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CLASSIFICATION OF THE CRETACEOUS VOLCANIC SEQUENCES OF BRITISH COLUMBIA AND YUKON*

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INTRODUCTION

Cretaceous arc sequences of British Columbia and Yukon are of limited extent when compared to those of the Triassic-Jurassic period. They are mostly subalkaline but show such remarkable differences in their potash and soda contents that they seemed worthy of a detailed investigation.

Such investigation entails determining and describing magmatic trends, classifying the sequences, and comparing them to Recent suites. Three problems confronting the researcher at the start are: the confusing nomenclature expressing alkali and iron contents and trends; the absence of a classification of volcanic arcs which would reflect differences in potash content; and the difficulty of determining the original alkali and lime contents of altered sequences. In consequence, a discussion of proposed changes in nomenclature, of a new classification of arcs and suites, and of a method for screening "unaltered" data will introduce this study of the Cretaceous volcanic sequences. The revised nomenclature and screening method were developed earlier (de Rosen-Spence, 1976), but the new classification of arcs and suites proposed here is a direct outcome of the present study.

The volcanic suites for which data are available include sequences from the late Lower and Middle Cretaceous Gambier, Spences Bridge, Kingsvale, South Forks and Kasalka Groups, and the late Upper Cretaceous Mount Nansen, Hutshi and Carmacks Groups and Tip Top Hill Volcanics. This paper establishes that these sequences belong to different arc types, and to different series within these arc types: further, the suites can be compared to specific Recent suites. It is hoped that their precise classification will be useful for correlation purposes and that Recent analogs will enable reconstruction of the subduction environment in Cretaceous time.

REVISED NOMENCLATURE

ALKALI CONTENT

In his pioneering work, Kuno (1959, 1966) divided the Alkali versus SiO_2 diagram into "tholeiitic", "high-alumina" and "alkaline" domains according to the plot of the three main chains which form a full arc. It is proposed here to replace the terms "tholeiitic" and "high-alumina" by "calcic" and "calcalkaline" used with their strict chemical meaning (*see* Figure 6-8-6). This change is needed for three reasons:

(1) Standardization of nomenclature because arc tholeiitic suites are also the most calcic, with Peacock Indices of 67 to 64, and high-alumina suites are intermediate between calcic and alkaline, with Peacock Indices of 62 to 59;

(2) The domains so redefined can then also be used to describe non-arc tholeiitic suites with different alkali contents, such as the ridge tholeiitic suites of the Galapagos and Thingmuli. High-alumina arc basalts and non-arc medium-K tholeiites, which plot in the same calcalkaline domain, are well separated on the Al_2O_3 versus Alkali diagram (Kuno, 1960);

(3) Many authors are uneasy with the term "arc tholeiitic" for suites which are potassium-rich but plot in the arc tholeiitic domain, such as that of the West Carpathian arc.

IRON CONTENT

The iron-enrichment trend was originally named "tholeiitic" because it was first recognized in tholeiitic suites, whereas the trend lacking enrichment was described as "calcalkaline" because it seemed typical of the calcalkaline suite of the High Cascades and other similar continental arc sequences.

As new data on arc volcanism accumulated, it became obvious that arc volcanism was more varied than previously thought. Kuno (1950, 1959, 1966) showed that not only were there three parallel volcanic chains, composed of tholeiitic, high-alumina, and alkaline sequences, but also that so-called "tholeiitic" and "calcalkaline" trends could be found in any of the three suites, even within a single volcano. To avoid confusion, he redefined the Fe-rich and Fe-poor suites as "pigeonitic" and "hypersthenic" respectively on the basis of the groundmass pyroxene, and showed that they are well separated on the AFM diagram (Kuno, 1954; Aramaki, 1963). Now these terms are rarely used; most authors use the old terminology, with resulting confusion. It is therefore proposed that the terms "Fe-rich" and "Fe-poor" replace the older terms as being more descriptive of the iron-enrichment trend (de Rosen-Spence, 1976). Calcalkaline should be reserved for a specific alkali content as defined on the Alkali versus SiO_2 diagram, and tholeiitic used only for true tholeiites.

When dealing with altered sequences the AFM diagram becomes inaccurate because it is sensitive to any gain of alkali or magnesium. It is then preferable to use MgO versus FeO_T or FeO_T versus SiO_2 diagrams (de Rosen-Spence, 1976).

CLASSIFICATION OF SUITES AND ARCS

Potassium is an essential element in the classification of suites and arcs. It is now well documented that potassium increases across an island arc because it reflects depth to the Benioff zone (Sugimura, 1960; Kuno, 1966; Dickinson, 1968); however, arcs may differ from one another in their potash contents (Jakes and White, 1972).

Two diagrams are useful in evaluating the potassium content and classifying the diverse suites and arcs. These are: (1) the K_2O versus SiO_2 diagram of Gill (1981), modified to include basalts, rhyolites and alkaline potassic suites (Spence, 1985), and (2) the K_2O versus Na_2O (for 70 per cent SiO_2) diagram developed here.

