Are mafic dykes in the Nor and Hart River areas of the Yukon correlative to the Bonnet Plume River Intrusions? Constraints from geochemistry

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ABSTRACT

Samples of mafic to intermediate dykes were collected from the Nor and Hart River areas of the Yukon in regions underlain by metasedimentary rocks and breccia that have been correlated to Wernecke Supergroup and/or Wernecke Breccia. The samples were analysed for whole-rock and trace-element geochemistry and the results compared to those for intrusive suites in the northern Yukon.

RÉSUMÉ

Des échantillons de dykes mafiques à intermédiaires ont été prélevés dans les roches et les brèches métasédimentaires de la région des rivières Nor et Hart, pour lesquelles une corrélation a été établie avec le Supergroupe de Wernecke et les brèches de Wernecke. Ces échantillons ont été soumis à des analyses géochimiques de la roche entière et des éléments traces. Les résultats ont été comparés à ceux obtenus pour les suites intrusives dans le nord du Yukon.

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INTRODUCTION

The Wernecke and Ogilvie mountains of the northern Yukon are largely underlain by metasedimentary rocks of the Wernecke Supergroup (WSG; Fig. 1; *e.g.*, Delaney, 1981; Abbott, 1997; Thorkelson, 2000). The Supergroup is host to a regional-scale mineralized breccia system known as Wernecke Breccia that is being actively explored for iron oxide-copper (± U ± Au) deposits (*e.g.*, Yukon MINFILE, Deklerk and Traynor, 2005; Hunt *et al.*, 2005). The absolute age of the Supergroup is not known but is constrained by the *ca.* 1710 Ma age of cross-cutting mafic to intermediate dykes and sills of the Bonnet Plume River intrusive suite (Thorkelson *et al.*, 2001).

Metasedimentary rocks and breccia also locally underlie the Nor and Hart River areas (Fig. 1). Little is known about these rocks, but they have been interpreted to be correlative with those of the WSG and Wernecke Breccia (*e.g.,* Norris, 1997; Abbott, 1997). Like those in the Wernecke and Ogilvie mountains, metasedimentary rocks in these areas are cut by mafic to intermediate dykes. Samples of the dykes were collected for geochemical and geochronological analyses to determine if they are correlative with the Bonnet Plume River intrusive suite. This paper presents the results of the geochemical analyses. Dating of the samples is currently taking place at the University of British Columbia.

BONNET PLUME RIVER INTRUSIONS – PREVIOUS WORK

The Bonnet Plume River Intrusions (BPRI) were emplaced as short dykes and small stocks, and most are composed of fine- to medium-grained diorite and gabbro; other (rare) compositions include syenite and anorthosite (Thorkelson, 2000; Thorkelson *et al.*, 2001). Primary mineralogy of the dioritic intrusions is dominated by plagioclase and clinopyroxene. However, regional low-grade metamorphism associated with the Paleoproterozoic Racklan orogeny and metasomatic alteration related to emplacement of the Wernecke Breccias have typically altered the mineral assemblage (*ibid.*). For example, pyroxene has altered to chlorite or actinolite, and plagioclase is pseudomorphed by sericite or scapolite. Other metasomatic effects include the introduction of hematite, magnetite, silica, carbonate, pyrite and chalcopyrite, in addition to sodium and potassium.

Generally, BPRI have a significant degree of large-ion lithophile element (LILE) enrichment and steep down-to-the-right trace-element profiles with modest depletions of Nb and Zr (Fig. 2a; Thorkelson *et al.*, 2001). Based on the geochemical data, Thorkelson *et al.* (2001) suggest that the BPRI were generated from mantle similar to that involved in the genesis of normal Mesozoic and Cenozoic sea floor. They suggest that the geochemical data are best explained by relatively small degrees of mantle anatexis,

