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CIPW NORM, TRACE ELEMENT, AND Sr ISOTOPIC DATA FOR IGNEOUS ROCKS OF THE TANANA B-1 QUADRANGLE AND VICINITY

by

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CIPW Norm, Trace element, and Sr isotopic data for igneous rocks of the Tanana B-1 quadrangle and vicinity

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R.J. Newberry[1] and S.A. Haug[1]

INTRODUCTION

As part of the Alaska Division of Geological and Geophysical Survey's study of the Tanana B-1 quadrangle, major oxide analyses were determined for 78 rocks in and near the quadrangle (Liss et al., 1997). Geologic relationships among these rocks are described in Reifenstuhl et al. (1997). In order to better understand the nature and origins of the igneous and meta-igneous rocks of this region we present additional analytical information for these rock. Sample locations are given in Liss et al. (1977). Three suites of igneous rocks were studied: Triassic gabbros and basalt (Rampart Group), mid-Cretaceous plutonic rocks of Elephant Mountain and vicinity (alkalic-quartz alkalic suite), and early Tertiary, bi-modal, rhyolite + basalt flows and associated dikes.

As described in detail below, the data show: (1) Rampart group gabbros and basalts and Triassic gabbro south of the Victoria Creek fault have essentially identical compositions, (2) Rampart group mafic rocks are clearly distinguishable in trace element composition from Tertiary basalts, (3) the early Tertiary volcanic rocks comprise a bi-modal, "within-plate" igneous suite, similar in composition from early Tertiary volcanic rocks found elsewhere in Interior Alaska, (4) the mid-Cretaceous plutonic rocks in and near Elephant Mountain comprise a continuous suite from monzodiorite through syenite to granite, and possess "volcanic arc" trace element signatures. (A location map of the Tanana B-1 Quadrangle and surrounding area is shown in appendix 1).

ANALYTICAL METHODS

CIPW norms for the major element analyses presented in Liss et al. (1997) were calculated using the basic program "Petcal", written for DOS by Richard Koch, U.S.G.S. FeO/Fe_2O_3 ratios were first estimated from previous analyses of these rocks and then modified as dictated by TiO2 contents, using the procedure of Irvine and Baragar (1971). CIPW norms are listed on Table 1.

Trace element analyses were performed at the University of Alaska X-Ray fluorescence spectrometry laboratory. Approximately 7 grams of minus 200 mesh sample material was split from the excess material submitted for major oxide analysis and pressed into flat disks. Analyses were performed on a Rigaku wavelength dispersive X-Ray spectrometer using counting times of 100 seconds and well-characterized, natural rock standards. Data acquisition and correction was made using programs developed by the Alaska Division of Geological and Geophysical Surveys. Three analyses of each pressed-powder disk were conducted and the results averaged. Analyses of well-characterized secondary standards and replicate analyses of these samples indicates the following uncertainties: for reported concentrations of 1 to 40 ppm, $\pm$ 2 ppm; for 40 to 100 ppm, $\pm$ 3 ppm; for 100 to 200 ppm, $\pm$ 4 ppm, for 200 to 1000 ppm, $\pm$ 5 ppm, and for greater than 1000 ppm, $\pm$ 10 ppm. Trace element data is listed in Table 2.

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Strontium isotopic analyses were performed on minus 200 mesh splits from two Elephant Mountain samples by Teledyne Laboratories, Westwood, New Jersey This laboratory employed standard Sr extraction and measurement techniques and reported uncertainties of 0.0001 in the $^{87}Sr/^{86}Sr$ ratio. Present-day Sr isotopic ratios and calculated initial Sr isotopic ratios are presented in Table 3.

RESULTS & DISCUSSION

Normative corundum contents for most of the igneous rocks analyzed are at or near-zero, indicating little hydrothermal alteration (Table 1). In contrast, most of the meta-igneous rocks analyzed possess high to very high normative corundum (1.7 to 10.5%), indicating that they are either very altered or not igneous. These rocks are consequently not considered further.

Classification the Triassic and Tertiary igneous rocks, employing the scheme of Streckeisen and LeMaitre (1979), shows the clearly bi-modal character of the Tertiary volcanic rocks (t=rhyolite and b=basalt, Fig. 1A). Dikes (D) dated as early Tertiary (Reifenstuhl et al., 1997) also exhibit bimodal compositions, similar to the coeval volcanic rocks. In contrast, igneous rocks of the Rampart group are clearly restricted to mafic compositions (g=gabbro, r= basalt, Fig. 1A). Triassic gabbro dike located south of the Victoria Creek fault has a composition within the range of Rampart gabbros. Rampart gabbros (including diabase) exhibit a wider range of compositions than the associated basalts, in part because the vast majority of Rampart Group mafic rocks encountered in the field and analyzed were gabbro and diabase.

Classification of the mid-Cretaceous igneous rocks, found at and near Elephant Mountain, shows an essentially continuous suite from gabbro/diorite through monzodiorite and syenite to quartz syenite and granite (Fig. 1B). Nearby, presumed mid-Cretaceous dikes (D, Fig. 1B) fall into the same compositional range as the Elephant Mountain pluton, different in most cases from the early Tertiary dikes (D, Fig. 1A). The continuous range in compositions for the Elephant Mountain pluton, from mafic to felsic alkalic, to granite, suggest a single body of magma, rather than separate mafic, alkalic, and granitic magmas. As the mafic rocks occur on the outer margin and the granites in the interior, mixing with crustal materials is an unlikely origin for the compositional variability. Given the compositional variations and spatial locations, inward-directed fractional crystallization is more likely.

Compositional differences between the Triassic and Tertiary igneous rocks is highlighted by their trace element contents (Table 2): the Tertiary rocks possess consistently elevated concentrations of immobile, incompatible elements (Y, Zr, Ce, Nb). This property not only serves to distinguish the two in areas where the geology is ambiguous, but emphasizes the different origins of the two suites. For example, a plot of Ce vs. Zr emphasizes (a) the highly enriched nature of Tertiary basalts relative to Triassic mafic rocks, (b) the bi-modal character of the Tertiary volcanic rocks, (c) that the Triassic gabbro south of the Victoria Creek fault possess trace element characteristics essentially identical to the Triassic Rampart gabbros, and (d) that the Rampart mafic rocks are slightly to significantly enriched in immobile elements relative to mid-ocean ridge basalt (MORB).

