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GOLD FAVORABILITY IN THE EAGLE QUADRANGLE, ALASKA, AS PREDICTED BY DISCRIMINANT ANALYSIS FOR NON-PORPHYRY GRANITIC ROCKS

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Introduction

New major and trace element geochemical data from plutonic rocks in the Eagle quadrangle, Alaska have been added to a compilation of published data in order to (1) study compositional characteristics of the plutons, (2) to evaluate their favorability for gold mineralization (Table 1), and (3) to evaluate the effectiveness of the Au plutonic discriminant (Newberry and Burns, 1989). Compositions of analyzed samples are metaluminous to peraluminous, and predominantly granite and granodiorite (Figure 1). Application of discriminant functions which numerically evaluate the favorability of each rock for non-porphyry plutonic gold mineralization shows that the granodiorites have the highest gold potential in the Eagle quadrangle. Of the group with high Au favorability, some but not all are associated with known high Au anomalies (ie, placers and/or reported rock geochemical anomalies). However, no appreciable-sized Au districts which can be ascribed to plutonic rocks are presently known in the Eagle quadrangle except for the 40-Mile District.

Data

New whole rock geochemical analyses for both major oxides and selected trace elements were obtained by ADGGS from thirty previously unanalyzed samples from the Eagle quadrangle, which were retrieved from the collections of the United States Geological Survey. The cooperation of H. L. Foster and F. R. Weber for the use of these samples is gratefully acknowledged. Previously published major oxide data is from Foster and others (1978) and Brabb and Hamachi (1977). Pluton map patterns (Plates 1 and 2) and pluton numbering system (Plate 1 and Table 1) are modified from Foster and others (1978). Gold and tin geochemical anomalies (Plate 2) are from Foster and Yount (1972) and Cathrall and others (1989).

Samples for new data were selected from each of the major plutons in the Eagle quadrangle, on the basis of sample size and apparent freshness. Weathered edges were removed from samples with a water-lubricated rock saw. Geochemical analyses were done by X-Ray Assay Laboratories, Don Mills, Ontario, Canada.

Discriminant Analysis for non-porphyry plutonic gold potential

Many plutonic rocks in the Eagle quadrangle are spatially associated with gold-bearing veins, hornfels, skarns, and gold placers. The gold potential of the plutonic rocks was investigated by using discriminant functions developed and discussed more fully by Newberry and Burns (1989). These discriminant functions predict which non-porphyry, unaltered plutons are gold-related and estimates their corresponding favorability. The following analysis of gold potential is only pertinent to non-porphyry plutonic gold systems. The term 'non-porphyry' is used here as a genetic term. We are excluding only porphyry copper deposits, and by no means are excluding all rocks with porphyritic textures. Highly altered rocks, even some from gold-rich porphyry copper systems, will not appear to be favorable by the discriminant functions described below. In general, rocks from Au-bearing Cu deposits have different compositions than other Au-related plutonic rocks. Hence, by analyzing unaltered rocks, we can only predict the likelihood for non-porphyry gold-related plutons.

In brief, the discriminant functions were constructed from major oxide analyses taken from the literature of about 650 plutonic rocks from 150 geographic locations. The compositions of the rocks range from diorite to granite. Forty percent of the analyses were related to non-porphyry gold deposits/prospects. Five quadratic discriminant functions were computed on random subsets of this data. These discriminant functions are an expression of the compositional characteristics typical of unaltered gold and non-gold-related plutonic rocks. Test cases on rocks with known gold and nongold affinity are then analyzed to establish how well the functions correctly classified the data. The equations yield about a 5 percent TYPE II error, the probability that a gold pluton will be misclassified, and about a 10 percent TYPE I error, probability that a non-gold pluton will be classified as a gold pluton. For exploration purposes, minimizing the TYPE II error, so that gold-related plutons will not be overlooked, is desirable. The error rates on the discriminant function are obviously low and make these discriminant functions a useful approach to estimating pluton-related gold potential.

The result from a discriminant function is a number, called the posterior probability, between 0 and 100; 100 meaning that the sample had compositional characteristics that are indistinguishable from those non-porphyry plutons related to gold, and 0 meaning the opposite. The average posterior probability computed after a sample is run through the five discriminant functions is not directly proportional to the amount of gold present, but is a good estimate of whether the sample belongs to a plutonic system which produced some gold. We have come to view these posterior probabilities in the following light:

values over 95 - excellent probability for association with non-porphyry gold

values over 85 or 80 - probably associated with gold,

values above 60 - possibly an altered rock from a good gold system or a good rock from a poor gold system

values below 60 - probably not associated with non-porphry gold.

Major oxide analyses of the plutonic rocks from the Eagle quadrangle were run through the discriminant program. Only one or two rocks were available from many of the plutons; in most cases, we do not know how representative that one sample was. However, field notes indicate that most samples were collected to represent the predominant rock types at each sample location. The average results of the discriminant analysis are displayed on Plate 2. Pluton subdivisions (*eg*, 3G-1, 3G-2) have been made in part on the basis of geochemical data and not field mapping, and as such are highly interpretive. Further subdivisions are entirely plausible and await detailed field mapping.