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POTASH CONTENT WITHIN A SINGLE ARC

The low-K (LK), medium-K (MK) and high-K (HK) domains on the K_2O versus SiO_2 diagram (Figure 6-8-1) are used mainly to describe the potassium content of a suite, bearing in mind that actual trends may be steeper than the domain boundaries and that an additional sharp increase in K_2O may occur in the rhyolites. On this diagram, the three series of any single arc are well separated by sharp boundaries. In some cases, as in the Cascades, the calcalkaline series itself can be subdivided (Wise, 1969, page 1003) into a "true Cascades" type (Mount Hood) with a Peacock Index of 62, and a "high-alumina" type (Badger Butte, Newberry) with a Peacock Index of 60.5, perhaps on the verge of being alkaline. If, however, arcs with different potash contents are plotted on the same diagram, there is a marked overlap of the calcic, calcalkaline and alkaline series of the different arcs. This is well shown in Figure 6-8-1 by the three positions of the alkaline and calcic boundaries of the Cascades (I), Honsyu and Hokkaido (II) and West Carpathian and Eolian (III) arcs.

POTASH CONTENT OF ARCS AND THEIR CLASSIFICATION

The new diagram presented here is K_2O versus Na_2O for 70 per cent SiO_2 (Figure 6-8-2). It takes into account the antipathetic variation of sodium and potassium in suites which have the same total alkali content but different potash content (up to 1.5 per cent difference). It was designed for 70 per cent SiO_2 to offer a more open plot, although this has the disadvantage that K_2O must be projected on K_2O versus SiO_2 when dealing with less siliceous sequences. This diagram was constructed with data from Kuno (1962) Fiske *et al.* (1963), Karolus *et al.* (1968), Wise (1969), Gill (1970), Ewart *et al.* (1973), Higgins (1973), Barbieri *et al.* (1974) and Cantagrel *et al.* (1981). On it, arcs can be classified into three types, each containing calcic, calcalkaline and alkaline series:

Type I (more sodic): Izu, Fiji, Cascades,
Type II (moderately sodic): Tonga, Honsyu, Hokkaido,
Type III (less sodic): West Carpathian, Eolian arcs.

Among the calcic series, the low-K arc tholeiitic suites of Fiji and Izu Islands (Type I), and of Tonga (Type II) were deposited on thin oceanic crust, whereas the medium-K pre-Mount Hood dacites, Shasta and Hakone (Type I) and Honsyu-Hokkaido arc tholeiitic suites (Type II) were deposited on thicker crust. The unusual West Carpathian arc has the highest K_2O content of the calcic series, and is considered to be an intracontinental arc deposited on thick continental crust, possibly above subducted continental crust (Channel and Horvath, 1976).

CLASSIFICATION OF RECENT SUITES

Table 6-8-1 illustrates how Recent suites are classified according to their total alkali, potash and iron contents using Alkali versus SiO_2, K_2O versus SiO_2, Na_2O versus K_2O for 70 per cent SiO_2 and AFM or FeO_T versus SiO_2 diagrams. When rhyolites are absent from the sequence plotted, Na_2O and K_2O values for 70 per cent SiO_2 were projected on Na_2O versus and K_2O versus SiO_2. Na_2O does not increase above 65 per cent SiO_2 whereas K_2O tends to increase more rapidly, and care must be taken that the projected values fall in the appropriate total alkali domain on Na_2O versus K_2O.

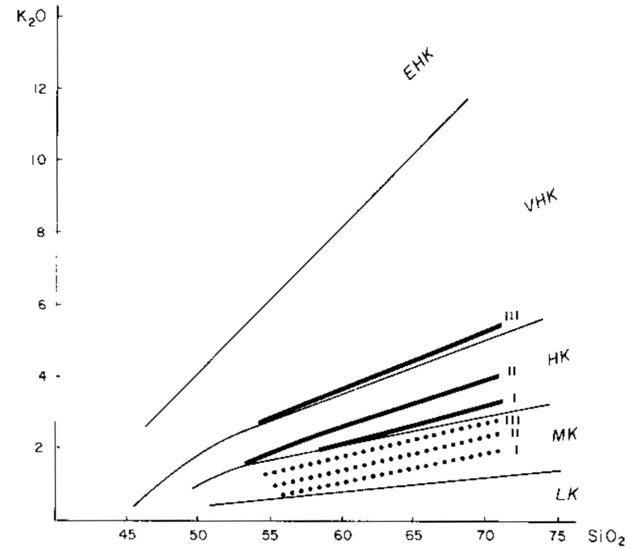

Figure 6-8-1. K_2O versus SiO_2 showing the calcic/calcalkaline (dotted lines) and calcalkaline/alkaline (heavy lines) boundaries for arcs with different K_2O contents: I = Fiji and Cascades (Shasta and Mount Hood); II = Honsyu and Hokkaido; III = West Carpathian and Eolian arcs [domains from Gill (1981) and Spence (1985)].