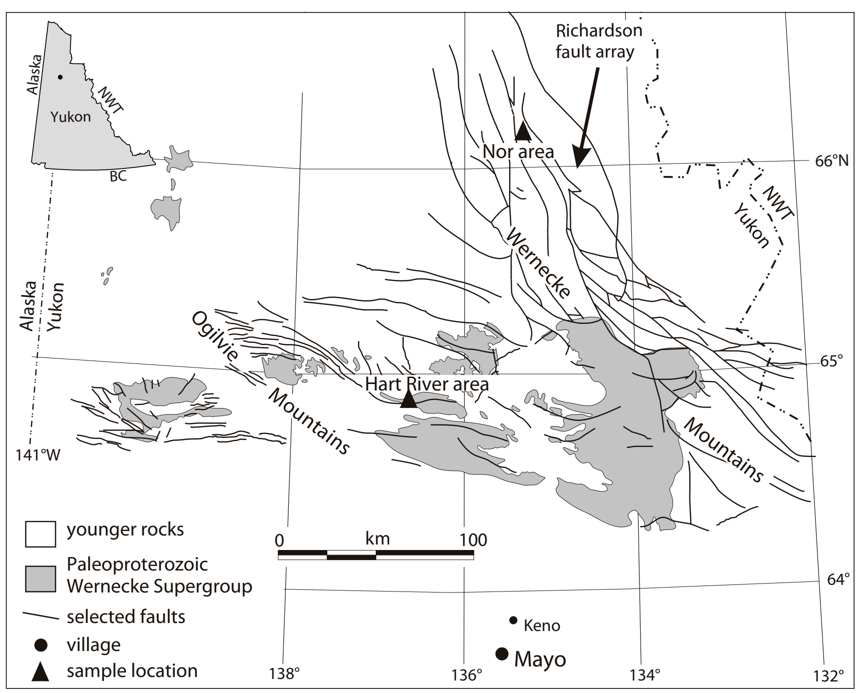

Figure 1. *Location map showing Nor and Hart River areas.*

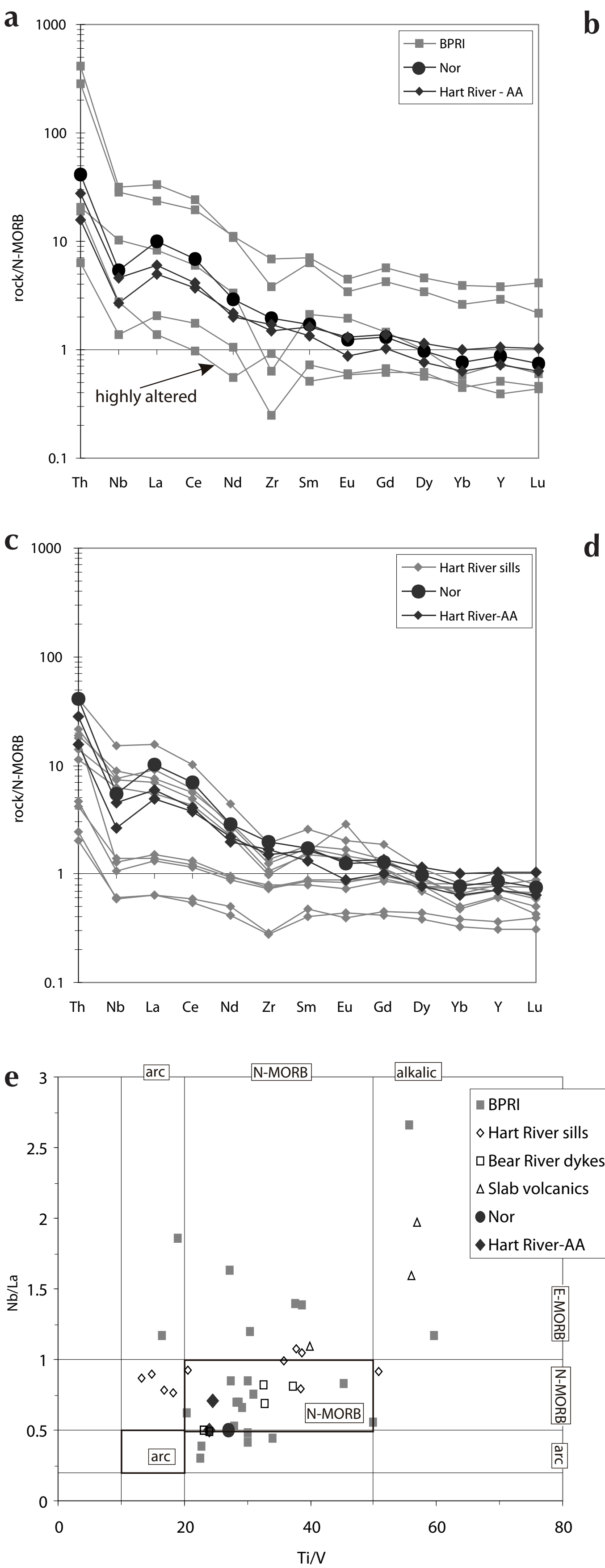

*Figure 2. Geochemical diagrams for the Nor and Hart River samples compared to those of intrusive suites in the northern Yukon. **(a) to (d)** N-MORB-normalized trace-element profiles: **(a)** compared to ca. 1710 Ma Bonnet Plume River Intrusions; **(b)** compared to > 1600 Ma Slab volcanics; **(c)** compared to ca. 1380 Ma Hart River sills; **(d)** compared to ca. 1270 Ma Bear River dykes; **(e)** bivariate plot using elemental ratios for distinguishing tectonic affinity (after Gill, 1981 and Shervais, 1982).*

possibly coupled with crustal assimilation; genesis in an extensional continental environment is their favoured interpretation.

PRESENT STUDY

LOCATION AND FIELD RELATIONS

Nor Area

The Nor area is located in the southern Richardson Mountains of north central Yukon, approximately 275 km north of the town of Mayo, and includes the Ewen (Nor) MINFILE occurrence located at 66°15'N, 135°23'W on NTS map sheets 106L/3 and 6 (Fig. 1; Yukon MINFILE 106L 061, Deklerk and Traynor, 2005). The Nor area is underlain by metasedimentary rocks that are likely correlative with the Fairchild Lake Group of the Wernecke Supergroup. These rocks are cut by hematitic breccia similar in appearance to bodies of Wernecke Breccia.

Subcrop, approximately 10 m x 3 m, of medium-grained, dark green chloritic 'syenite' occurs in an area of breccia (location: NAD83, UTM E0482884, N7349174, Zone 8). Specular hematite occurs locally on fractures within the syenite. Additional subcrop (~10 m x 2 m) of 'syenite' occurs approximately 1 km to the south (location: NAD83, UTM E0482697, N7348130, Zone 8); here, grey carbonate veins up to 1 cm across cut the syenite. A sample of the syenite was collected for petrographic and geochemical analyses and geochronology (sample JH05-22; Table 1).

Hart River Area