Discussion

Many plutonic rocks in the Eagle quadrangle appear to be very favorable for association with either gold lodes or gold placers. The composition of the rocks most favorable for gold from this quadrangle is granodiorite (Figure 1). The granites from the quadrangle appear to be too evolved for gold systems; many are possibly associated with weak- to moderate-quality tin systems. Tin anomalies in rock and stream sediment samples (Foster and Yount, 1972) are most common in and around plutons of medium to low Au favorablity (Plate 2). Alteration, particularly oxidation, may cause favorable samples to appear less favorable.

Too few age dates are available on unmetamorphosed granitic rocks in the Eagle quadrangle to show any correlation between pluton age and mineralization (Wasserberg and others, 1963; Foster, 1976; Cushing and others, 1984; Aleinikoff and others, 1987). In general, however, there are two major times of Cretaceous - Tertiary intrusion of intermediate to silicic plutons in interior Alaska. The older suite of plutons is about 90 Ma, and is commonly related to tungsten skarns [*eg*, Gilmore Dome (Blum, 1985; Newberry and Swanson, 1986) and Table Mountain (Newberry, 1987)], and is generally predicted by the gold discriminant functions to be strongly gold-related. Known gold anomalies occur more commonly near these older plutons in the Big Delta quadrangle (Solie and others, 1990). The younger suite of plutons is about 60 Ma. Several of these younger plutons [*eg*, the Hope granite suite (Burns and Newberry, 1987) and the Circle Hot Springs pluton] have previously been identified as tin-related. In the Big Delta quadrangle, Sn anomalies are known around some plutons of this younger group (Solie and others, 1990). On the basis of these correlations, it could be predicted that the plutons in the Eagle quadrangle with high gold favorability are probably in the 90 Ma age range, and that those plutons associated with tin anomalies are of the 60 Ma range.

The characteristics of the plutons in the Eagle quadrangle which appear to be favorable for gold concentration may be similar to those described by Newberry and others (1988) for gold-related plutons in the Kantishna-Circle gold belt. The Kantishna-Circle gold belt plutons have 1) only small amounts of pervasive hydrothermal alteration, 2) relatively deep emplacement, and 3) generally early Tertiary or older ages, and are thus typical of gold systems related to 'mesothermal' veins/replacement bodies.

Most of the plutons in east and central Eagle quadrangle are of appreciably greater surficial extent than almost any other plutons in interior Alaska. This greater surficial extent for plutons of the same ages (90 - 50 Ma) strongly implies that these Eagle quadrangle plutons are exposed at much deeper erosional levels than other plutons of interior Alaska. Northeast-trending faults, such as the Shaw Creek fault, represent potential locations of vertical displacement. If, for example, the area between the Shaw Creek fault and the 40-Mile lineament is an area which has been structurally elevated relative to the rest of interior Alaska, plutons in this area have been systematically more eroded than plutons in other areas. If this is the case, the bulk of the gold (and tin) potential in Eagle quadrangle is probably in placers, not in lodes (which are typically concentrated in the cupolas of plutons). Consequently, the gold favorability discriminant by itself is clearly not an effective tool for predicting gold resources; rather, the discriminant must be combined with available geologic data.

Conclusion

Based on the discriminant analysis for gold mineralization favorability in non-porphyry granitic plutons, the Eagle quadrangle contains some very favorable localities. Rock compositions which show most favorable gold potential in the Eagle quadrangle are granodiorites. Spatial association with known gold anomalies (placers and/or rock geochemical anomalies) is additional substantiating evidence for the favorable potential of many of the plutons.