Standard trace element plots further illustrate the character of the igneous rocks. Employing the scheme of Pearce and Cann (1973), the tectonic setting for both the Triassic and Tertiary mafic igneous rocks (Fig. 3) is "within-plate". That the Tertiary basalts of the Rampart area yield such results is not surprising, as this seems to be characteristic of early Tertiary basalts of Interior Alaska (Newberry and others, 1995). That the Triassic gabbros and basalts plot as "within-plate" (Fig. 3a) suggests that the Rampart group mafic rocks represents some variety of partial rifting in a marine environment (e.g., back-arc rift?), rather than true ocean crust.

Trace element discrimination plots for felsic rocks (Fig. 4) illustrate similar features. On a Pearce et al. (1984) discrimination diagram (Fig. 4b) the Tertiary rhyolites have "within-plate" compositional signatures, congruent with the setting for the associated basalts (Fig. 3b). Plutonic rocks of the 90 Ma, alkalic- to quartz-alkalic suite, in contrast, have characteristics of arc-related magmas, although the data also plot in the adjacent "within-plate" field. How exactly the rocks of the alkalic-quartz alkalic suite relate to the extensive mid-Cretaceous arc-related rocks present to the southeast (Eagle, Circle, Tanacross, Big Delta, Livengood, Fairbanks, and Nabesna quadrangles) is unclear, but the trace element and age similarities suggest a genetic link.

Sr isotopic data for a representative granite (RN 79) and syenite (RN85a) from the Elephant Mountain pluton yield essentially identical values for initial $^{87}Sr/^{86}Sr$ ratios (Table 3). That these values are the same indicates derivation of the quartz-poor and quartz-rich units from the same parent magma, as is suggested by the lack of a compositional hiatus between the two suites (Fig. 1b). The calculated values for Elephant Mountain pluton initial Sr isotopic ratios (Table 3) are within the range of observed values for mid-Cretaceous, calc-alkalic plutonic rocks of Interior Alaska (Fig. 5), again suggesting a genetic link between the mid-Cretaceous alkalic and calc-alkalic plutons, despite significant differences in major element compositions (Fig. 1b).

CONCLUSIONS

The three suites of igneous rocks (Triassic, mid-Cretaceous, and early Tertiary) in the Rampart area can be readily distinguished based on trace element compositions. The trace element compositions further suggest "within-plate" (i.e., extensional) settings for the Triassic and Early Tertiary volcanic and plutonic rocks, and an arc-related setting for the mid-Cretaceous plutonic rocks. Comparison of data for these rocks to other studied suites in Interior Alaska indicates that the mid-Cretaceous suite is most likely related to other mid-Cretaceous plutons, and that the Early Tertiary volcanic rocks represent a small part of a much larger, Interior Alaska-wide, Early Tertiary extensional event.

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Table 1: CIPW norms for rocks of the Tanana B-1 quadrangle and vicinity

sample #	QTZ	COR	OR	AB	AN	DIOP	HYP	OL	MT	ILM	AP
96BT259	3.3	0.0	0.7	15.3	31.3	15.9	25.7	0.0	3.0	4.1	0.5
96BT273B	0.0	0.0	3.0	19.3	23.1	18.4	13.0	11.3	5.7	5.9	0.4
96BT281	0.0	0.0	3.4	22.1	33.1	12.4	13.0	8.8	3.4	3.3	0.6
96BT293	1.8	0.0	2.4	20.0	27.0	17.8	22.7	0.0	3.8	4.1	0.4
96BT294B	0.0	0.0	1.5	17.7	30.7	21.6	19.1	1.5	4.8	2.8	0.4
96BT298B	16.1	0.0	24.5	31.6	12.3	0.9	10.3	0.0	2.3	1.6	0.5
96BT306	2.0	0.0	4.7	19.0	28.8	14.5	21.3	0.0	3.8	5.0	0.9
96BT328	0.7	0.0	1.7	21.3	25.3	15.2	28.9	0.0	3.4	3.1	0.4
96KC135	0.8	5.9	12.9	45.7	1.2	0.0	20.2	0.0	4.6	6.4	2.3
96KC165	9.7	10.5	1.9	30.8	0.0	0.0	30.2	0.0	6.8	5.8	14.3
96KC185	0.0	0.0	4.7	20.6	31.7	17.3	16.8	4.1	2.7	1.9	0.3
96KC187	0.0	0.0	2.6	9.0	26.2	19.4	23.3	7.1	6.5	5.8	0.3
96KC192B	9.8	0.0	3.1	31.2	15.9	0.2	16.7	0.0	2.8	4.0	1.3
96KC192r	42.5	4.3	18.4	24.4	5.8	0.0	3.8	0.0	0.5	0.2	0.1
96KC212	0.8	0.0	0.4	20.9	27.0	18.8	23.8	0.0	4.0	3.9	0.6
96KC222	49.8	3.2	17.7	21.4	3.9	0.0	3.3	0.0	0.5	0.3	0.0
96KC227	4.3	0.0	3.0	21.0	26.7	17.2	20.0	0.0	3.7	3.7	0.5
96KC235	3.5	0.0	2.5	16.6	26.6	17.6	23.2	0.0	4.8	4.8	0.4
96KC171	0.0	0.0	1.4	28.7	24.6	17.6	9.0	12.1	3.6	2.8	0.3
96KC74	25.9	2.7	7.1	31.6	13.9	0.0	14.5	0.0	2.2	1.7	0.4
96RN102B	1.2	0.0	2.7	19.0	26.6	18.2	25.4	0.0	3.5	3.2	0.4
96RN103	0.0	0.0	3.5	16.5	33.0	22.5	15.2	4.7	2.7	2.0	0.2
96RN108	4.8	0.0	16.1	30.7	20.8	6.1	15.1	0.0	2.6	2.9	1.0
96RN110B	0.0	0.0	10.1	16.5	24.2	24.8	8.9	9.7	3.4	2.0	0.3
96RN110C	5.7	0.0	14.5	26.7	23.6	6.0	18.5	0.0	2.3	2.3	0.4
96RN114C	9.5	0.0	11.1	21.2	27.1	3.0	20.7	0.0	3.1	3.5	0.8
96RN129	3.2	0.0	1.4	28.2	23.2	8.8	30.0	0.0	3.3	1.7	0.2
96RN131	4.6	0.0	1.7	26.7	26.1	5.4	27.7	0.0	3.5	3.7	0.5
96RN147	41.7	0.6	38.9	15.4	1.0	0.0	1.8	0.0	0.4	0.2	0.1
96RN148A	0.0	0.0	1.8	5.8	22.2	44.4	10.7	5.7	3.6	5.1	0.7
96RN149A	30.1	2.1	11.2	39.8	8.9	0.0	5.7	0.0	1.0	1.0	0.4
96RN149B	31.6	0.3	33.5	24.6	5.5	0.0	2.9	0.0	0.7	0.8	0.3
96RN150	0.0	0.0	1.1	29.3	30.0	4.6	19.5	3.8	4.2	6.8	0.8
96RN155	25.0	0.0	9.7	4.1	26.5	22.5	8.1	0.0	2.4	1.3	0.4
96RN167	12.2	0.2	33.5	38.5	4.5	0.0	8.0	0.0	1.8	1.0	0.3
96RN174	5.7	0.0	33.7	22.4	12.8	9.3	12.2	0.0	1.9	1.2	0.7
96RN175	17.5	1.0	20.2	16.9	21.8	0.0	17.9	0.0	2.1	1.5	1.0
96RN184	3.3	0.0	35.1	22.1	11.3	11.3	12.7	0.0	1.9	1.4	0.9
96RN186	12.7	0.0	3.4	25.7	24.6	5.3	20.1	0.0	3.6	3.8	0.8
96RN193	3.4	0.0	28.7	21.8	14.0	12.3	15.5	0.0	2.0	1.4	1.0
96RN200	2.0	0.0	30.4	19.9	14.3	13.6	15.2	0.0	2.2	1.4	1.0
96RN201	14.7	0.1	30.3	32.9	11.7	0.0	7.9	0.0	1.2	0.8	0.5
96RN208B	5.7	0.0	6.5	17.1	29.2	10.4	23.8	0.0	3.5	3.5	0.4
96RN209	21.3	0.0	5.8	23.8	20.9	9.2	15.0	0.0	2.3	1.6	0.2
96RN21	5.7	0.0	23.8	26.5	16.2	9.6	12.8	0.0	2.1	2.3	1.1
96RN22	0.0	0.0	5.4	8.6	31.1	24.8	15.4	8.6	3.4	1.8	0.9

