THE PETROGENESIS OF MAFIC DIKES AND THEIR RELATIONSHIP TO THE COAST STEEP ZONE, PRINCE RUPERT, BRITISH COLUMBIA

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INTRODUCTION

The Central Gneiss Complex (CGC) of coastal British Columbia lies east of a major N30W lineament known as the Coast Steep Zone (Davidson et al., this volume). Mafic dikes are abundant in the CGC along the Skeena River from Prince Rupert to Terrace, specifically between longitude 129°45.705' and 129°00.348'. The Mafic dikes crosscut most structures of the CGC, are rare in the Coast Steep Zone (CSZ), and have not been noted west of the CSZ. Information on the dikes is sparse although Hutchinson (1982) reported a north strike for the dikes along the Skeena River (See Fig. 2 in Davidson et al., this volume) between Telegraph Point and the mouth of the Exstew River.

The project focuses on three main questions. What is the nature and origin of the dikes? What is the structural relationship of the dikes to the CSZ? What is the age relationship of the dikes to the CSZ and the surrounding country rocks? The methods used to address these questions include field descriptions and measurements, thin section petrography, whole-rock geochemical analysis, and Ar^{40}/Ar^{39} dating.

STRUCTURAL RELATIONSHIPS

A total of 130 dikes were evaluated in the field. The dikes range in width from 5 cm to 4 meters with a typical width of 20cm – 50cm. They encompass approximately 0.1% of the total outcrop area. All dikes were located using a GPS unit and measured for structural orientation (Fig. 1). The dikes strike north to northwest with 37% striking N30W $\pm$ 10°. A majority of the dikes are vertical or near vertical, the lowest recorded dip for a single dike was 55°. The dikes have variable dip directions.

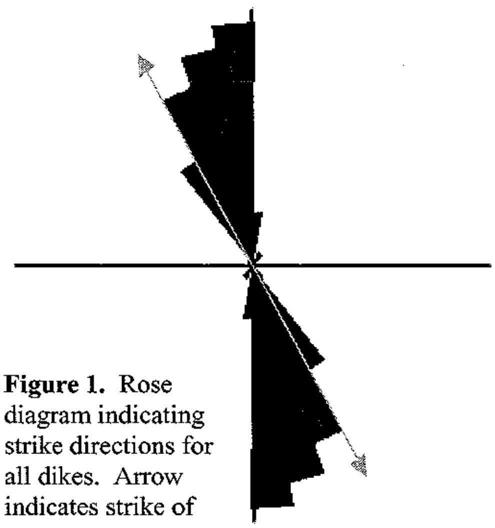


Figure 1. Rose diagram indicating strike directions for all dikes. Arrow indicates strike of CSZ.

FIELD DESCRIPTIONS AND PETROGRAPHY

In general, the dikes are melanocratic and fine-grained, have sharp contacts with the country rock, and many have chill margins. Forty-two samples were collected for thin section analysis based on spatial representation and accessibility. A modal analysis of each thin section was completed at 600 counts per slide in order to achieve a statistical representation with a 95% confidence interval. Textural analysis of each thin section was completed in order to evaluate the crystallization and alteration history of the rock.

Overall the thin sections are fine-grained, with no preferred orientations. Seven minerals compose the majority of the thin sections with hornblende, plagioclase, and biotite, accounting for approximately 70% of the minerals in the samples. In general the hornblende grains range from 0.5mm-1.0mm, are mostly euhedral to subhedral and have no preferred orientation. Plagioclase grains are fine to very fine-grained and constitute the bulk of the groundmass. Biotite grains are fine-grained and subhedral with no preferred orientation. Alteration throughout the samples is mostly moderate. Locally, plagioclase is ophitic. Many of the samples are vesiculated. Most vesicles have calcite infill with minor amounts of secondary plagioclase.

ROCK GEOCHEMISTRY

Twenty-five representative samples were selected for geochemical analysis. Major and selected trace elements were analyzed by X-ray fluorescence at Michigan State University. Additional elemental analysis, including rare earth element analysis, was performed on these same samples utilizing an ICP-MS at the same location. The major and trace element data were characterized and modeled using the computer program IGPET.