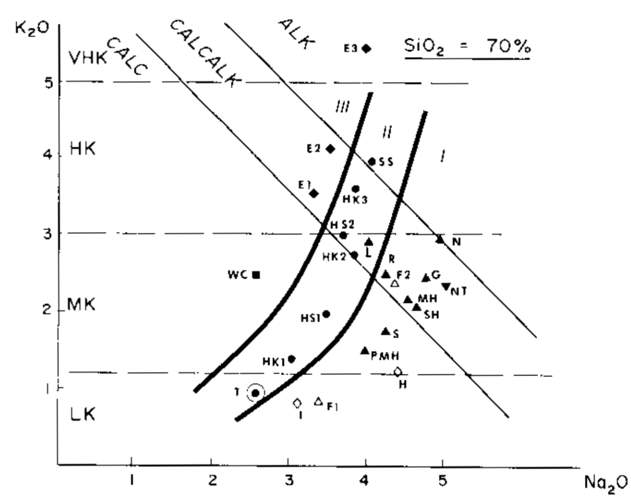

Figure 6-8-2. K_2O versus Na_2O for 70 per cent SiO_2 showing the distribution of Recent arcs and individual volcanoes into three types: I = Fiji-Izu-Cascades; II = Tonga-Honsyu-Hokkaido; III = West Carpathian-Eolian. (Type I: F1, 2 = Fiji arc; G = Garibaldi; H = Hakone (Izu Peninsula); I = Izu Islands; MH- = Mount Hood; MR = Mount Rainier; S = Mount Shasta; N = Newberry; NT = Novo de Toluca (Mexico); PMH = Pre-Mount Hood dacites. Type II: T = Tonga; HK1, 2, 3 = Hokkaido arc; HS1, 2 = Honsyu arc; SS = Sidara sheet (Honsyu). Type III: WC = West Carpathian arc; E1, 2, 3 = Eolian arc).

RETRIEVAL OF "UNALTERED" DATA FROM ALTERED SEQUENCES

Original magmatic trends in altered sequences generally can be determined by screening the data on certain diagrams in order to retrieve "unaltered" or "least altered" analyses.

CaO LOSS

CaO is lost in many types of alteration unless it is trapped as calcite. Treatment of data on MgO versus CaO (Figure 6-8-3) separates a large number of altered samples. This diagram has the

**TABLE 6-8-1.
CLASSIFICATION OF RECENT
SUBALKALINE ARC SUITES**

		TYPE I		TYPE II		TYPE III	
		Fe-poor	Fe-rich	Fe-poor	Fe-rich	Fe-poor	Fe-rich
MILDLY ALKALINE	VHK					Eolian.3	
	HK						
	HK/MK			-- Sidara Sheet --			
	MK						
CALC-ALKALINE	HK					Eolian.2	
	HK			Hokkaido.3		Eolian.1	
	HK/MK	Newberry					
	MK	Mt. Hood		----Honsyu.2----			
	MK	St. Helens		---Hokkaido.2---			
	MK	Rainier		Lassen			
	MK	Fiji.2	Huzi		Talasea		
	LK						
CALCIC	HK						
	MK	Shasta					
	MK	Pre-Mt. Hood		----Honsyu.1----		West Carpathian	
	MK/LK	--- Hakone ---		---Hokkaido.1---			
	LK		Izu	Tonga			
	LK		Fiji.1				

advantage of being valid for all volcanic suites, though lavas with plagioclase cumulates plot as enriched in calcium (de Rosen-Spence, 1976; Spence, 1985).

Na_2O GAIN OR LOSS

Plotting the screened "unaltered" data from Figure 6-8-3 on an Na_2O versus SiO_2 (Figure 6-8-4) allows the elimination of spilitized or sericitized samples where CaO was retained as calcite, as well as samples with marked K-Na exchanges. Such exchanges can be recognized by the antipathetic variation of potassium and sodium on Na_2O versus SiO_2 and K_2O versus SiO_2 (Figure 6-8-5) plots.

MgO GAIN

Rocks which have gained MgO also plot as "altered" and MgO gains can be assessed by plotting MgO versus SiO_2 (Spence, 1985, Figure 136). Care must be taken though, that there has been no silicification as this would also cause a shift of the data points into the magnesium-enriched field.

CRETACEOUS VOLCANISM OF BRITISH COLUMBIA AND YUKON

Two periods of Cretaceous volcanism have been recognized in the Canadian Cordillera by numerous workers and re-emphasized by Armstrong (1986, in press): one is in the late Lower and Middle Cretaceous, the other in latest Upper Cretaceous time. The first period is also one of vigorous plutonism and uplift, consequently much of the contemporaneous volcanic rock has been eroded. The event is subdivided into two episodes, Aptian (?) to Albian, and late Albian to Cenomanian, separated by the uplift of the Coast Plutonic Complex. Remnants of the once extensive submarine Albian Gambier Group are found in roof pendants of the southern Coast Plutonic Complex. In south-central British Columbia, the subaerial arc sequences of the late Albian Spences Bridge Group and Albian (?) "Kingsvale" Group near Aspen Grove occur east of the Fraser fault, those of Kingsvale Group of Chilko Lake form a thick sequence south of the Yalakom fault and are dated as Cenomanian. In the Bella Coola area, submarine and subaerial sequences may belong respectively to the Gambier and Kingsvale Groups. In central British Columbia, the shallow marine Albian volcanics of the Skeena Group and the later subaerial Cenomanian (?) Kasalka Group are but small remnants. In the Yukon, the unusual subaerial Albian South Forks Volcanics developed on the North American platform.

The second period, in Maastrichtian time (Grond *et al.*, 1984), is one of more subdued subaerial volcanism along a narrow belt which extends from Yukon to northern British Columbia; it is represented by the Mount Nansen, Carmacks and Hutshi Groups. In central British Columbia, the Tip Top Hill Volcanics mark the southern extension of this belt. Plutonism was also weak and only small plutons are found (Armstrong, 1986, in press).