Table 1: CIPW norms for rocks of the Tanana B-1 quadrangle and vicinity, cont.

sample #	QTZ	COR	OR	AB	AN	DIOP	HYP	OL	MT	ILM	AP
96RN231	48.6	0.0	25.8	21.6	2.6	0.2	0.9	0.0	0.2	0.2	0.0
96RN250	11.7	0.0	6.1	22.6	21.3	0.4	19.0	0.0	3.2	3.9	1.7
96RN253	3.0	0.0	1.8	13.7	32.5	18.9	22.9	0.0	3.8	3.1	0.4
96RN79	20.4	0.0	35.5	25.9	9.9	0.5	6.3	0.0	0.8	0.6	0.2
96RN80	21.6	1.7	33.1	31.8	5.4	0.0	4.9	0.0	0.8	0.6	0.2
96RN82	5.4	0.0	37.3	24.6	12.1	9.5	8.2	0.0	1.5	1.0	0.6
96RN84	5.6	0.0	32.5	21.1	13.2	10.9	12.5	0.0	1.9	1.4	1.0
96RN85A	2.6	0.0	37.0	19.0	12.9	10.2	14.1	0.0	2.0	1.4	0.8
96SL142	10.9	0.0	2.7	18.2	25.9	4.8	24.2	0.0	4.9	5.7	2.8
96SL146	1.0	0.0	3.5	31.0	23.5	9.8	22.4	0.0	4.0	4.4	0.5
96SL16	14.8	0.0	34.4	27.5	10.0	3.2	7.7	0.0	1.2	0.8	0.4
96SL161	10.4	0.0	1.3	12.9	30.2	16.7	21.1	0.0	3.7	3.4	0.5
96SL29	0.0	0.0	39.1	15.9	6.9	25.2	0.0	7.1	2.3	1.4	1.7
96SL30	5.8	0.0	30.7	20.9	12.1	12.5	13.8	0.0	2.1	1.3	0.9
96SL31	5.7	0.0	37.9	22.6	10.5	8.1	11.4	0.0	1.8	1.3	0.7
96SL32	3.5	0.0	39.9	25.0	7.8	10.5	9.7	0.0	1.8	1.1	0.7
96SL33	1.9	0.0	27.6	19.1	11.3	11.7	13.8	0.0	2.0	1.5	1.1
96SL36	7.7	0.0	34.4	22.0	11.6	8.6	11.9	0.0	1.7	1.3	0.7
96SL39B	0.0	0.0	1.2	34.9	15.7	11.4	4.0	14.8	3.9	3.6	0.5
98KC30	0.0	0.0	3.7	26.9	24.7	15.4	6.6	14.3	3.8	4.2	0.5
98KC37	8.5	2.0	4.1	46.1	13.7	0.0	18.5	0.0	1.2	2.0	0.5
98KC68	13.0	6.7	0.2	33.2	8.4	0.0	24.3	0.0	9.3	4.2	0.7
98KC146b	0.0	3.7	0.3	46.0	16.1	0.0	0.5	23.6	3.7	5.0	1.0
98KC149f	0.0	1.9	0.1	38.9	24.0	0.0	4.3	18.5	5.9	5.1	1.1
98KC158	0.0	0.0	4.1	28.4	23.0	11.9	18.5	7.8	2.7	3.3	0.4
98KC191	0.0	0.0	5.0	16.5	23.4	21.2	20.2	3.0	2.0	7.4	1.3
98KC192e	13.4	0.0	12.8	22.1	25.4	5.1	9.4	0.0	3.8	6.1	1.9
98KC210	5.4	0.0	0.5	17.2	29.7	11.5	27.8	0.0	2.3	5.0	0.7
98KC223	0.0	0.0	3.9	22.4	31.4	18.7	11.0	5.4	2.6	3.8	0.7
98KC227'	5.3	0.0	2.7	19.5	28.0	13.9	23.0	0.0	3.3	4.0	0.5
98KC234	0.0	0.0	1.7	8.4	32.7	19.8	14.4	9.6	7.5	5.7	0.3
98KC239	0.2	0.0	6.2	13.4	32.7	19.3	21.3	0.0	2.9	3.4	0.6
96BT330G	0.0	0.0	0.7	23.6	22.7	24.1	0.0	18.7	3.7	2.9	0.3