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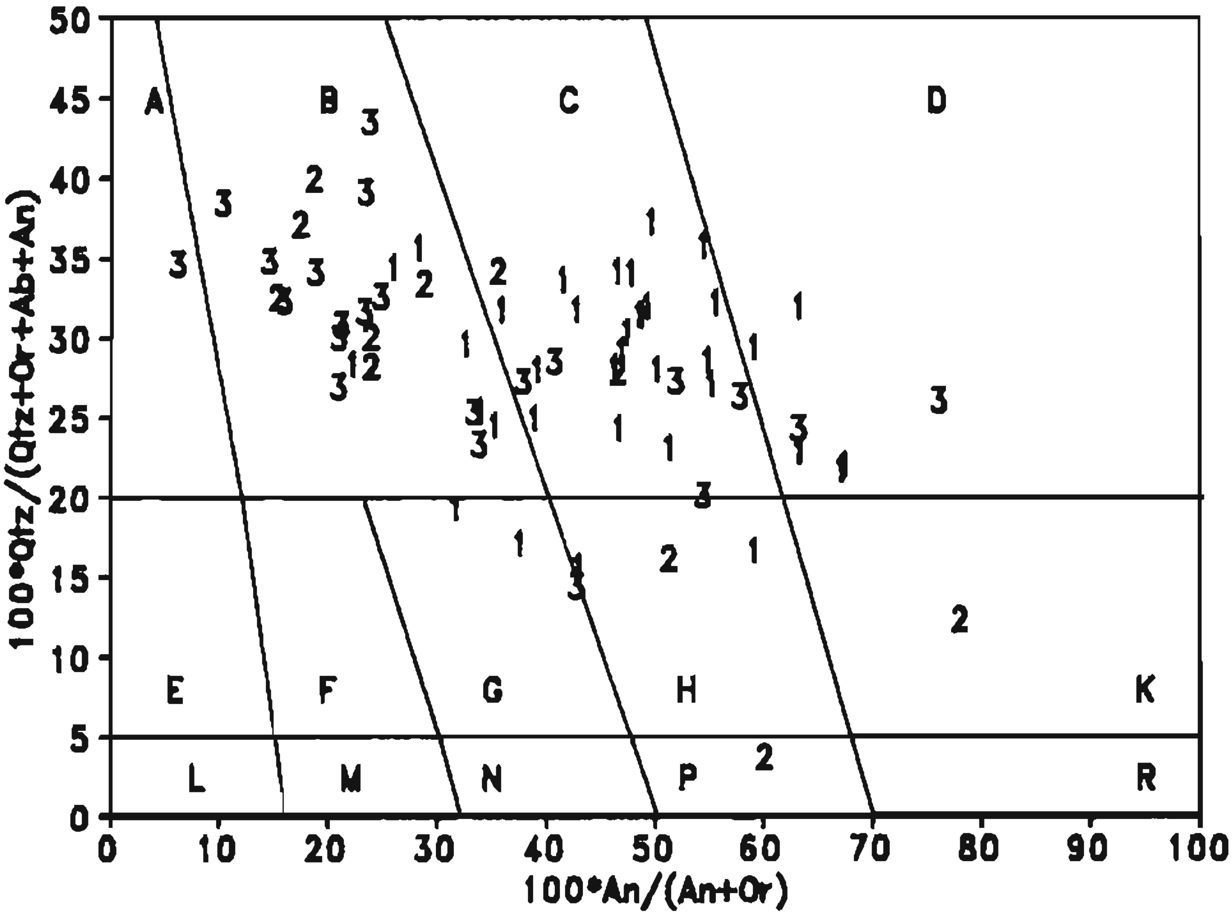

Figure 1: Composition and gold potential of plutonic rocks in Eagle quadrangle based on normative mineralogy. 1 = excellent favorability, posterior probability 85-100, 2 = moderate favorability, 60-85, 3 = weak favorability, 0-60. A = Alkali-feldspar granite, B = Granite, C = Granodiorite, D = Tonalite, E = Alkali-feldspar quartz syenite, F = Quartz syenite, G = Quartz monzonite, H = Quartz monzodiorite, K = Quartz diorite, L = Alkali-feldspar syenite, M = Syenite, N = Monzonite, P = Monzodiorite, R = Diorite/Gabbro. Diagram modified from Streckeisen (1973).

Table 1:

SAMPLENO	63AFr2c*	64AFr2*	64AFr70^	68AFr66*	68AFr2038*	69AWr87*
QUAD	A5	B6	A6	A4	D2	B5
PLUTON	6	3-G	3-G	7	3-B	3-G
WT.%:						
SIO2	58.90	66.51	68.30	64.40	65.70	73.70
AL2O3	15.17	15.97	15.70	17.10	15.90	14.20
FE2O3	1.75	1.08	0.50	2.00	1.10	0.40
FEO	5.37	3.13	2.40	2.20	3.20	1.20
MGO	3.48	1.65	1.20	1.30	1.50	0.32
CAO	6.18	4.01	3.00	5.00	4.10	1.20
NA2O	2.08	2.92	2.90	3.60	2.70	3.00
K2O	4.32	3.21	3.30	2.30	2.60	4.10
TIO2	0.76	0.59	0.47	0.42	0.47	0.10
P2O5	0.51	0.10	0.15	0.21	0.15	0.05
MNO	0.16	0.09	0.07	0.10	0.10	0.05
H2OPLUS	1.01	0.72	0.94	0.83	0.91	0.75
H2OMINUS	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.06	0.01	0.01	0.01
LOI	na	na	na	na	na	na
SUM	99.69	100.04	98.99	99.47	98.44	99.08
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	11.77	24.75	30.09	22.05	28.15	37.46
COR	0.00	0.65	2.31	0.10	1.59	2.81
OR	25.87	19.10	19.90	13.78	15.75	24.64
AB	17.84	24.88	25.04	30.88	23.43	25.82
AN	19.56	19.37	14.19	23.76	19.85	5.72
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	6.70	0.00	0.00	0.00	0.00	0.00
HYP	13.04	8.32	6.47	5.19	8.32	2.64
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	2.57	1.58	0.74	2.94	1.64	0.59
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	1.46	1.13	0.91	0.81	0.92	0.19
AP	1.20	0.23	0.35	0.49	0.36	0.12
DISCR#	100.0	97.9	97.3	9.7	99.0	71.3