GAMBIER GROUP

The Gambier Group is a submarine arc assemblage of basalts, andesites and dacite flows and tuffs with associated flysch and argillites. In the Harrison Lake area, there is evidence (Arthur, 1986) of episodes of Middle Triassic, Lower and Upper Jurassic and early Lower Cretaceous arc volcanism, all separated by unconformities. On Gambier Island, the Gambier Group rests unconformably on folded, intruded and eroded Triassic (?) greenstones of the Bowen Island Group and Late Jurassic diorite (Roddick, 1965). It is intruded by late Albian (?) and Cenomanian plutons (White, 1968). The existence of older arc sequences and intrusive rocks, together with reported Carboniferous zircon ages (Roddick *et al.*, 1979), indicates that the Gambier Group was deposited on a well-developed arc crust.

BRITANNIA MINE AREA

Data described following are from Margaret McColl (M.Sc. thesis, The University of British Columbia, in preparation). The Gambier Group in the mine area is altered (Figure 6-8-3), basalts are spilitized and dacitic flows and tuffs are mainly sericitized (Figures 6-8-4 and 6-8-5). Andesitic and dacitic dykes and some massive dacite samples plot as "unaltered" on MgO versus CaO (Figure 6-8-3) and give consistent magmatic trends. From these, the Britannia mine sequence can be defined as a medium-K (Figure 6-8-5), calcic (Figure 6-8-6) suite with a Peacock Index of 64; it is an **arc tholeiitic sequence.** It is Fe-poor, though close to the Fe-rich (tholeiitic) boundary, and belongs (Figure 6-8-7) to a Type I arc as defined previously. Heah *et al.* (1986) found that basalts of the nearby Sky Pilot area are also arc tholeiites showing Fe-rich and Fe-poor trends. The Gambier Group is close in composition to the Mount Shasta and Kuroko suites. The presence of older arc crust but deep marine conditions, together with volcanogenic deposits (Payne *et al.*, 1980), suggests an intra-arc extensional environment similar to that of the Green Tuffs-Kuroko trough in Japan (Sillitoe, 1982; Cathles *et al.*, 1983).

HARRISON LAKE AREA

On the west shore of Harrison Lake, the Gambier Group is represented by the Fire Lake Group and the Doctor's Point volcanics (Ray *et al.*, 1985). The Fire Lake Group is composed of altered andesites, whereas the Doctor's Point volcanics include dacites, and are relatively well preserved. The latter sequence plots as a low-K

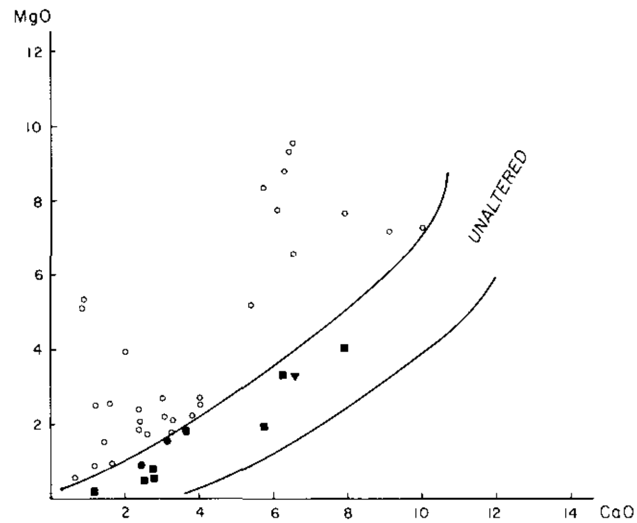

Figure 6-8-3. MgO versus CaO. Gambier Group, Britannia mine (circles = lavas; triangles = tuffs; squares = dykes in the mine; open symbols = altered; filled symbols = "unaltered"). Analyses from M. McColl (in preparation), domains from de Rosen-Spence (1976).

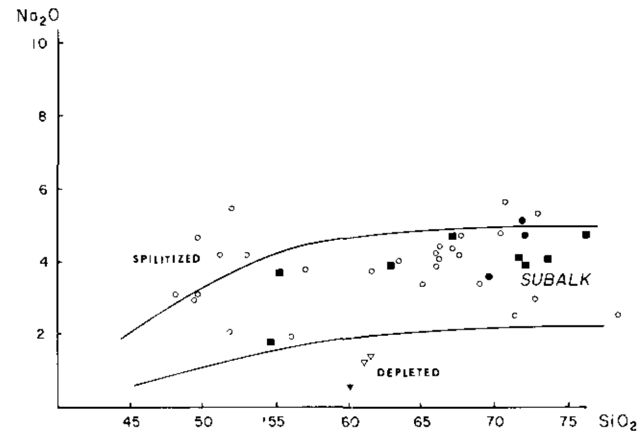

Figure 6-8-4. Na_2O versus SiO_2. Gambier Group, Britannia mine (notice the spilitized basalts and Na-depleted tuffs) (domains from de Rosen-Spence, 1976).