Table 2: Trace element data for rocks of the Tanana B-1 quadrangle and vicinity
(all concentrations in parts per million)

sample #	description	Ba	Ce	Nb	Rb	Sr	Y	Zr
96BT259	Rampart basalt	643	14	14	2	197	27	121
96BT273B	Rampart gabbro	732	15	12	16	269	23	82
96BT281	Rampart basalt	226	31	11	17	358	25	123
96BT293	Rampart basalt	449	29	14	10	242	22	110
96BT294B	Rampart diabase	197	26	12	4	236	21	86
96BT298B	Tertiary dacite	2134	126	35	125	321	57	598
96BT306	Tertiary basalt	583	41	20	30	313	40	227
96BT328	Rampart diabase	1481	23	12	7	327	23	100
96KC135	pre-C/Pz metabasalt	1613	133	75	58	318	48	335
96KC165	Prot? greenstone	354	52	26	9	132	38	189
96KC185	Rampart diabase	900	15	8	28	374	14	58
96KC187	Rampart gabbro	540	17	11	14	239	16	64
96KC192B	Tertiary basalt	1330	76	20	92	186	40	261
96KC192r	Tertiary rhyolite	1396	115	23	96	1118	37	180
96KC212	Rampart gabbro	248	36	15	3	165	30	137
96KC222	Tertiary rhyolite	165	130	16	175	77	88	183
96KC227	Rampart gabbro	634	25	14	13	273	26	118
96KC235	Rampart gabbro	388	31	12	6	617	22	92
96KC171	pre-C/Pz metabasalt	69	2	6	4	95	28	67
96KC74	pre-C/Pz metatuff	316	27	6	26	364	21	109
96RN102B	Rampart gabbro	879	20	12	11	287	22	103
96RN103	Rampart gabbro	459	10	8	16	278	13	55
96RN108	T mafic dike	1010	106	24	90	426	44	425
96RN110B	pre-Tert amphibolite	624	22	12	44	119	22	127
96RN110C	Tert mafic dike	821	52	19	76	263	39	329
96RN114C	Tert mafic dike	855	70	21	75	357	43	293
96RN129	pre-Tert amphibolite	89	22	10	5	99	22	84
96RN131	Rampart gabbro	530	38	13	6	196	21	113
96RN147	Tertiary rhyolite	283	80	16	274	16	32	136
96RN148A	Tertiary basalt	113	44	29	7	240	30	162
96RN149A	Tertiary rhydacite	928	85	19	269	183	41	296
96RN149B	Tertiary rhyolite	890	87	18	244	119	38	262
96RN150	Tertiary basalt	89	44	21	7	87	36	202
96RN155	pre-Tert amphibolite	199	70	16	83	174	56	147
96RN167	Tertiary qtz syenite dike	1584	136	24	110	126	57	1075
96RN174	Eleph Mtn syenite	1848	94	19	254	713	28	239
96RN175	K mafic dike	2502	93	20	147	812	30	236
96RN184	Eleph Mtn trach syenite	2179	116	25	268	677	29	253
96RN186	Rampart gabbro	1180	39	17	15	390	33	160
96RN193	Eleph Mtn syenite	1845	89	19	241	607	26	189
96RN200	Eleph Mtn syenite	2159	102	20	223	661	27	194
96RN201	K qtz monzonite dike	2224	77	17	193	817	23	218

Table 2: Trace element data for rocks of the Tanana B-1 quadrangle and vicinity, cont.
(all concentrations in parts per million)

sample #	description	Ba	Ce	Nb	Rb	Sr	Y	Zr
96RN208B	Rampart diabase	1108	32	14	30	255	26	135
96RN209	Rampart andesite	770	52	18	22	133	36	232
96RN21	K monz S of Eleph Mtn	2681	88	22	155	665	26	106
96RN22	K diorite dike	906	59	9	24	849	19	37
96RN231	Tertiary rhyolite	66	75	22	241	14	41	141
96RN250	Tertiary basalt	4240	86	24	91	417	53	381
96RN253	Rampart diabase	140	31	13	7	187	25	99
96RN79	Eleph Mtn granite	766	71	17	293	440	20	157
96RN80	EM-alt'd granite	1040	79	21	254	412	19	156
96RN82	Eleph Mtn qtz syenite	1329	89	24	347	656	28	159
96RN84	Eleph Mtn qtz syenite	2204	103	21	247	664	30	204
96RN85A	Eleph Mtn syenite	2045	99	22	262	673	27	212
96SL142	Rampart gb S of pT amph	1141	40	18	12	149	40	151
96SL146	Rampart gabbro	637	16	14	14	296	26	109
96SL16	Eleph Mtn qtz syenite	1108	93	23	328	551	26	197
96SL161	Rampart gb S of pT amph	725	26	13	9	199	26	105
96SL29	Eleph Mtn syenite	3676	165	22	262	1229	39	304
96SL30	Eleph Mtn qtz syenite	2016	99	20	241	662	30	170
96SL31	Eleph Mtn qtz syenite	1413	87	27	309	663	29	245
96SL32	Eleph Mtn syenite	1747	82	27	323	682	29	278
96SL33	Eleph Mtn monzonite	3135	107	21	273	860	30	264
96SL36	Eleph Mtn qtz syenite	1482	95	25	296	594	30	225
96SL39B	Tr gabbro S. of VC flt	1317	34	14	6	217	27	121
98KC30	pre-C/Pz metabasalt	299	8	9	8	179	43	145
98KC37	pre-C/Pz metabasalt	220	44	7	15	347	29	141
98KC68	pre-C/Pz metabasalt	18	22	23	1	89	9	169
98KC146b	pre-C/Pz metabasalt	38	41	27	2	107	29	242
98KC149f	pre-C/Pz metabasalt	71	33	23	0	262	27	224
98KC158	Rampart diabase	5699	1·	7	13	413	24	86
98KC191	Tertiary gabbro	426	91	38	17	403	28	293
98KC192e	Tertiary basalt	1264	94	22	66	439	44	413
98KC210	Rampart gabbro	155	25	15	4	173	29	144
98KC223	Rampart basalt	264	33	14	10	396	32	170
98KC227'	Rampart gabbro	531	29	14	10	203	27	126
98KC234	Rampart gabbro	498	11	10	9	293	16	56
98KC239	pre-C/Pz metabasalt	1692	41	26	21	483	27	141
96BT330G	Rampart gabbro	461	32	12	2	299	26	88

