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PRECAMBRIAN GEOLOGY OF THE PRINCE ALBERT HILLS, WESTERN MELVILLE PENINSULA, NORTHWEST TERRITORIES

THOMAS FRISCH

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Critical Reader

W.W. Heywood

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PREFACE

One objective of the Geological Survey of Canada is to determine the mineral resources available to Canada and to provide the geoscientific information needed to facilitate the discovery of such resources. It is only by increasing our knowledge of the geological framework of Canada, that we are in a better position to evaluate our resources. Such information allows the development of policies designed to encourage the best use of our resources and possibly to reduce our dependence on mineral commodities from foreign sources. Operation Wager, the first systematic geological mapping of Melville Peninsula, was initiated in 1964 to contribute to this objective by means of a reconnaissance survey of a hitherto geologically unknown region. The project identified assemblages of metamorphosed sedimentary and volcanic rocks that looked favourable for further investigations.

In 1972 the present study was started to examine the petrology, structure and stratigraphy of the Prince Albert Group and adjacent rocks. Field observations were supplemented with data from other ongoing Geological Survey projects such as radiometric, geochemical and aeromagnetic surveys undertaken in the seventies.

The similarities between the rocks of the Prince Albert Group and belts of known economic importance elsewhere in the world and the results presented in this and previous reports indicate that this assemblage of rocks in western Melville Peninsula is an attractive target for uranium, nickel, iron and gold exploration.

W.W. Hutchison
Director General
Geological Survey of Canada

Ottawa, January 1981

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The Folster Lake area on the eastern shore of Committee Bay, western Melville Peninsula. Weakly metamorphosed, well bedded arkose of the Proterozoic Folster Lake Formation abuts against the Archean granite-greenstone terrane. Note the aufeis upstream from the delta of the Kammaneluk River. (National Air Photo Library Oblique T-377L-81.)

PRECAMBRIAN GEOLOGY OF THE PRINCE ALBERT GROUP, WESTERN MELVILLE PENINSULA, NORTHWEST TERRITORIES

Abstract

Western Melville Peninsula is an Archean granite-greenstone terrane of the Churchill Structural Province. Several belts of highly metamorphosed and deformed volcanic and sedimentary rocks, collectively termed the Prince Albert Group, trend northeast, concordant with the main structural grain of this part of the Canadian Shield. The metavolcanic rocks are predominantly basaltic but rhyolite and dacite are abundant; andesite appears to be rare. Ultramafic rocks include lavas and intrusions. Pelitic schists and major deposits of magnetite-quartz iron formation dominate the metasedimentary component of the Prince Albert Group; quartzite is negligible and marble absent. Widespread occurrence of andalusite, locally accompanied by garnet, cordierite and traces of sillimanite, indicates mid-amphibolite metamorphic grade with pressures and temperatures well below 4 x 10^5 *kPa and 700°C. Gneissic to massive quartzofeldspathic rocks of chiefly igneous origin, from tonalite to granite, commonly intrude and deform the Prince Albert Group. Granite and greenstone together have been affected by at least two periods of deformation. U-Pb zircon and Rb-Sr whole rock ages on a variety of supracrustal and plutonic rocks range from 2700 to 2900 Ma, suggesting emplacement, metamorphism, and deformation of the granite-greenstone terrane within a limited time span of the late Archean. The lithology and distribution of the Prince Albert Group and its apparent development in a sialic environment bear many similarities to the Archean greenstone belts of Western Australia.*

South of Committee Bay, the Archean granitic terrane is traversed by narrow, ill-defined belts of amphibolite-grade, chiefly mafic, schistose rocks that may be correlative with the Prince Albert Group.

In the northern part of the map area, an 800 m thick sequence of weakly metamorphosed arkose and minor phyllite, conglomerate and marble rests unconformably on a metamorphosed regolith developed on the Archean basement. This sequence, named the Folster Lake Formation, is thought to be a littoral deposit formed at the margin of a granitic highland in Proterozoic time. Metamorphism, of up to greenschist grade, appears to have occurred in the late Paleohelikian and may be responsible for a pervasive diaphthoresis of the Archean rocks.