The Hart River area is approximately 150 km northwest of the town of Mayo and includes the AA mineral property located at 64°50'58" N, 136°40'48"W on NTS map sheet 116A/15 (Fig. 1). The AA area is underlain by metasedimentary rocks that are likely correlative with the Fairchild Lake and Quartet groups of the Wernecke Supergroup (Norris, 1997). Like the Nor area, the metasedimentary rocks are cut by hematitic breccia similar in appearance to bodies of Wernecke Breccia.

Subcrop (~10 m x 2 m) of medium-grained, dark green-grey, chloritic, weakly foliated diorite (location: NAD83, UTM E0419922, N7192733, Zone 8) occurs within limey, fine-grained metasedimentary rocks that are locally brecciated. Blebs of sulphide minerals up to 5 cm across and red iron-staining occur locally within the diorite. Additional diorite outcrops approximately 1 km to the east within an area of breccia (location: NAD83, UTM E0421245, N7192037, Zone 8). This diorite is medium- to fine-grained, dark to medium green, and chloritic. Minor disseminated epidote, specular hematite and specular hematite-bearing quartz veins occur locally within the diorite. Samples of the diorite were collected for petrographic and geochemical analyses and geochronology (samples JH05-H56 and JH05-H57; Table 1).

GEOCHEMISTRY

Samples from the Nor and Hart River areas were analysed by x-ray fluorescence for major oxides and by research-grade inductively coupled plasma mass spectrometry for trace elements; results are in Table 1.

The samples are somewhat altered; however, aspects of original composition can be revealed by using elements of relatively low mobility (*cf.* Thorkelson *et al.*, 2001). Figure 2 shows profiles of selected high-field-strength elements (HFSE), including rare-earth elements (REE) that have been normalized to normal mid-ocean ridge basalt (N-MORB). For comparative purposes, the Nor and Hart River area samples are plotted along with results for Bonnet Plume River Intrustions (BPRI; Thorkelson *et al.*, 2001) and other intrusive suites known to occur in the northern Yukon. BPRI data are from Thorkelson *et al.*, 2001. Remaining comparative data are from the Yukon Geochemical Database (Héon, 2003).