TABLE 3: Strontium Isotopic data for quartz-poor and quartz-rich units of the Elephant Mountain Pluton

sample number	analyzed $^{87}Sr/^{86}Sr$	Rb	Sr ppm[1]	calculated[2] $^{87}Rb/^{86}Sr$	Age[3] (years)	calculated Sri[4]	description
96rn79	0.71284	293	440	1.8978	9.0E+06	0.71041	Eleph Mtn granite
96rn85a	0.71171	262	673	1.1095	9.0E+06	0.71029	Eleph Mtn syenite

Notes: [1] by XRF analysis, see Table 2; [2] from concentrations of Rb and Sr; [3] from K-Ar data
[4] Sri is the $^{87}Sr/^{86}Sr$ ratio calculated for the time of intrusion

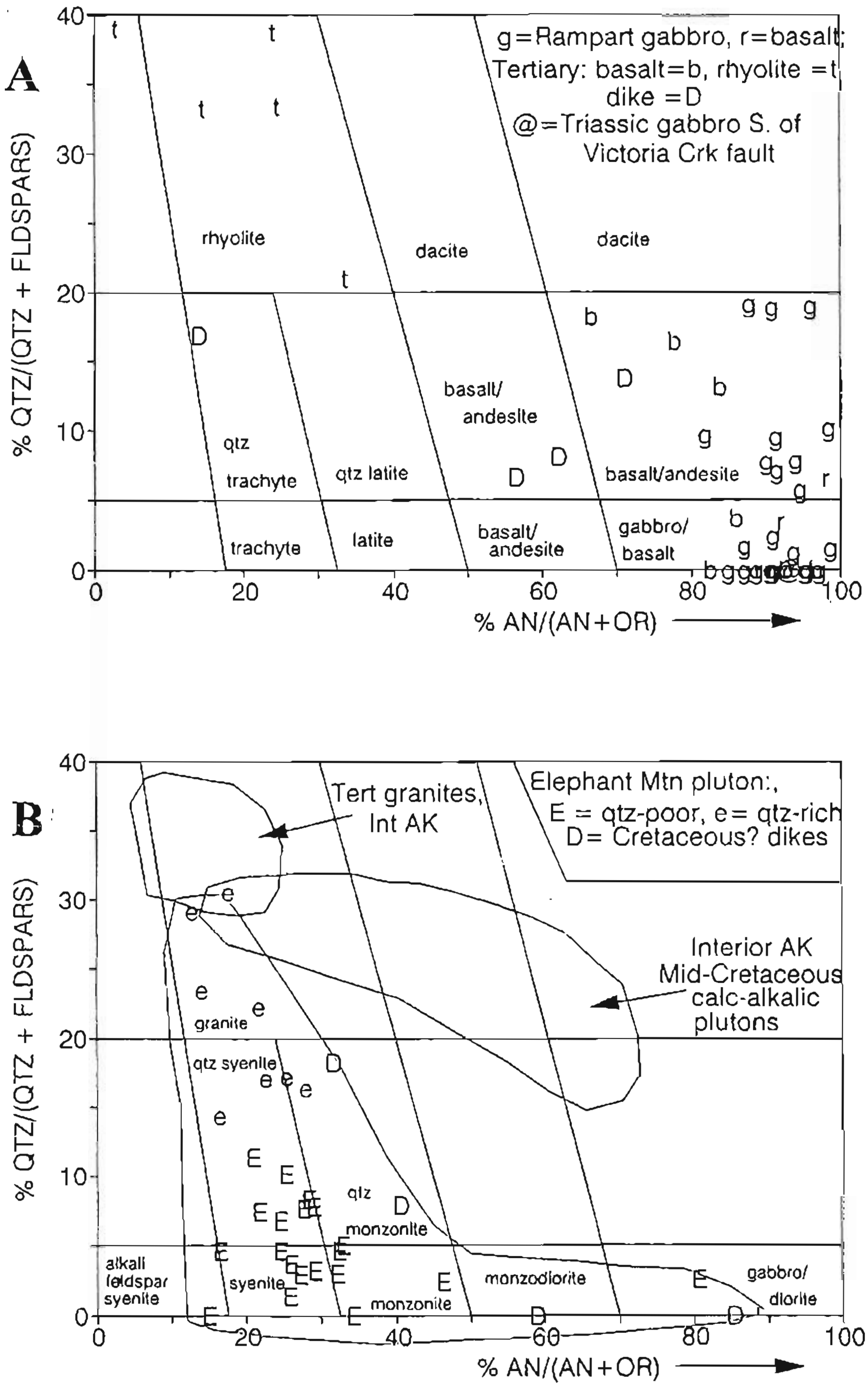


Fig. 1: Normative classification of Rampart area igneous rocks, employing the classification scheme of Streckeisen and LeMaitre (1979). A = Triassic and Tertiary rocks, B = mid-Cretaceous rocks. Interior Alaska granite fields from Newberry and Solie (1995). Data from this study.