Résumé

L'ouest de la péninsule de Melville est un terrain archéen, composé de granites et roches vertes, appartenant à la province structurale de Churchill. Plusieurs zones de roches volcaniques et sédimentaires fortement métamorphisées et déformées, appelées collectivement groupe de Prince Albert, y ont une orientation nord-est, qui concorde avec la principale direction structurale de cette partie du Bouclier canadien. Les roches métavolcaniques sont surtout basaltiques, mais les rhyolites et dacites sont abondantes; l'andésite est rare. Les roches ultramafiques comprennent des laves et des intrusions. Les schistes pélitiques et d'importants gîtes inclus dans une formation ferrifère à magnétite et quartz dominent la composante méta-sédimentaire du groupe de Prince Albert. Les quantités de quartzite sont négligeables et il n'y a pas de marbre. L'abondance de l'andalousite, localement accompagnée de grenats, de cordiérite et de traces de sillimanite, indique que le degré de métamorphisme se situait au milieu du faciès des amphibolites, et que les pressions et températures étaient bien inférieures à 4 x 10^5 *kPa et 700°C. Des roches quartzofeldspathiques, gneissiques à massives, d'origine principalement ignée, allant des tonalites aux granites, sont fréquemment intrusives dans les roches du groupe de Prince Albert et les déforment. Les granites et roches vertes ont été touchés par au moins deux périodes de déformation. L'âge de diverses roches supracrustales et plutoniques, déterminé par les méthodes radioactives (U-Pb, zircon; Rb-Sr, roche entière), et compris entre 2700 et 2900 Ma, suggère que la mise en place, le métamorphisme et la déformation du terrain à granites et roches vertes ont eu lieu pendant un intervalle de temps restreint à la fin de l'Archéen. La lithologie et la distribution du groupe de Prince Albert et l'évolution apparente de celui-ci dans un milieu sialique rappellent à beaucoup d'égards des zones archéennes de roches vertes de l'Australie occidentale.*

Au sud de la baie Comité, le terrain granitique archéen est parcouru par des zones étroites et mal définies de roches schisteuses principalement mafiques, métamorphisées dans le faciès amphibolite et pouvant éventuellement être corrélées avec le groupe de Prince Albert.

Dans la partie nord du secteur de la carte, une succession de 800 m d'épaisseur composée d'arkoses faiblement métamorphisées ainsi que de phyllades, conglomérats et marbres en petites quantités, reposent en discordance sur un régolithe métamorphisé formé sur le socle archéen. On pense que cette succession, appelée formation de Folster Lake, est un dépôt littoral formé sur le bord d'un plateau granitique au cours du Protérozoïque. Le métamorphisme, qui atteint le faciès des roches vertes, semble avoir eu lieu à la fin du Paléohélikien, et pourrait expliquer la diaphthorèse (métamorphisme régressif) profonde des roches archéennes.