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	69AFr485*	69AFr674*	69AFr689*	69AFr900*	69AFr901*	70AFr179*
QUAD	B3	C4	C3	A2	C3	B2
PLUTON	9	3-D	3-D	13	9	10
WT.%:						
SIO2	59.20	71.20	66.00	65.87	61.78	58.80
AL2O3	13.60	15.30	16.60	16.72	13.24	15.60
FE2O3	2.10	0.30	0.60	1.45	1.75	1.90
FEO	4.70	1.60	3.10	2.60	5.37	4.70
MGO	4.40	0.53	1.50	1.31	3.32	3.70
CAO	5.70	1.90	3.50	4.74	5.57	7.10
NA2O	2.30	3.00	2.90	3.20	2.57	2.80
K2O	4.10	3.60	2.90	2.72	4.31	2.60
TIO2	0.58	0.22	0.52	0.66	0.74	0.65
P2O5	0.41	0.09	0.17	0.60	0.51	0.36
MNO	0.14	0.08	0.08	0.14	0.15	0.14
H2OPLUS	1.00	0.79	1.10	0.48	0.95	0.73
H2OMINUS	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.04	0.07	0.08	0.00	0.00	0.01
LOI	na	na	na	na	na	na
SUM	98.27	98.68	99.05	100.49	100.26	99.09
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	12.40	35.00	27.32	25.18	14.28	12.49
COR	0.00	3.30	2.79	1.33	0.00	0.00
OR	24.92	21.75	17.51	16.07	25.65	15.62
AB	20.02	25.95	25.07	27.07	21.90	24.09
AN	15.09	9.04	16.61	19.60	11.94	22.69
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	9.13	0.00	0.00	0.00	10.33	8.77
HYP	13.21	3.88	8.40	6.01	10.75	11.44
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	3.13	0.45	0.89	2.10	2.56	2.80
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	1.13	0.43	1.01	1.25	1.42	1.26
AP	0.98	0.21	0.40	1.39	1.19	0.85
DISCR#	99.9	III COR	99.9	88.7	100.0	99.7

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1.

SAMPLENO	70AFr225*	70AFr312*	70AFr372*	70AFr437a*	70AFr450*	70AFr995*
QUAD	A3	B4	D6	D6	C5	A3
PLUTON	14	9	3-F	3-F	3-E	14
WT.%:						
SIO2	66.00	65.10	74.80	66.10	65.30	63.90
AL2O3	17.10	14.60	14.20	15.80	17.20	17.20
FE2O3	1.60	1.80	0.28	0.76	0.48	1.90
FEO	1.70	2.50	0.84	3.40	3.20	2.30
MGO	1.20	2.10	0.14	1.70	1.30	1.40
CAO	3.90	4.00	0.84	4.00	3.00	5.70
NA2O	4.80	3.00	3.10	2.40	2.90	3.60
K2O	2.50	4.40	4.80	3.70	4.40	1.40
TIO2	0.42	0.44	0.13	0.54	0.66	0.44
P2O5	0.19	0.25	0.13	0.13	0.23	0.25
MNO	0.07	0.08	0.00	0.03	0.05	0.11
H2OPLUS	0.71	0.83	0.68	0.89	1.00	0.76
H2OMINUS	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.05	0.36	0.00	0.00	0.00	0.07
LOI	na	na	na	na	na	na
SUM	100.24	99.46	99.94	99.45	99.72	99.03
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	18.52	20.06	36.53	24.42	22.12	23.46
COR	0.00	0.00	2.71	1.91	2.80	0.00
OR	14.85	26.46	28.58	22.18	26.34	8.42
AB	40.83	25.83	26.43	20.60	24.86	31.02
AN	17.82	13.61	3.34	19.27	13.56	27.13
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.31	3.98	0.00	0.00	0.00	0.01
HYP	4.10	5.97	1.46	9.15	7.82	5.72
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	2.33	2.66	0.41	1.12	0.71	2.81
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	0.80	0.85	0.25	1.04	1.27	0.85
AP	0.44	0.59	0.30	0.31	0.54	0.59
DISCR#	4.5	30.8	50.5	99.9	100.0	37.4

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this repor

Table 1:

SAMPLENO	70AFr3078*	70AFr3112*	71AWr80*	71AWr90*	71AFr185*	71AFr201*
QUAD	C6	C5	D5	D4	D4	D5
PLUTON	3-F	3-E	3-E	3-D	3-D	3-E
WT.%:						
SIO2	71.60	69.00	68.30	71.20	69.70	66.70
AL2O3	14.70	15.70	15.50	14.90	14.90	15.40
FE2O3	0.20	0.22	0.50	0.60	0.60	0.80
FEO	1.60	1.80	2.60	2.00	2.10	2.90
MGO	0.70	1.10	1.20	0.50	1.10	1.50
CAO	1.30	2.20	2.90	2.10	2.90	3.50
NA2O	2.90	2.70	2.60	2.80	2.40	2.40
K2O	5.30	5.40	4.10	4.20	4.20	3.70
TIO2	0.27	0.39	0.39	0.21	0.32	0.49
P2O5	0.11	0.12	0.11	0.08	0.09	0.14
MNO	0.04	0.00	0.08	0.06	0.07	0.08
H2OPLUS	0.62	0.84	1.10	0.76	1.00	0.90
H2OMINUS	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.04	0.00	0.02	0.01	0.07	0.03
LOI	na	na	na	na	na	na
SUM	99.38	99.47	99.40	99.42	99.45	98.54
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	30.23	25.84	28.53	32.93	31.23	28.09
COR	2.12	1.72	1.81	2.15	1.37	1.45
OR	31.72	32.35	24.65	25.16	25.23	22.40
AB	24.86	23.16	22.38	24.02	20.64	20.80
AN	5.81	10.27	13.91	10.03	14.03	16.85
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	0.00	0.00	0.00
HYP	4.20	5.29	6.97	4.24	5.80	7.93
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	0.29	0.32	0.74	0.88	0.88	1.19
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	0.52	0.75	0.75	0.40	0.62	0.95
AP	0.26	0.28	0.26	0.19	0.21	0.33
DISCR#	67.8	84.9	97.1	86.6	78.2	97.0