The chemical composition of the dikes is represented in Figures 2 and 3. There are three groupings. The majority of the samples have 40-45% SiO_2 content, the middle group contains one sample with 55% SiO_2, and the final group has 3 samples between 63%-65% SiO_2. Trace element data, with the exception of some large ion lithofile elements, reflect major element chemistry.

Figure 2. K_2O vs. SiO_2 plot

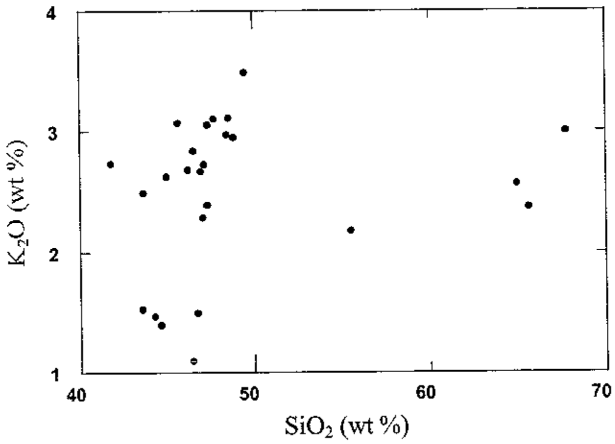
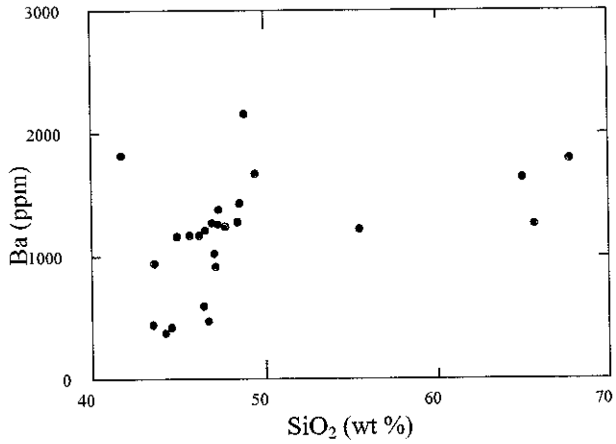


Figure 3. Ba vs. SiO_2 plot



A chemical classification of the samples is represented in Figure 4. A comparison of SiO_2 and Alkalies indicate that most of the samples plot in the alkaline field. One sample on the boarder and the samples in the subalkaline field correspond to the middle and higher SiO_2 compositions, respectively.

Compositional fields of the dikes based on alkalies and SiO_2 are plotted in Figure 5. The samples dominantly lie in the tephrite basanite and trachy-basalt fields. Essentially these are basaltic dikes with elevated levels of alkalis. The four extraneous points fall in the trachy-andesite and dacite fields.

Figure 4. Classification plot of alkalies vs. SiO_2 plot (Irvine and Baragar, 1971).

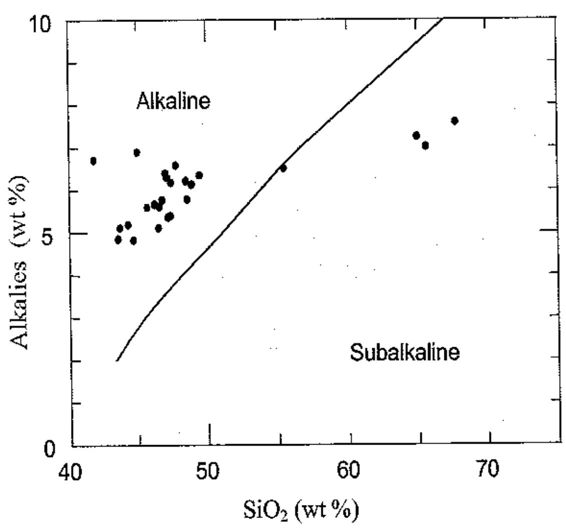
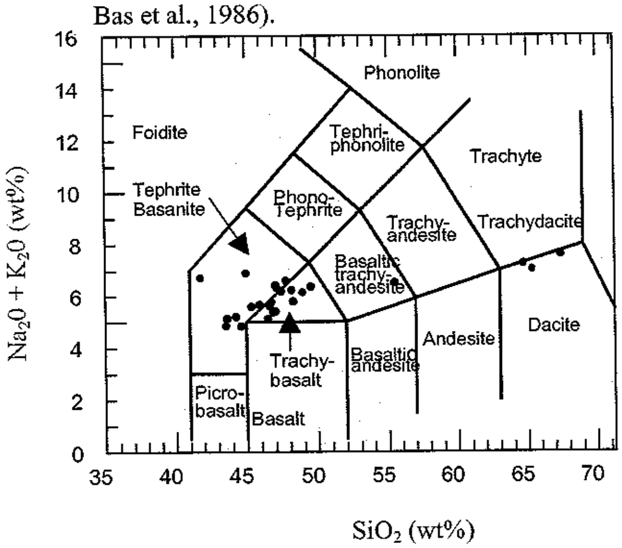