Results for the Nor and Hart River areas samples are similar (Fig. 2 a to d). They plot in the middle of the range for *ca.* 1710 Ma BPRI, have values lower than those of the >1600 Ma Slab volcanics, plot towards the upper part of the range for *ca.* 1380 Ma Hart River sills and are similar to *ca.* 1270 Ma Bear River dykes. Figure 2e is a bivariate plot that indicates tectonic affinity. The Nor and Hart River area samples plot in the N-MORB field and are similar to the BPRI and Bear River dykes in this respect.

SUMMARY

Geochemical results for samples of mafic to intermediate rocks from the Nor and Hart River areas are similar to those for a number of intrusive suites in the northern Yukon (Fig. 2). Thus, they cannot be definitively correlated with a particular regional intrusive suite based solely on chemistry. Results of geochronology, currently underway at the University of British Columbia, should help resolve this.

Table 1. *Geochemical analyses of samples from Hart River and Nor areas.*

sample #	**JH05 22**	**JH05 H56**	**JH05 H57**
material:	**syenite**	**diorite**	**diorite**
NTS map area:	**106L/6**	**116A/15**	**116A/15**
UTM Easting:	**482884**	**419922**	**421245**
UTM Northing:	**7349174**	**7192733**	**7192037**
SiO_2	50.03	52.23	48.53
Al_2O_3	13.57	12.78	14.02
Fe_2O_3	10.04	10.08	16.97
MnO	0.13	0.18	0.12
MgO	7.41	6.52	6.07
CaO	7.36	7.06	4.77
Na_2O	5.03	3.97	3.71
K_2O	0.71	0.61	0.78
TiO_2	1.03	0.88	1.73
P_2O_5	0.11	0.09	0.16
Cr_2O_3	0.05	0.03	0.01
LOI	4.57	4.71	2.56
original totals	100	99.14	99.41
V	229	215	434
Cr	340	200	60
Co	36	34	51
Ni	130	90	50
Cu	80	10	40
Zn	40	100	<30
Ga	18	15	19
Ge	2.2	1.8	2.4
As	<5	<5	<5
Rb	19	9	25
Sr	96	69	115
Y	24.2	20.1	29.3
Zr	146	125	110
Nb	12.7	10.6	6.2
Mo	<2	<2	<2

sample #	**JH05 22**	**JH05 H56**	**JH05 H57**
material:	**syenite**	**diorite**	**diorite**
NTS map area:	**106L/6**	**116A/15**	**116A/15**
UTM Easting:	**482884**	**419922**	**421245**
UTM Northing:	**7349174**	**7192733**	**7192037**
Ag	<0.5	<0.5	<0.5
In	<0.1	0.2	0.1
Sn	<1	<1	<1
Sb	3	2.9	3.1
Cs	0.6	0.5	0.5
Ba	157	89	141
La	25.2	14.9	12.3
Ce	51.8	30.6	28.1
Pr	5.91	3.73	3.82
Nd	21.2	14.5	15.9
Sm	4.54	3.49	4.3
Eu	1.27	0.892	1.33
Gd	4.77	3.75	5.03
Tb	0.8	0.63	0.91
Dy	4.46	3.51	5.27
Ho	0.88	0.71	1.08
Er	2.48	2.09	3.16
Tm	0.374	0.309	0.479
Yb	2.36	1.94	3.07
Lu	0.339	0.29	0.473
Hf	3.4	3	2.7
Ta	0.93	0.73	0.49
W	0.6	0.6	<0.5
Tl	<0.05	0.09	0.09
Pb	<5	10	<5
Bi	0.4	2.3	1.2
Th	4.96	3.36	1.89
U	3.72	0.81	0.37

Note: Sample locations are in Fig. 1. Major oxides are in wt.% and trace elements in ppm. LOI, loss on ignition (as reported in original total. NTS, National Topographic system; UTM, Universal transverse Mercator coordinates (Zone 8); Original total, all oxides plus LOI as reported by the laboratory.

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