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	71AFr341*	71AFr348*	71AFr364*	71AFr507*	71AFr596b*	71AFr635*
QUAD	C2	C2	D3	A5	A6	B6
PLUTON	3-A	3-B	3-C	5	3-G	3-G
WT.%:						
SIO2	69.70	66.00	63 20	62.20	60.20	67.50
AL2O3	15.70	15.50	17.60	13.50	15.70	15.80
FE2O3	0.50	1.00	0.90	2.00	1.00	1.10
FEO	2.70	3.10	3.40	4.40	4.90	2.30
MGO	1.20	1.50	0.88	3.30	5.20	1.20
CAO	3.10	3.60	5.10	4.60	5.90	3.30
NA2O	3.00	2.80	3.40	2.20	2.10	3.00
K2O	2.50	3.00	2.40	4.00	2.20	2.80
TIO2	0.35	0.53	0.42	0.87	0.69	0.48
P2O5	0.11	0.15	0.12	0.34	0.00	0.17
MNO	0.09	0 10	0.09	0.16	0.14	0.08
H2OPLUS	1.60	1.80	1.20	1.30	1.60	1.00
H2OMINUS	0.00	0.00	0 00	0.00	0.00	0.00
CO2	0.08	0 06	0.01	0.01	0.01	0.01
LOI	na	na	na	na	na	na
SUM	100.63	99.14	98.72	98.88	99.64	98.74
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	33.03	27 56	20.59	19.53	16.69	30.43
COR	2.71	1.50	0.44	0.00	0.00	2.29
OR	14.93	18.22	14.54	24.23	13.26	16.93
AB	25.65	24.35	29.50	19.08	18.13	25.97
AN	14.82	17.35	25.14	15.52	27.46	15.62
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0 00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	4.56	1.95	0.00
HYP	7.20	8.13	7.35	11 52	13.70	5.79
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	0.73	1 49	1.34	2.97	1.48	1.63
HEM	0 00	0.00	0.00	0.00	0.00	0.00
ILM	0.67	1.04	0.82	1.69	1.34	0.93
AP	0.26	0.36	0.29	0.81	0.00	0.40
DISCR#	99 6	98.6	99.9	96.2	100.0	89.8

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	71AFr662*	71AFr664*	71AFr701*	71AFr793*	71AFr800*	71AFr2024*
QUAD	B6	B6	C6	D4	C4	D4
PLUTON	3-G	3-G	3-H	3-D	3-D	3-D
WT.%:						
SIO2	66.00	63.30	70.40	74.20	68.70	75.20
AL2O3	16.20	16.80	15.20	14.10	15.90	13.30
FE2O3	1.30	1.20	0.40	0.30	0.30	0.20
FEO	2.50	3.40	1.80	1.00	1.60	1.00
MGO	1.40	2.40	0.60	0.40	0.70	0.35
CAO	3.50	4.70	2.00	1.60	1.80	1.70
NA2O	3.00	2.40	2.90	2.90	3.30	2.20
K2O	2.80	2.60	4.30	4.20	4.80	4.40
TIO2	0.52	0.60	0.32	0.15	0.33	0.13
P2O5	0.18	0.16	0.14	0.04	0.12	0.03
MNO	0.10	0.10	0.05	0.04	0.04	0.02
H2OPLUS	1.00	1.20	0.89	0.73	1.00	0.40
H2OMINUS	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.03	0.02	0.03	0.01	0.02	0.02
LOI	na	na	na	na	na	na
SUM	98.53	98.88	99.03	99.67	98.61	98.95
PPM:						
RB	na	na	na	na	na	na
SR	na	na	na	na	na	na
Y	na	na	na	na	na	na
NB	na	na	na	na	na	na
ZR	na	na	na	na	na	na
BA	na	na	na	na	na	na
CR2O3(wt%)	na	na	na	na	na	na
NORM:						
QTZ	28.17	24.75	31.74	37.10	26.20	41.42
COR	2.36	1.92	2.52	1.99	2.35	1.93
OR	16.97	15.73	25.90	25.09	29.06	26.39
AB	26.03	20.79	25.01	24.80	28.61	18.89
AN	16.60	22.81	9.18	7.76	8.35	8.36
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	0.00	0.00	0.00
HYP	6.49	10.67	4.11	2.44	4.06	2.40
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	1.93	1.78	0.59	0.44	0.45	0.29
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	1.01	1.17	0.62	0.29	0.64	0.25
AP	0.43	0.38	0.33	0.09	0.29	0.07
DISCR#	91.7	99.5	87.6	53.9	88.7	41.4