Figure 5. Compositional fields of volcanic rocks in terms of total alkalies and silica (Le Bas et al., 1986).



DISCUSSION

The majority of the dikes are low silica (less than 50% SiO_2) with elevated alkalies (Fig. 4). On various tectonic plots (Figs. 6-8) the dikes dominantly fall within the fields of ocean island, ocean island alkali, and within plate, respectively. A subduction signature is absent for the low silica samples. The origin of this magma is inferred to be the result of low degrees of partial melting of the mantle. The variation in the chemistry of this magma, particularly the incompatible trace elements (Figs. 9 & 10), could be accounted for by different degrees of partial melting. Conversely, and less likely, the variation could be accounted for by a heterogeneous mantle source.

The structural relationship between the dikes and the Coast Steep Zone is unclear. However the mafic dikes are not found west of the CSZ (at the latitude of Prince Rupert) and the three-dimensional orientation of the dikes and the CSZ are nearly coincident (Fig. 1). The origin of the lower silica magma is consistent with derivation from a deep-seated source, the mantle. Seismic data indicates that the CSZ is truly crustal-scale and is nearly vertical from the surface to the Moho (Morozov et al., 1998). By inference, the mechanism that produced the CSZ might have some structural control on the orientation and spatial emplacement of the dikes.

Preliminary Ar^{40}/Ar^{39} data from hornblende and biotite grains from a dike that cuts the Quottoon pluton (Fig. 2 in Davidson et al., this volume) suggests that these dikes are older than 46 Ma (Rodriguez, unpublished data). The Quottoon pluton has an age range of 55-60 Ma and the Kasiks sill which intruded sillimanite-grade migmatitic country rocks has an age of 53 Ma (Hollister and Andronicos, 2000). Both are cut by mafic dikes that contain vesicles and have fine-grained chill margins. Therefore, several kilometers of denudation and rapid cooling must have occurred within 7 Ma between the emplacement of Kasiks pluton and the intrusion of the mafic dikes.

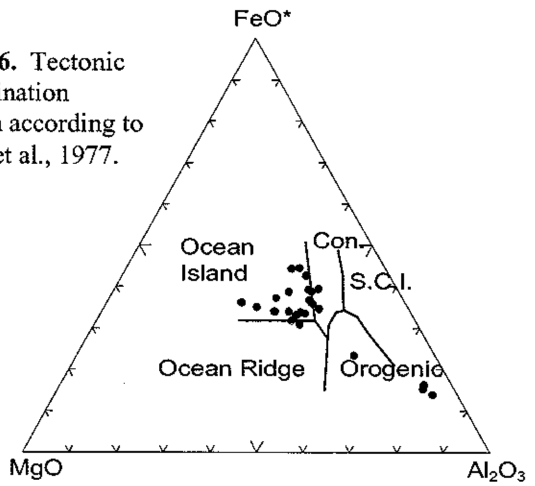


Figure 6. Tectonic discrimination diagram according to Pearce et al., 1977.

