44.9	49.6-56.6	62.0-69.0
SiO_2	52.2	67.0	71.7	62.3	54.9	64.8
Al_2O_3	16.1	16.9	17.6	17.0	15.5	13.4
Fe_2O_3	19.0	0.71	0.78	9.98	16.9	3.21
MgO	0.51	1.20	0.17	0.20	0.30	1.71
CaO	0.12	2.46	<0.04	<0.04	0.16	3.47
Na_2O	0.43	0.49	0.45	0.29	0.87	2.10
K_2O	1.02	3.37	3.06	2.77	2.96	2.79
TiO_2	0.81	0.38	(0.50)	0.40	0.38	0.33
MnO	0.10	<0.04	<0.04	0.40	1.32	0.06
SO_3	0.12	<0.1	<0.1	<0.1	<0.1	1.83
Ag	0.1	0.6	1.0	0.6	0.5	1.0
As	100	12	17	270	110	60
Au	0.53	0.11	0.08	0.57	1.12	0.62
B	150	200	160	230	230	60
Ba	380	770	570	510	620	510
Co	28	<5	<5	31	66	11
Cr	470	58	(120)	72	25	36
Cu	96	7	13	89	22	17
Ga	40	30	28	30	35	20
Ge	4	2	2	1	3	2
Mo	5	1	2	9	8	2
Ni	110	<20	<20	170	110	32
Pb	28	5	10	41	46	12
Sb	40	30	35	93	<30	<30
Sc	20	5	(16)	13	6	5
Sn	4	4	2	1	1	2
Sr	48	140	73	97	140	200
V	330	73	(110)	110	76	52
W	40	10	10	40	30	10
Y	13	4	6	8	12	6
Zn	64	6	7	74	160	35
Zr	200	86	91	170	120	97