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	71AFr2025*	71AFr2179*	73AFr3191*	63Ba3084^	60ABa297^	63AFr223
QUAD	D4	C2	B2	D1	D1	A3
PLUTON	3-D	3-A	10	gabbro	basalt	14
WT.%:						
SIO2	67.50	65.40	53.30	41.90	48.30	68.10
AL2O3	15.20	15.90	16.60	14.70	11.30	15.10
FE2O3	0.60	1.00	3.70	1.80	5.50	1.14
FEO	3.10	3.40	4.70	7.80	6.60	1.30
MGO	1.30	1.70	4.40	5.40	5.00	0.87
CAO	3.50	4.50	8.30	8.90	11.00	2.86
NA2O	2.50	2.80	3.20	3.20	2.30	3.76
K2O	3.20	2.10	2.60	2.10	0.85	4.10
TIO2	0.49	0.49	0.72	5.40	0.88	0.28
P2O5	0.12	0.14	0.29	0.96	0.29	0.14
MNO	0.08	0.12	0.17	0.17	0.18	0.08
H2OPLUS	0.86	1.30	0.91	3.20	0.91	na
H2OMINUS	0.00	0.00	0.00	0.39	0.19	na
CO2	0.01	0.07	0.02	3.40	6.50	na
LOI	na	na	na	na	na	0.85
SUM	98.46	98.92	98.91	99.32	99.80	98.58
PPM:						
RB	na	na	na	na	na	138
SR	na	na	na	na	na	784
Y	na	na	na	na	na	0
NB	na	na	na	na	na	16
ZR	na	na	na	na	na	110
BA	na	na	na	na	na	1570
CR2O3(wt%)	na	na	na	na	na	0.02
NORM:						
QTZ	30.28	27.78	2.59	0.00	6.52	23.77
COR	1.59	1.20	0.00	0.00	0.00	0.00
OR	19.38	12.72	15.68	13.44	5.45	24.79
AB	21.68	24.29	27.63	19.59	21.11	32.55
AN	16.99	21.95	23.73	21.17	19.52	12.50
NE	0.00	0.00	0.00	5.27	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	13.19	15.90	30.48	0.88
HYP	7.97	9.29	9.62	0.00	5.73	2.95
OL	0.00	0.00	0.00	8.29	0.00	0.00
MT	0.89	1.49	5.48	2.83	8.65	1.69
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	0.95	0.95	1.40	11.11	1.81	0.54
AP	0.29	0.33	0.69	2.41	0.73	0.33
DISCR#	99.3	99.5	64.9	NORM NE	73.2	0.6

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	64AFr31	64AFr79	64AFr138	64AFr142	64AFr172	64AFr227
QUAD	A6	A2	B6	B6	B6	B6
PLUTON	3G	14	3G	3G	3G	3G
WT.%:						
SIO2	62.20	70.80	66.80	64.70	71.60	66.20
AL2O3	16.40	15.10	15.60	15.40	14.20	16.00
FE2O3	1.52	0.69	1.37	0.95	0.51	1.65
FEO	4.20	1.00	2.50	4.30	1.70	2.50
MGO	2.07	0.75	1.47	2 92	0.79	1.57
CAO	5.10	2.83	3.62	4.09	1.96	4.00
NA2O	3.61	4.23	3.23	1.73	3.40	3.32
K2O	1.89	3.15	3.28	2.77	3.86	2.93
TIO2	0.68	0 23	0.49	0.67	0.22	0.55
P2O5	0.14	0.09	0.14	0.10	0.06	0.16
MNO	0.18	0.05	0.10	0.08	0.08	0.11
H2OPLUS	na	na	na	na	na	na
H2OMINUS	na	na	na	na	na	na
CO2	na	na	na	na	na	na
LOI	1.62	0.77	1.00	2.08	1.39	0.85
SUM	99.61	99 69	99.60	99.79	99 77	99.84
PPM:						
RB	101	72	107	131	149	129
SR	314	1040	320	242	183	392
Y	38	0	0	0	45	26
NB	19	16	26	11	39	17
ZR	109	98	141	204	97	156
BA	970	2020	1330	884	1220	1160
CR2O3(wt%)	0.00	0.02	0.00	0 01	0.01	0.00
NORM:						
QTZ	18.45	27 18	24.97	29.07	31.22	24.32
COR	0.00	0.00	0.50	2.41	1.03	0.48
OR	11.40	18.82	19.66	16.75	23.19	17 49
AB	31.17	36.18	27.72	14 98	29.24	28.38
AN	23.43	13.05	17.29	20.10	9.49	18.99
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	1.21	0.44	0.00	0.00	0.00	0.00
HYP	10.45	2.66	5.59	13 74	4.53	6.50
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	2.25	1.01	2.02	1.41	0.75	2.42
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	1.32	0.44	0.94	1.30	0.43	1.06
AP	0.33	0.21	0 33	0.24	0.14	0.37
DISCR#	99.7	19.3	67.2	100.0	71.6	53.3