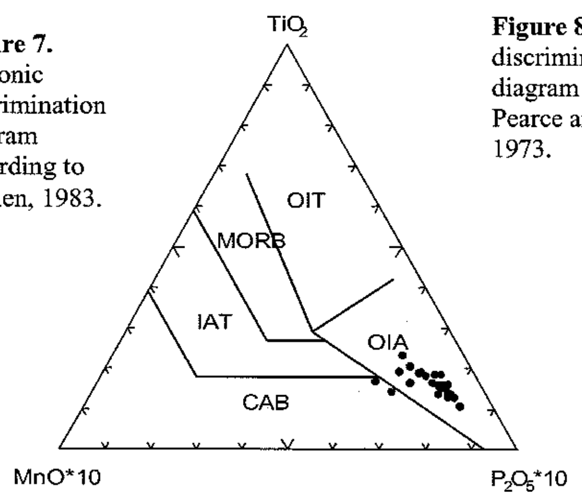


Figure 7. Tectonic discrimination diagram according to Mullen, 1983.

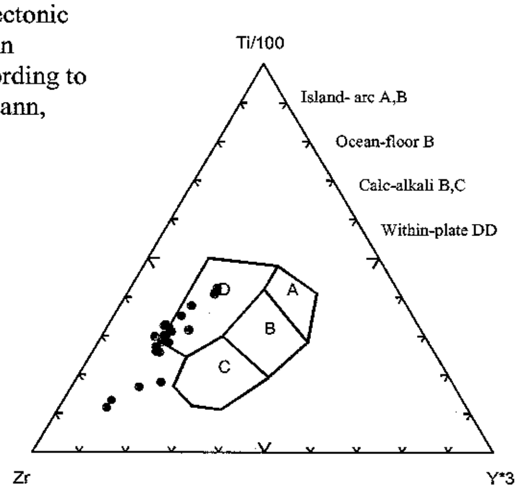
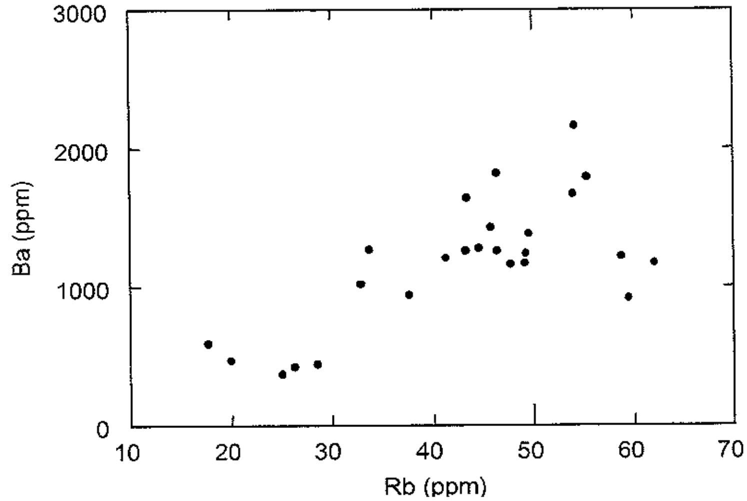


Figure 8. Tectonic discrimination diagram according to Pearce and Cann, 1973.



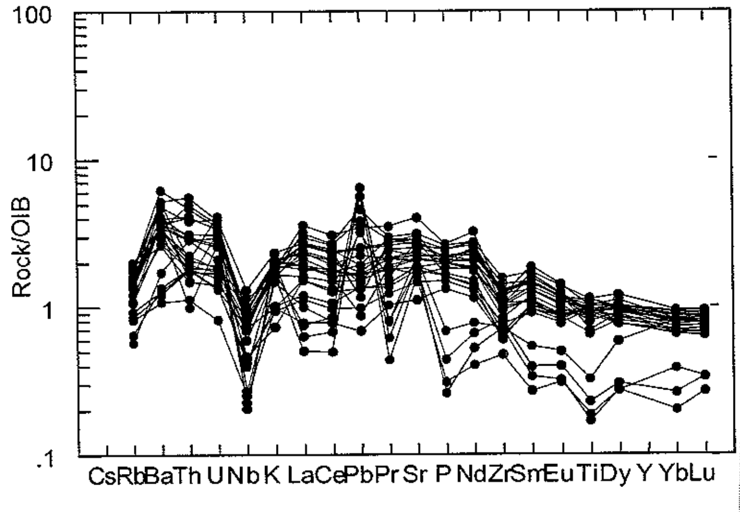


Figure 9. Ba vs. Rb incompatible element plot.

Figure 10. Spider diagram normalized to ocean island basalts (Sun and McDonough, 1989).

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