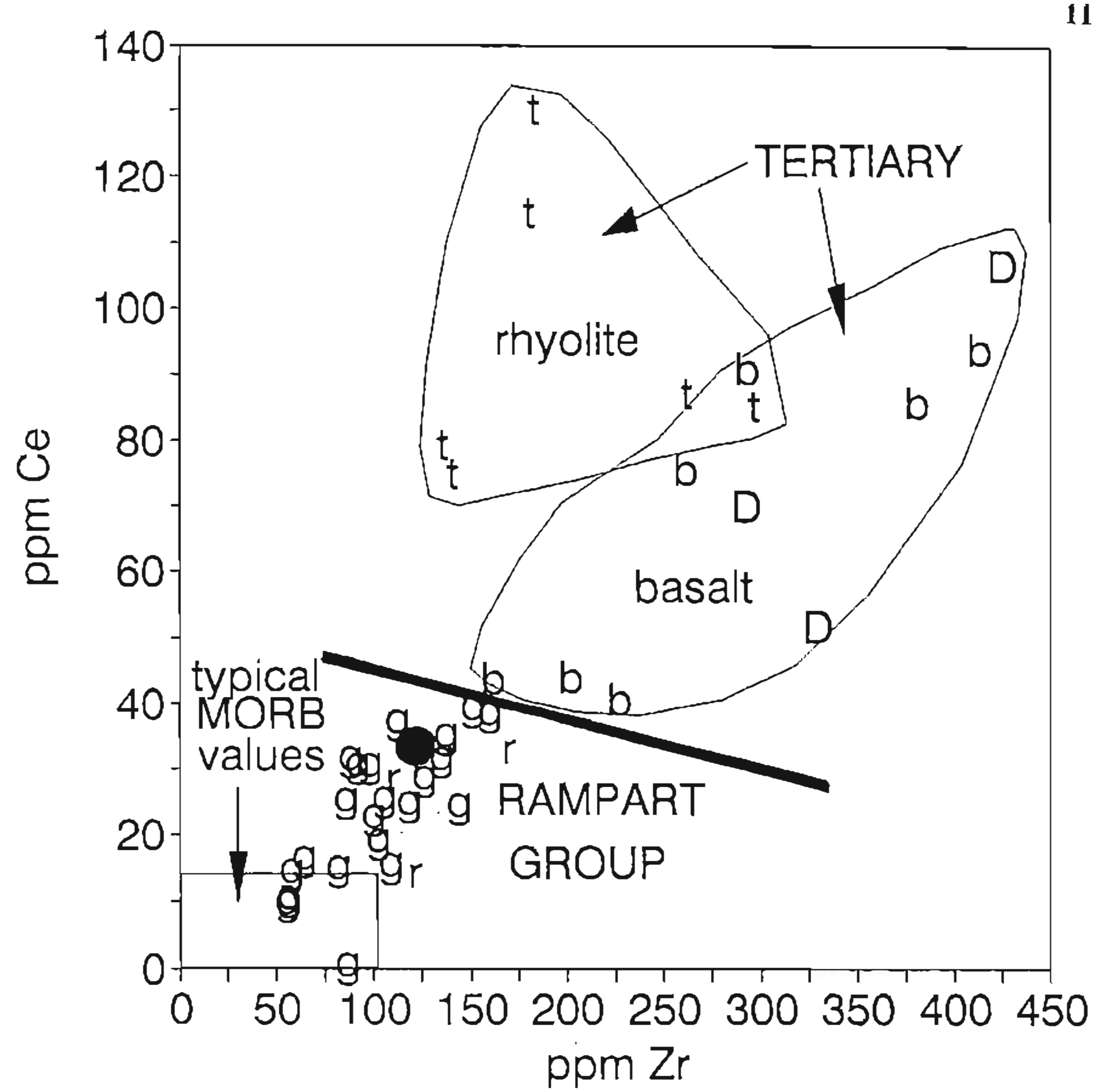


Fig. 2. Cerium vs. Zirconium concentrations (in parts per million) for Tertiary and Triassic igneous rocks of the Rampart area. Symbols as in Fig. 1A. Data from this study.

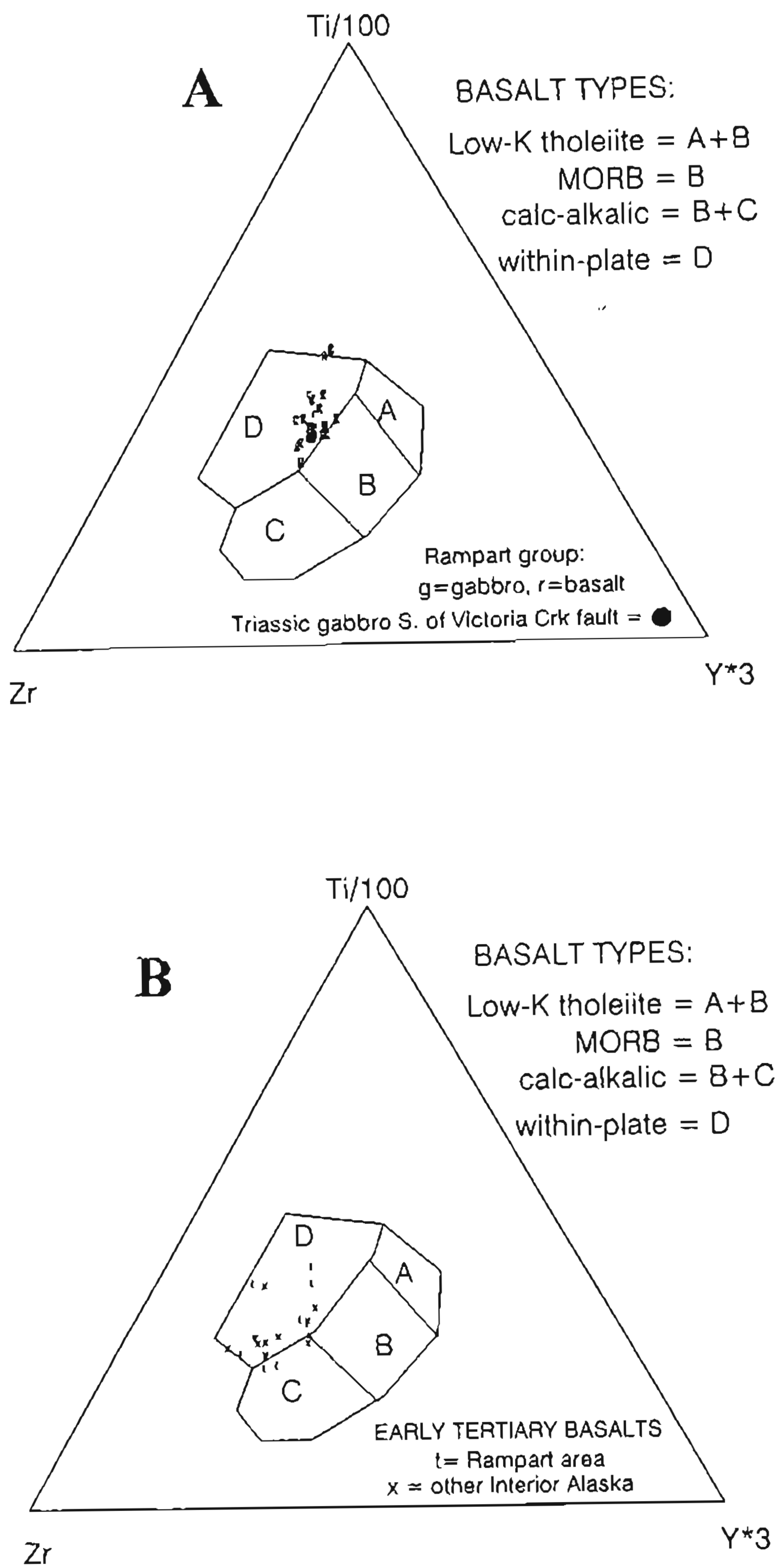
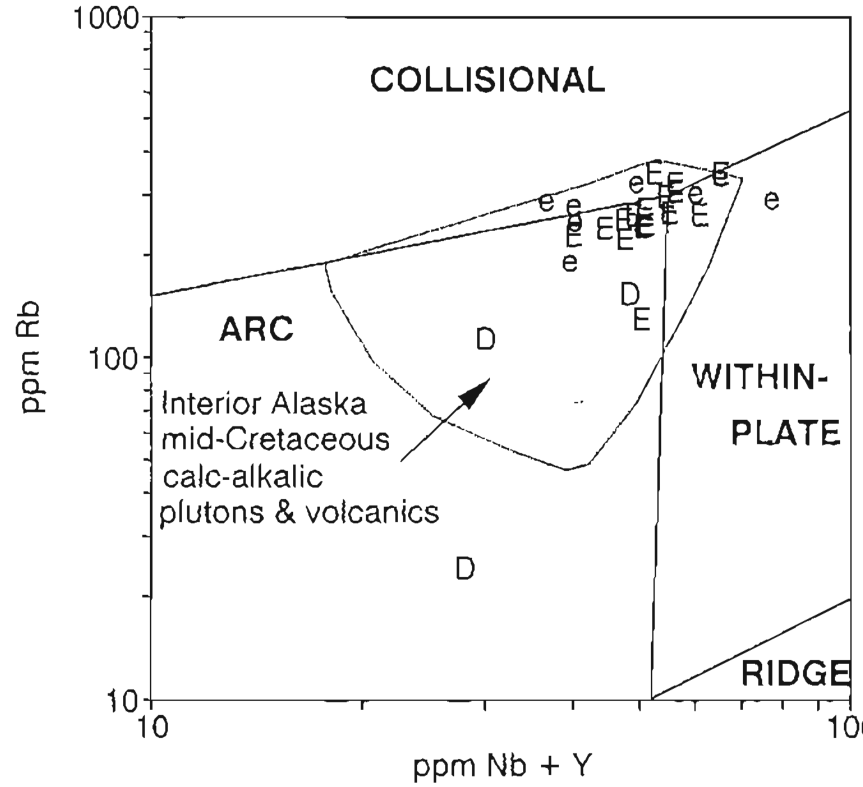