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	68AFr107	68AFr227	69AFr664	69AFr696	69AFr721	69AFr900A
QUAD	A5	A4	C4	C3	B4	A2
PLUTON	6	6	3H	3D	3H	13
WT.%:						
SIO2	55.70	57.50	67.60	67.20	57 20	65 80
AL2O3	14.10	14.20	15.50	15.80	15.40	16.30
FE2O3	3.46	4.69	0.65	0.83	0.85	1.63
FEO	5.80	4.40	2.70	2.70	2.70	2.30
MGO	4 01	3.58	1.28	1.35	1.39	1 35
CAO	6.27	6.77	3.58	3.54	3.71	4.53
NA2O	2.46	3.04	3.11	3.05	2.94	3.45
K2O	2.98	3.39	3.26	3.11	2.83	2.60
TIO2	0.96	0.84	0.42	0.49	0.46	0.45
P2O5	0.53	0 49	0.10	0.14	0.11	0.19
MNO	0.19	0 20	0.09	0.09	0.09	0.14
H2OPLUS	na	na	na	na	na	na
H2OMINUS	na	na	na	na	na	na
CO2	na	na	na	na	na	na
LOI	2.54	3.47	1.08	1.39	1.85	0.93
SUM	99 00	99.57	99.37	99.69	89.53	99.67
PPM:						
RB	69	74	124	125	117	113
SR	967	996	296	327	323	606
Y	45	33	28	31	15	30
NB	11	10	16	14	18	28
ZR	217	204	138	164	137	146
BA	1400	1090	1470	1090	1600	1880
CR2O3(wt%)	0.00	0.00	0.00	0 00	0.01	0 00
NORM:						
QTZ	11.44	10.33	26 42	27.17	20.41	23.81
COR	0.00	0 00	0.60	1.34	1.16	0.03
OR	18.26	20 21	19.60	18.70	19.07	15.56
AB	21 58	25.96	26.77	26.25	28 37	29.56
AN	19.31	15.23	17.41	16.94	20 17	21.50
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	7.63	12.39	0.00	0.00	0 00	0 00
HYP	13.43	6.27	7 21	7.11	8.13	5.83
OL	0 00	0.00	0.00	0.00	0.00	0.00
MT	5.20	5.86	0.96	1 22	1.41	2.39
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	1 89	1.61	0.81	0.95	1.00	0.87
AP	1.27	1.15	0.24	0.33	0.29	0.45
DISCR#	69 1	1 1	95.6	96.2	100.0	44.0

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1.

SAMPLENO	70AFr310	70AFr430	70AFr466	70AFr2466B	70AFr2467	70AFr2471
QUAD	C5	C6	C5	D5	C5	C6
PLUTON	3E	3E	3E	3E	3E	3G
WT.%:						
SIO2	72.40	69.60	68.90	66.70	71.20	73.20
AL2O3	14.60	15.20	15.70	16.10	15.10	14.40
FE2O3	0.23	0.73	0.48	0.65	0.56	0.21
FEO	1.20	1.40	2.20	2.40	1.20	1.30
MGO	0.47	0.85	0.92	1.19	0.82	0.43
CAO	1.43	1.80	2.50	3.03	1.72	1.26
NA2O	3.20	3.49	3.36	3.27	3.19	3.18
K2O	4.65	5.02	3.94	4.33	4.92	4.31
TIO2	0.22	0.39	0.40	0.49	0.31	0.18
P2O5	0.10	0.15	0.16	0.16	0.10	0.12
MNO	0.05	0.06	0.07	0.09	0.05	0.05
H2OPLUS	na	na	na	na	na	na
H2OMINUS	na	na	na	na	na	na
CO2	na	na	na	na	na	na
LOI	1.39	1.00	0.85	0.77	0.93	1.08
SUM	99.94	99.69	99.48	99.18	100.10	99.72
PPM:						
RB	202	220	171	206	232	145
SR	221	868	302	361	321	205
Y	31	25	24	17	24	19
NB	0	27	25	10	13	20
ZR	97	182	123	225	113	90
BA	890	1670	994	1180	813	1220
CR2O3(wt%)	0.01	0.01	0.01	0.00	0.01	0.00
NORM:						
QTZ	32.18	25.07	26.96	22.18	28.83	34.77
COR	1.97	1.13	1.77	0.92	1.65	2.53
OR	27.88	30.06	23.61	26.00	29.32	25.82
AB	27.47	29.92	28.82	28.12	27.22	27.28
AN	6.54	8.06	11.52	14.21	7.95	5.54
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	0.00	0.00	0.00
HYP	2.96	3.60	5.48	6.29	3.39	3.12
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	0.34	1.07	0.71	0.96	0.82	0.31
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	0.42	0.75	0.77	0.95	0.59	0.35
AP	0.24	0.35	0.38	0.38	0.23	0.28
DISCR#	55.8	49.2	92.8	93.6	48.4	63.5