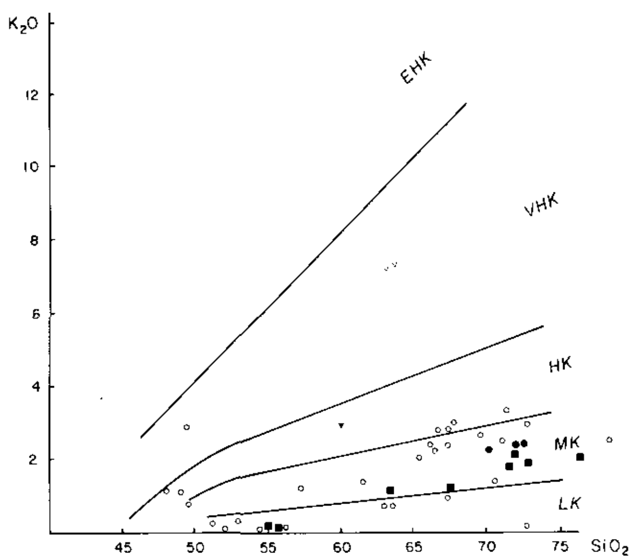

Figure 6-8-5. K_2O versus SiO_2. Gambier Group, Britannia mine (notice the well-defined trend of the "unaltered" dykes and the high K_2O content of the tuffs).

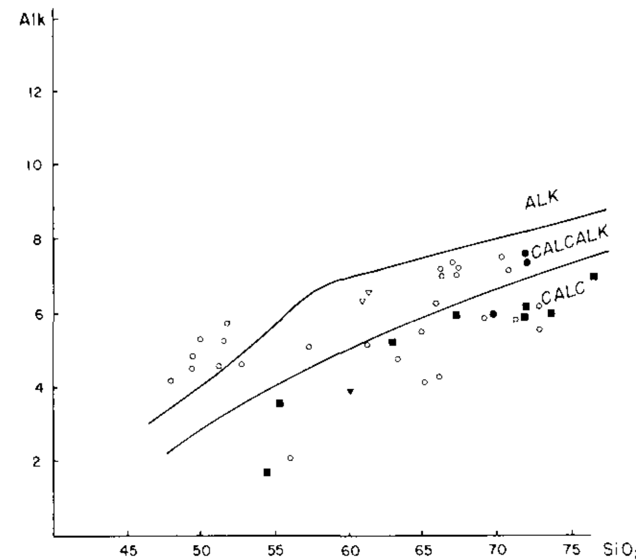

Figure 6-8-6. Alkali versus SiO_2. Gambier Group, Britannia mine (notice the well-defined trend of the "unaltered" dykes) (domains from Kuno, 1966).

(Figure 6-8-8), calcic (Figure 6-8-9) suite of Type I (Figure 6-8-7) similar to the Britannia sequence, though apparently less potassic. It is generally Fe-poor except for a few Fe-rich basalts (G.E. Ray, personal communication, 1986).

MOUNT RALEIGH PENDANT

The Mount Euridyce dacite is a low to medium (?)-K dacite of Type I (Woodsworth, 1979).

CALLAGHAN PENDANT

The andesites around the Northair mine are heavily altered. They are subalkaline and aluminous, and possibly — but not certainly — akin to those of the Britannia mine area (Miller, 1979).

SPENCES BRIDGE AND KINGSVALE GROUPS

The Spences Bridge and Kingsvale Groups were first defined east of the Fraser fault, where they form a 200-kilometre-long belt of differentiated subaerial volcanics resting unconformably over the Triassic and Jurassic volcanics of Stikinia. Both have recently been re-examined and analysed (Thorkelson, 1986) and redated by fossils to be of Late Albian age (Thorkelson and Rouse, in preparation). In the Kingsvale area, the two groups were found to be in stratigraphic continuity and similar in major element chemistry. As a result the Kingsvale Group has now lost its status as a group. Kingsvale andesites were renamed Spius Formation and integrated into the Spences Bridge Group. Near Aspen Grove, to the east, a small inlier of Lower Cretaceous volcanics was attributed to the Kingsvale Group by Preto (1979). Analyses from both sequences will be examined following. In the Chilko Lake area south of the Yalakom fault, other subaerial volcanics were also attributed to the Kingsvale Group but are reported to be unlike those east of the Fraser fault and have been dated as Cenomanian (Kleinspehn, 1985). No analyses are available.

SPENCES BRIDGE GROUP IN KINGSVALE AREA

Thorkelson (1986) showed that the Lower Spences Bridge Group and the Spius Formation, though similar in their major element compositions, differ in their titanium, phosphorus and trace element contents. The Spius andesites seem to have a plume component indicating the beginning of rifting of the Spences Bridge arc.

Plots of the Spences Bridge Group reveal that it is a medium-K (Figure 6-8-8), calcic (Figure 6-8-9) suite with a Peacock Index of 65 to 66; it is Fe-poor and belongs to a Type II arc (Figure 6-8-7) similar to the hypersthenic arc tholeiitic suite of Honsyu.