Fig. 3. Tectonic classification of basaltic and gabbroic rocks from the Rampart area, using the scheme of Pearce and Cann (1973). A = Triassic rocks, B = Tertiary rocks. Data from Newberry and Solie (1995) and this study.



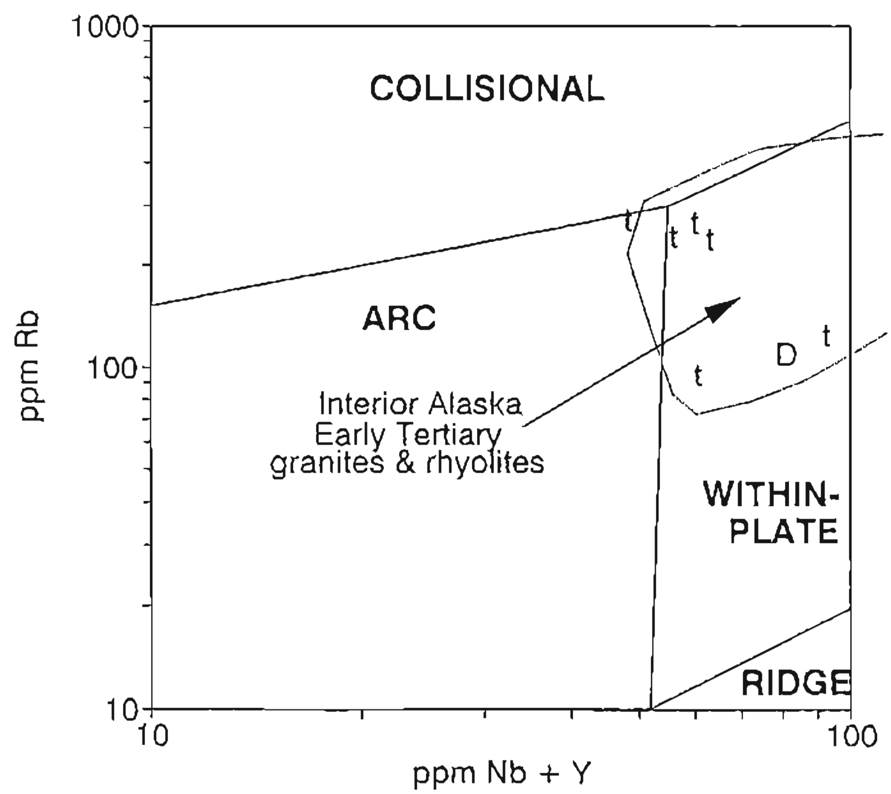


Fig. 4. Tectonic classification of granitic rocks from the Rampart area, employing the scheme of Pearce and others (1984). A = mid-Cretaceous rocks, B = Tertiary rocks. Symbols as in Fig. 1. Interior Alaska granite fields from Newberry and Solie (1995). Data from this study.