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	70AFr2497A	70AFr2497B	70AWr67B	71AFr99	71AFr357	71AFr363
QUAD	C6	C6	D5	D4	C3	D3
PLUTON	3G	3G	3D	3D	3C	3C
WT.%:						
SIO2	70.90	76.00	74.00	65.00	65.80	69.00
AL2O3	14.70	13.40	13.60	15.80	16.00	15.40
FE2O3	0.40	0.40	0.41	1.03	1.22	1.03
FEO	1.60	0.20	1.10	3.30	2.70	1.60
MGO	0.67	0.09	0.25	1.76	1.39	0.57
CAO	1.69	0.42	1.08	4.13	4.18	2.65
NA2O	3.67	3.98	3.21	2.86	3.31	3.98
K2O	4.27	4.74	4.98	3.71	2.73	3.52
TIO2	0.20	0.03	0.13	0.53	0.45	0.25
P2O5	0.06	0.03	0.04	0.13	0.12	0.06
MNO	0.08	0.04	0.06	0.10	0.12	0.06
H2OPLUS	na	na	na	na	na	na
H2OMINUS	na	na	na	na	na	na
CO2	na	na	na	na	na	na
LOI	0.85	0.62	0.70	1.00	1.31	1.31
SUM	99.09	99.95	99.56	99.35	99.33	99.43
PPM:						
RB	171	255	188	126	124	150
SR	176	0	237	422	392	342
Y	40	50	34	34	17	45
NB	10	14	18	0	14	0
ZR	86	45	110	151	123	235
BA	1360	138	1120	1330	1260	1430
CR2O3(wt%)	0.01	0.02	0.02	0.00	0.00	0.01
NORM:						
QTZ	28.16	33.96	33.36	21.43	24.33	25.69
COR	1.13	1.04	1.07	0.00	0.29	0.38
OR	25.68	28.20	29.77	22.29	16.46	21.20
AB	31.61	33.90	27.47	24.61	28.57	34.32
AN	8.14	1.90	5.16	19.64	20.36	13.00
NE	0.00	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	0.27	0.00	0.00
HYP	4.17	0.29	2.23	8.92	7.03	3.27
OL	0.00	0.00	0.00	0.00	0.00	0.00
MT	0.59	0.58	0.60	1.52	1.81	1.52
HEM	0.00	0.00	0.00	0.00	0.00	0.00
ILM	0.39	0.06	0.25	1.02	0.87	0.48
AP	0.14	0.07	0.09	0.31	0.28	0.14
DISCR#	71.7	0.0	43.2	97.7	88.7	36.2

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report

Table 1:

SAMPLENO	71AFr717	71AFr718	71AFr719	71AFr728	71AWr86A
QUAD	D6	D6	D6	D6	D4
PLUTON	3F	3F	3F	3F	3D
WT.%:					
SIO2	71.30	71.90	67.10	72.50	71.70
AL2O3	14.60	13.90	15.50	14.70	14.60
FE2O3	0.62	0.50	0.71	0.19	0.56
FEO	1.20	1.10	2.60	1.20	1.40
MGO	0.53	0.51	1.19	0.53	0.35
CAO	1.48	1.32	3.23	1.53	1.85
NA2O	3.91	3.10	2.93	4.05	3.11
K2O	4.27	5.21	3.99	3.63	4.89
TIO2	0.28	0.33	0.42	0.23	0.17
P2O5	0.09	0.10	0.12	0.07	0.05
MNO	0.04	0.05	0.09	0.04	0.06
H2OPLUS	na	na	na	na	na
H2OMINUS	na	na	na	na	na
CO2	na	na	na	na	na
LOI	1.23	0.85	0.85	0.85	0.85
SUM	99.55	98.87	98.73	99.52	99.59
PPM:					
RB	228	248	155	162	184
SR	237	381	327	313	408
Y	13	0	26	0	17
NB	18	19	22	0	23
ZR	182	204	168	100	178
BA	784	1650	1230	1380	2480
CR2O3(wt%)	0.01	0.01	0.01	0.01	0.02
NORM:					
QTZ	28.40	30.71	25.30	30.30	30.05
COR	1.09	1.02	0.79	1.51	0.96
OR	25.66	31.41	24.09	21.74	23.26
AB	33.65	26.76	25.33	34.73	25.65
AN	6.87	6.02	15.57	7.23	8.95
NE	0.00	0.00	0.00	0.00	0.00
AC	0.00	0.00	0.00	0.00	0.00
DIOP	0.00	0.00	0.00	0.00	0.00
HYP	2.67	2.47	6.77	3.10	2.65
OL	0.00	0.00	0.00	0.00	0.00
MT	0.91	0.74	1.05	0.28	0.82
HEM	0.00	0.00	0.00	0.00	0.00
ILM	0.54	0.64	0.82	0.44	0.33
AP	0.21	0.24	0.28	0.16	0.12
DISCR#	46.0	42.8	94.3	57.3	56.0

na=not analyzed; *=Foster and others, 1978; ^=Brabb and Hamachi, 1977; other data=this report