"KINGSVALE" GROUP OF ASPEN GROVE

Preto (1979) recognized two units, 10 and 11, in the Aspen Grove area and correlated them with the Kingsvale Group. Unit 10, containing andesites and rhyolites, was broadly dated as Albian and is intruded by a Cenomanian granite. Unit 11 is basaltic, is not dated, and is not in contact with Unit 10. Both units belong to a medium-K (Figure 6-8-10), calcalkaline (Figure 6-8-11) suite with a Peacock Index of 62. They are Fe-poor and belong to an arc transitional between Types I and II (Figure 6-8-7). Unit 11 however, is slightly richer in iron, titanium and phosphorus, suggesting a late or behind-the-arc setting. The Kingsvale sequence from Aspen Grove is therefore different in total alkali content from the Spences Bridge Group, including the Spius Formation, suggesting that it belongs to a different volcanic event.

SOUTH FORKS VOLCANICS

The South Forks volcanic rocks are a subaerial intracontinental arc sequence deposited on the North American platform and composed of differentiated flows and tuffs (Wood and Armstrong, 1982). These are described as potassic with a calcalkaline (Fe-poor) trend and are characterized by a high initial strontium ratio indicating a strong crustal influence. They have been dated as Albian and are intruded by a Cenomanian quartz monzonite (Wood and Armstrong, 1982).

The South Forks Volcanics plot as a high-K (Figure 6-8-12), calcic (Figure 6-8-8) suite with a Peacock Index of 66. They are very calcic and poor in sodium (Figure 6-8-9) in spite of their high potassium content and distinctly belong to an arc of Type III (Figure 6-8-7). The most comparable Recent suite is that of the intracontinental West Carpathian arc (Karolus *et al.*, 1968). The quartz monzonite, also of Type III, is calcalkaline, indicating an increase in alkali with time.

KASALKA GROUP

MacIntyre (1976) showed that the andesites and rhyolites of the Kasalka Group were preserved in a cauldron subsidence complex. They were deposited subaerially, in early Late Cretaceous time, over a folded and eroded sequence of the shallow marine Skeena Group of Albian age. The sequence was intruded by the Mount Bolum granophyres and the varied plutons of the Bulkley suite. The latter was dated as latest Upper Cretaceous (Carter, 1982), contemporaneous with the next volcanic period.

The Kasalka Group data plot along the medium-K to high-K boundary (Figure 6-8-13), calcalkaline (Figure 6-8-14) and Fe-poor, and belonging to a Type II, near Type I arc (Figure 6-8-7), similar to the Kingsvale Group of Aspen Grove. The Mount Bolum granophyres are at the alkaline limit whereas the Bulkley intrusions are calcalkaline and less sodic (Figure 6-8-7).

MOUNT NANSEN GROUP AND TIP TOP HILL VOLCANICS

Data presented are from Grond *et al.* (1984) for the Mount Nansen Group in Yukon and from Church (1970) for one analysis of the Tip Top Hill Volcanics in central British Columbia. This subaerial volcanism is similar to that of the Kasalka Group (Figures 6-8-13, 6-8-14 and 6-8-7). The Montana Mountain sequence, which belongs to the Hutshi Group (Roots, 1982), is also similar but very altered.

CARMACKS GROUP

Data presented are from Grond *et al.* (1984). The Carmacks Group overlies the Mount Nansen Group and has the same radiometric age. It is composed of shoshonite flows and of breccias including calcalkaline andesite clasts (Figures 6-8-13 and 6-8-14). This shoshonitic volcanism is important as it indicates disturbance through collision of the Maastrichtrian subduction zone.

CONCLUSION

The methods presented here for screening altered samples and classifying volcanic suites have allowed more accurate definition and comparison of Cretaceous volcanic sequences with more recent suites. It is hoped that this may eventually lead to a more accurate reconstruction of the old subduction zones and arc margins.

The main results of interest are:

(1) Identification of the Gambier Group as an arc tholeiitic suite of Type I, similar to other arc sequences hosting copper-zinc massive sulphides, such as the Miocene Kuroko and Archean Noranda sequences;

(2) Identification of the Spences Bridge Group and South Forks Volcanics — previously described as "calcalkaline" — as calcic suites (Peacock Index of 66) with high potash and cor-

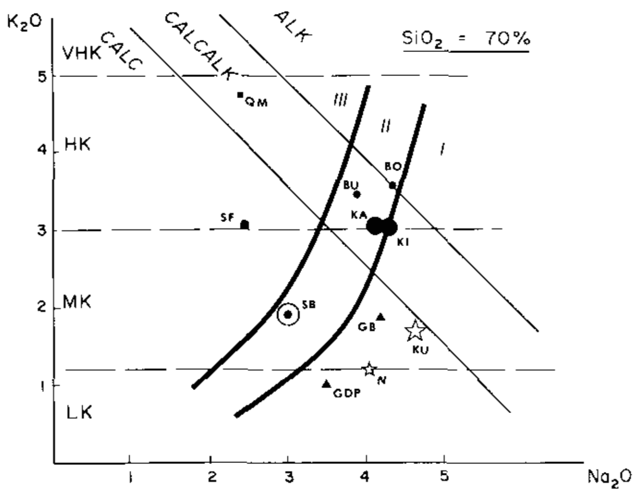

Figure 6-8-7. K_2O versus Na_2O for 70% SiO_2, showing the distribution of the Cretaceous arcs into three types: I = Gambier Group (GDP = Doctor's Point; GB = Britannia mine) and Noranda (N) and Kuroko (K) dacites for comparison; II = Spences Bridge (SB), "Kingsvale" of Aspen Grove (KI), Kasalka and Mount Nansen (KA) Groups and Mount Bolum (BO) and Bulkley (BU) intrusions; III = South Forks Volcanics (SF) and Quartz Monzonite (QM).