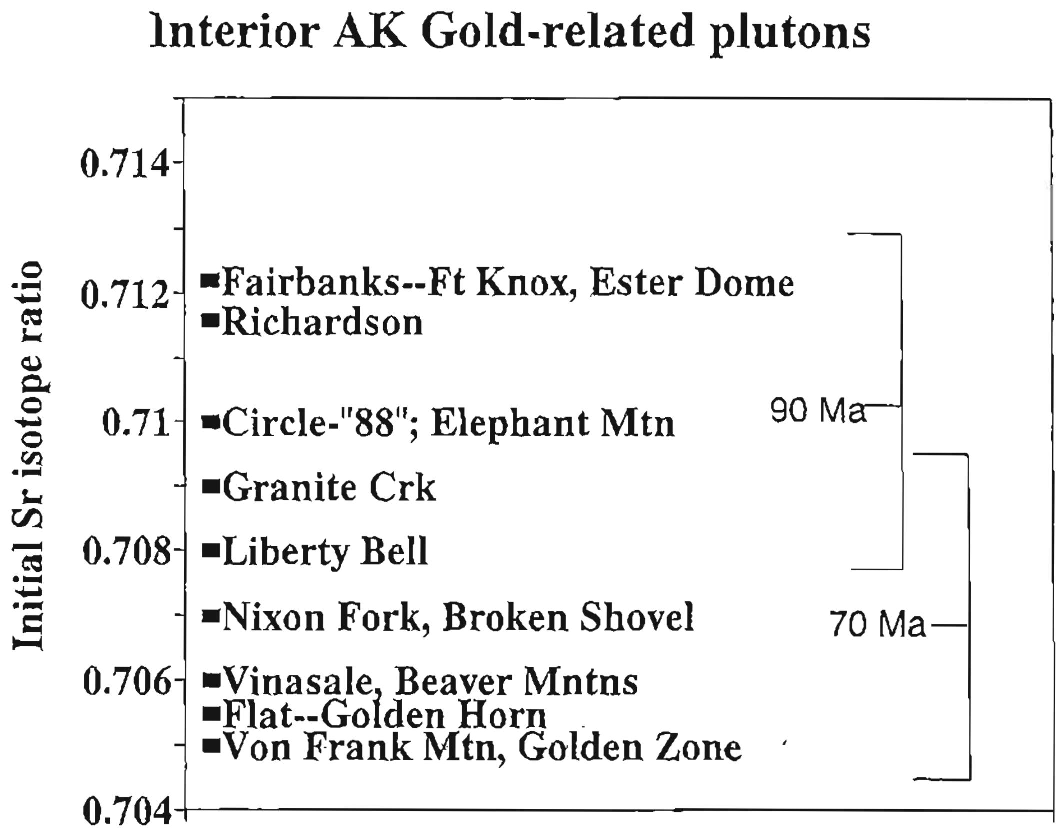
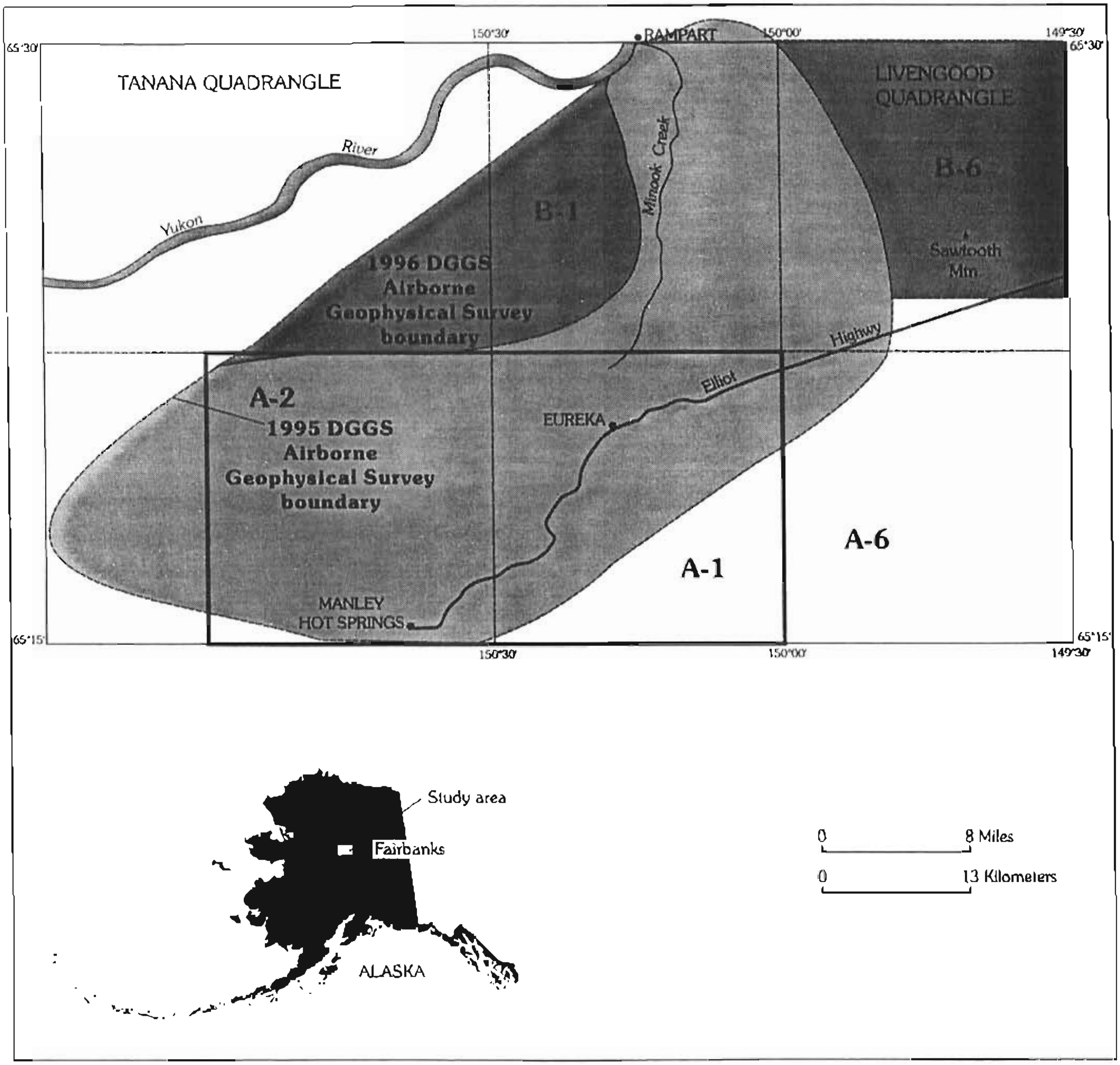


Fig. 5. Initial $^{87}Sr/^{86}Sr$ isotopic ratios from the Elephant Mountain pluton, compared to those of other Interior Alaskan plutons. Data from Newberry and Solie (1995) and this study.



Appendix 1. Location map of the Tanana B-1 Quadrangle and the surrounding area.