NOTE: Values in parentheses affected by mafic rock in zone

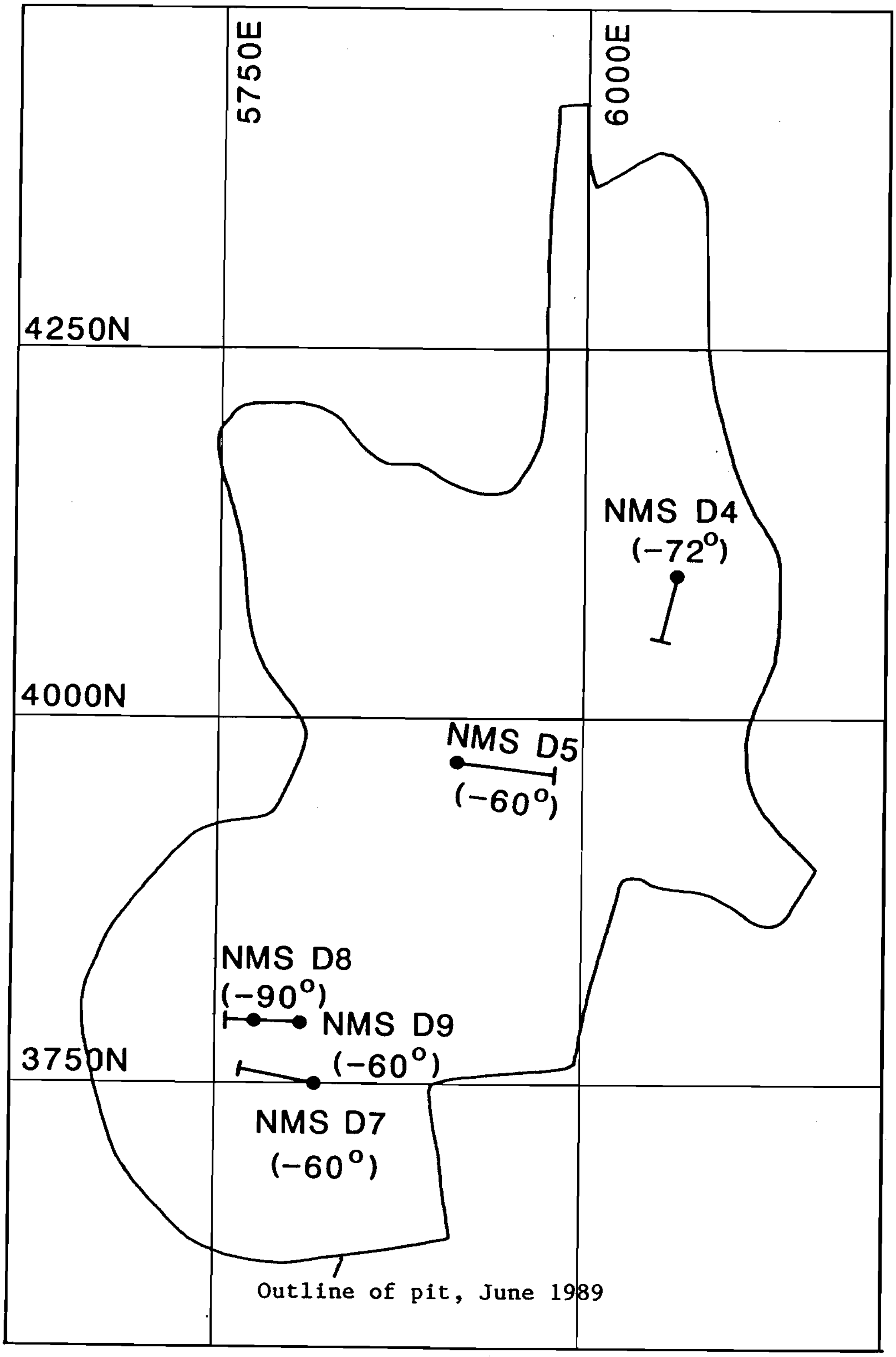

Figure 1. Location of studied drill holes in Parkinson Pit, Mt Magnet