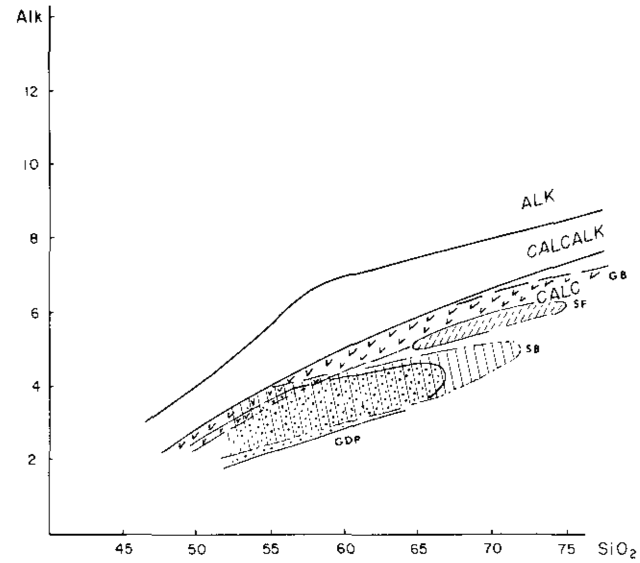

Figure 6-8-8. Alkali versus SiO_2 for the Gambier and Spences Bridge Groups and South Forks Volcanics. Legend as in Figure 6-8-12.

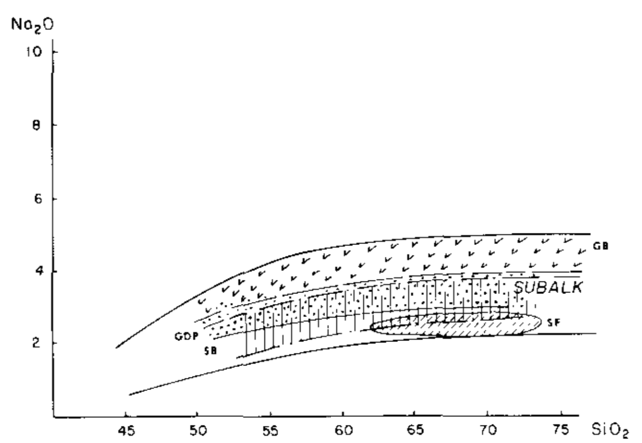

Figure 6-8-9. Na_2O versus SiO_2 for the Gambier and Spences Bridge Groups and South Forks Volcanics. Legend as in Figure 6-8-12.

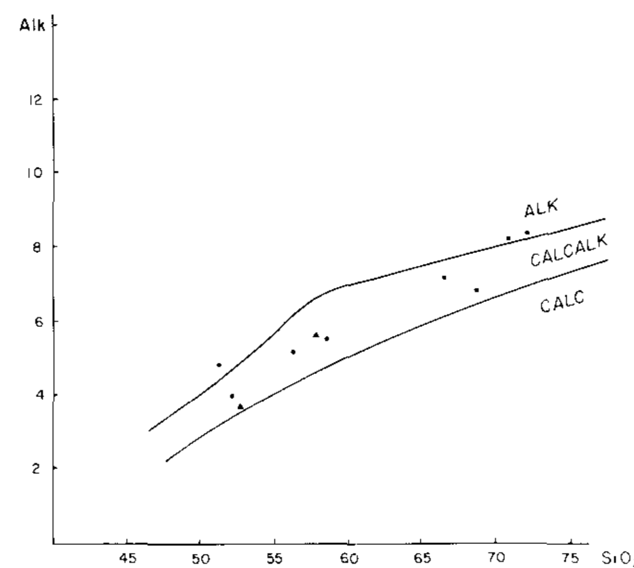

Figure 6-8-10. Alkali versus SiO_2 for the "Kingsvale" Group of Aspen Grove (Unit 10 = circles; Unit 11 = triangles). Analyses from Preto (1979).

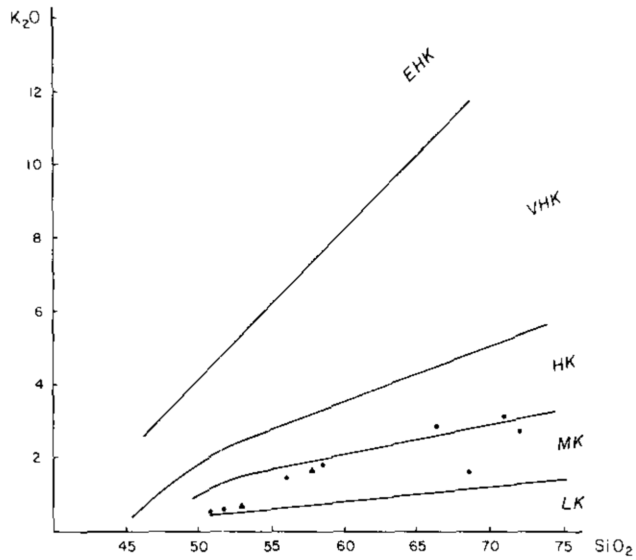

Figure 6-8-11. K_2O versus SiO_2 for the "Kingsvale" Group of Aspen Grove (Unit 10 = circles; Unit 11 = triangles).

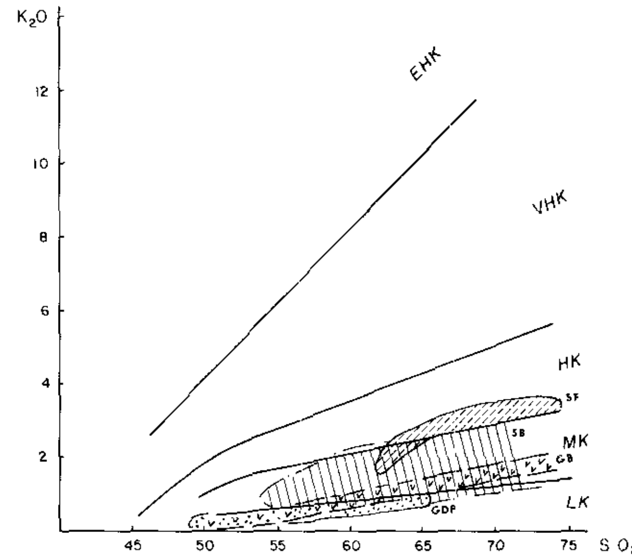

Figure 6-8-12. K_2O versus SiO_2 for the Gambier Group in Doctor's Point areas (dots), and Britannia mine area (VVV), Spences Bridge Group (lines) and South Forks Volcanics (dashes). Analyses from Ray (personal communication), McColl (in preparation), Thorkelson (1986) and Wood and Armstrong (1982).

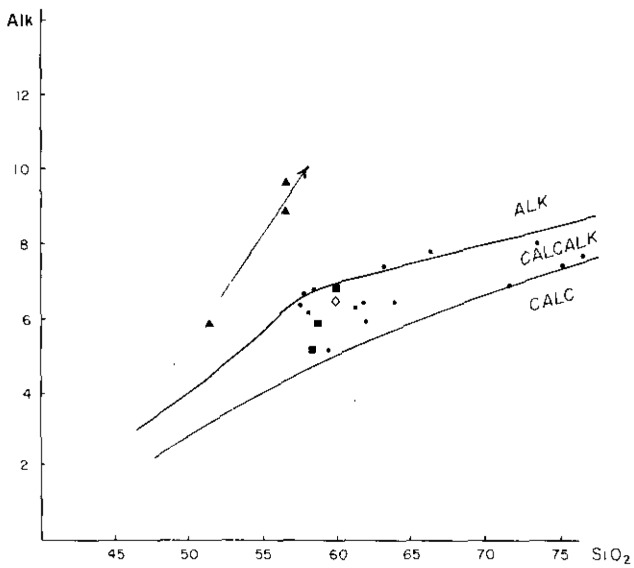

Figure 6-8-13. Alkali versus SiO_2 for the Kasalka (circles), Mount Nansen (squares), Tip Top Hill (diamond) and Carmacks (triangles) Groups. Analyses from Church (1970), MacIntyre (1976) and Grond *et al.* (1984).

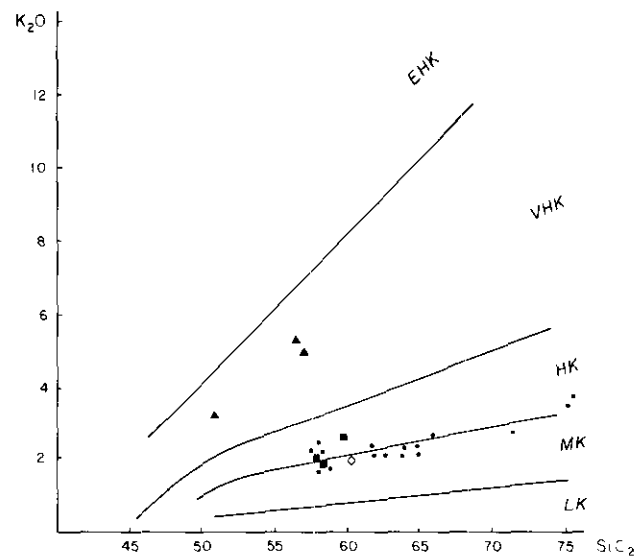

Figure 6-8-14. K_2O versus SiO_2 for the Kasalka, Mount Nansen, Tip Top Hill and Carmacks Groups. Legend as in Figure 6-8-13.

relatively low soda contents, and their comparison to the Honsyu arc tholeiites and West Carpathian arc respectively;

(3) Differentiation of Spences Bridge Group and Kingsvale volcanic rocks from the Aspen Grove area, which precludes their correlation;

(4) Identification of important differences between the Gambier and Spences Bridge Groups indicating that they belong to two different episodes or to two different arc segments. Similar differences are found between the Miocene Green Tuffs-Kuroko rhyolites and the present Honsyu arc in the same area, or between the Recent Izu and Honsyu arcs. This difference in composition is thought to result from differences in the conditions of subduction in time and/or location;

(5) Recognition that there is a need for data from the Cretaceous sequences of the Chilko Lake and Bella Coola areas.

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