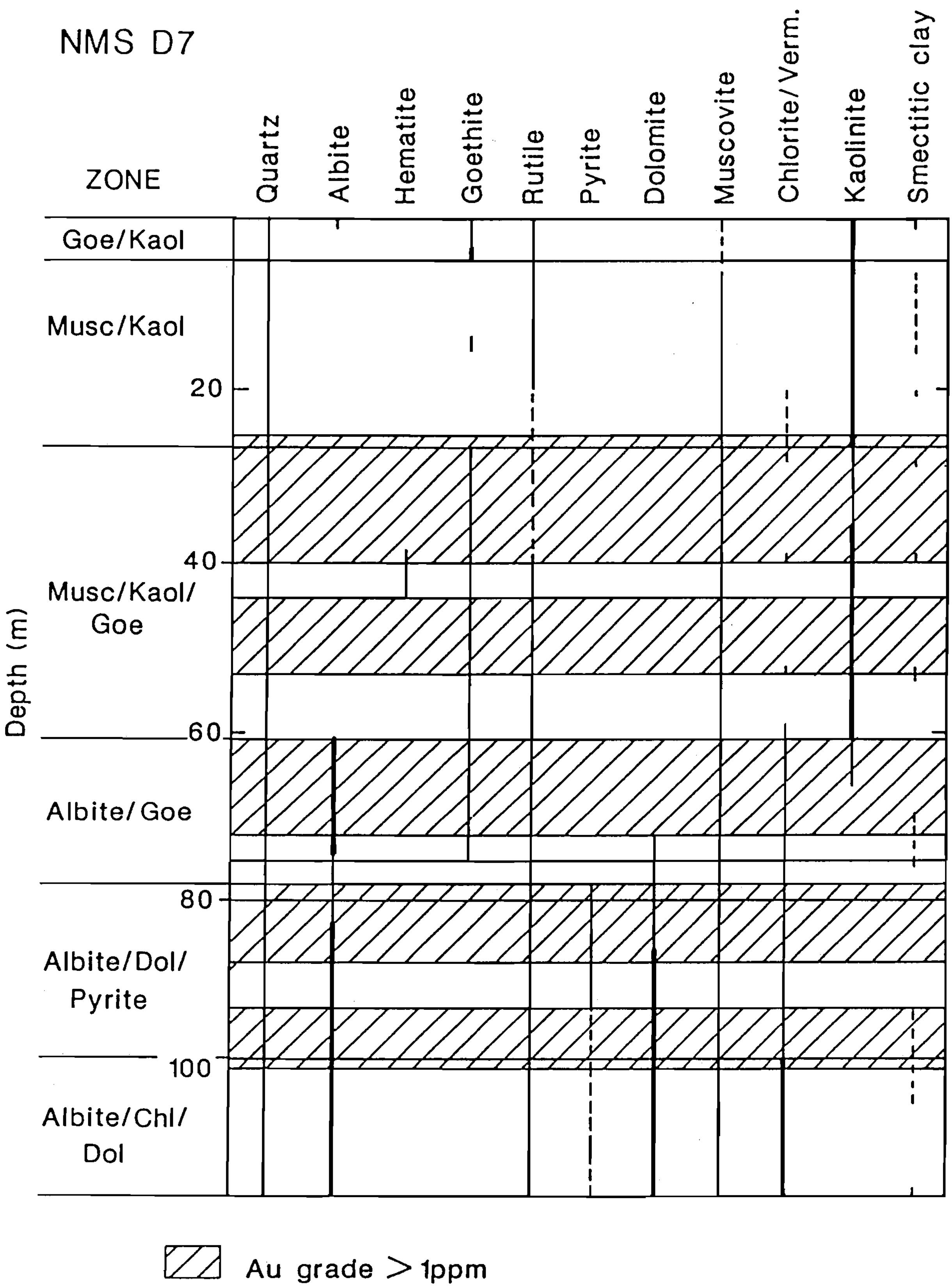

Figure 2. Mineralogical profile through NMS D7

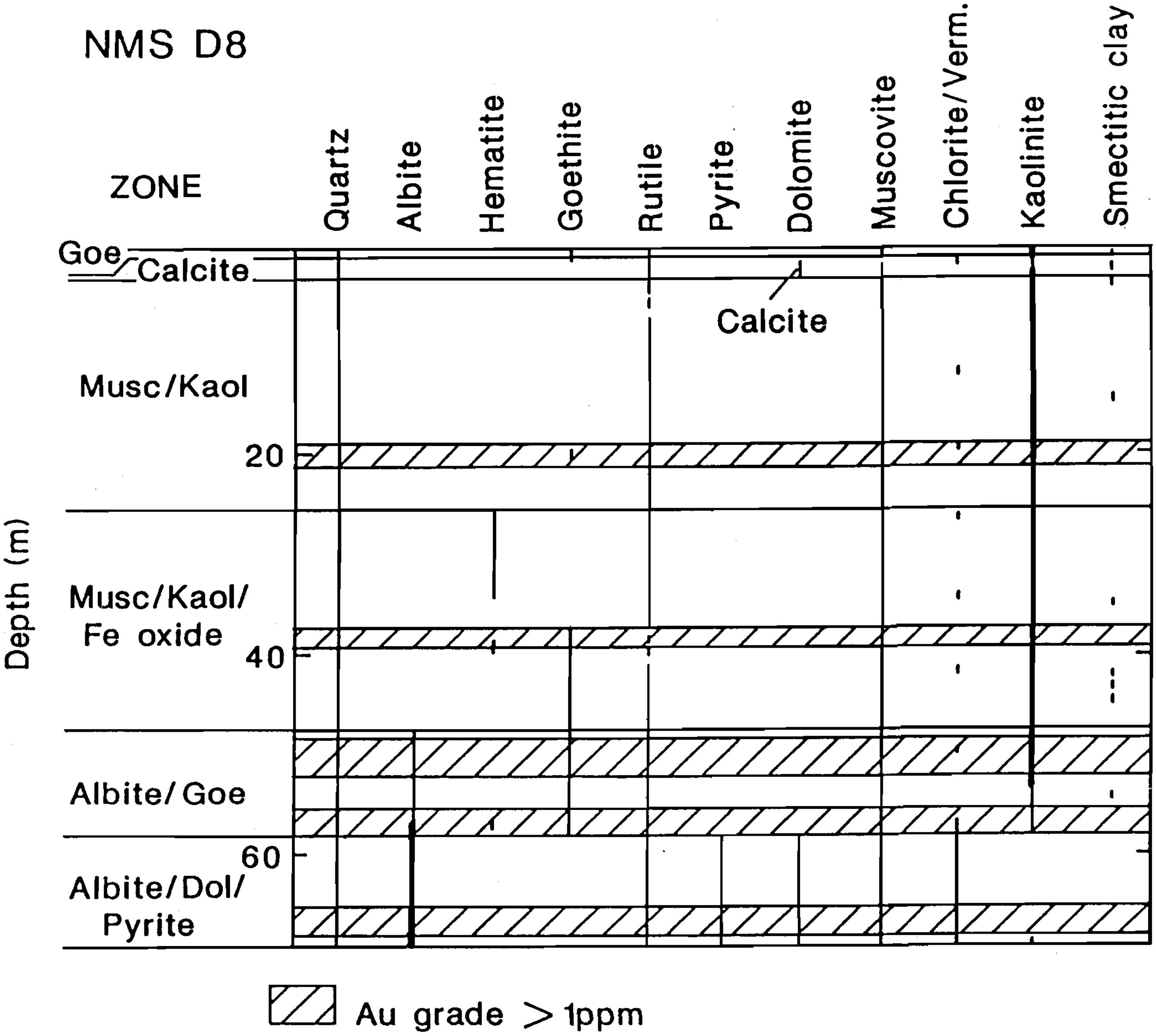

Figure 3. Mineralogical profile through NMS D8