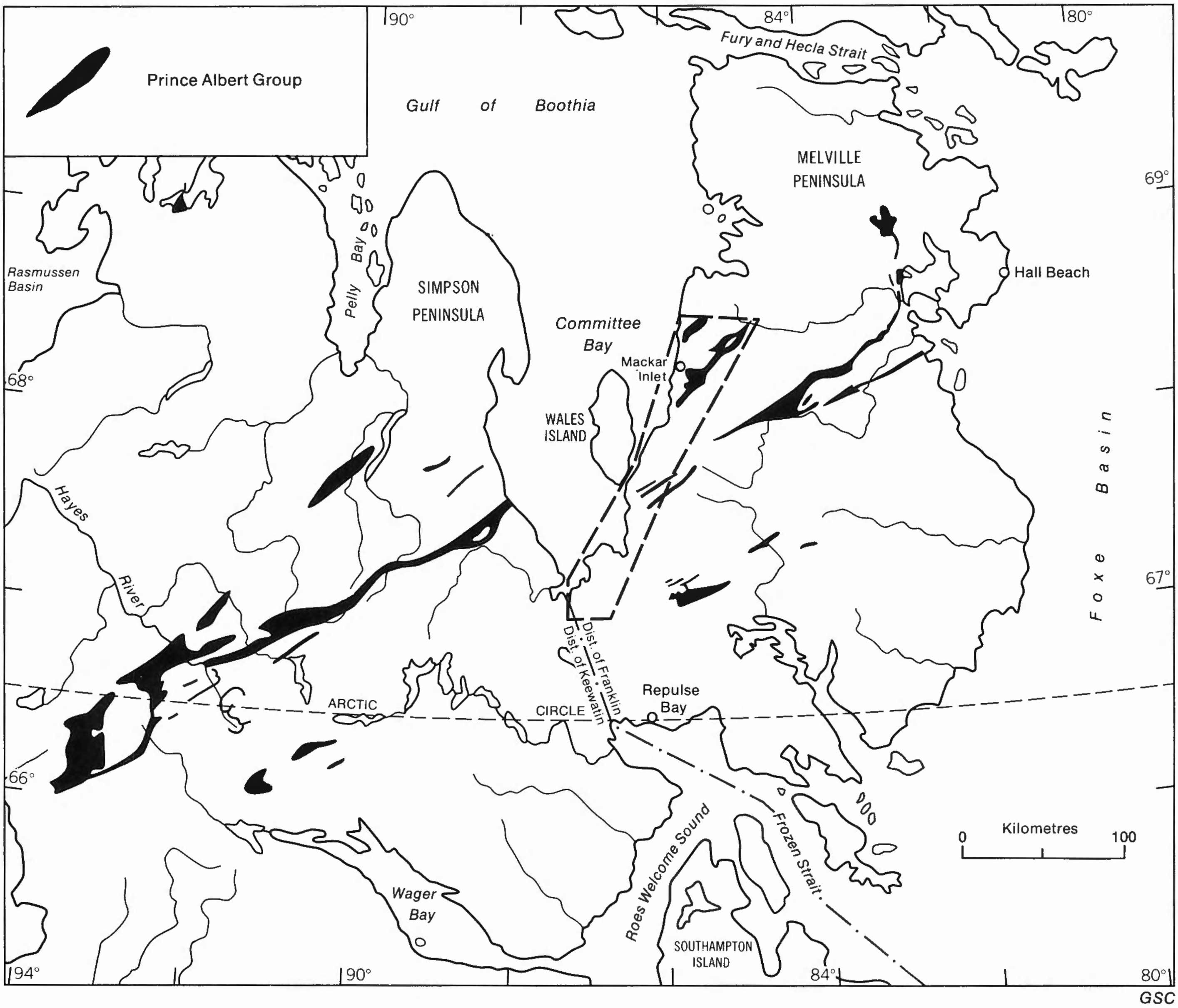


Figure 1. Distribution of the Prince Albert Group (modified after Schau, 1977, Fig. 1) and location of study area.

INTRODUCTION AND GENERAL GEOLOGY

This report describes the Precambrian geology of part of western Melville Peninsula in the District of Franklin, Northwest Territories. The map area lies in an Archean, predominantly granite-greenstone terrane of the Churchill Structural Province of the Canadian Shield.

Location

The map area is bounded by 67°05'N and 68°30'N and extends inland as much as 38 km east and south from the coast of Committe Bay (Fig. 1). This area encompasses the bulk of the Prince Albert Hills and the south coastal region of Committee Bay east of the Keewatin-Franklin boundary.

Topographic maps of the area at a scale of 1:250 000 are Committe Bay (47B), Lefroy Bay (46M) and Mierching Lake (46N). Maps of the area at 1:50 000, issued in 1975, are 47B/2, 7; 46M/2,3,6,7,8,9; and 46N/12,13.

Access

The map area is accessible from Hall Beach, in northeastern Melville Peninsula and from Repulse Bay in southern Melville Peninsula. Commercial air service is available to both communities.

A Distant Early Warning (DEW) Line radar station, Mackar Inlet (Cam-5), is located on the coastal highlands south of Bagnall Lake, on the west coast of Melville Peninsula. It has a gravel airstrip 1140 m long. Prior permission must be obtained for use of these facilities. No other settlement exists in the map area.

Many lakes in the area are of adequate size and depth for floatplane operations but ice may be a hindrance. The terrain is not suitable for STOL aircraft equipped with big wheels and low-pressure tires. River travel by canoe is not practical.

Previous geographic and geological exploration

Western Melville Peninsula was given little attention by the early explorers, the east coast being the major travel route to points north for both Inuit and white men.

Assigned the task of completing the exploration of the north coast of America, the Hudson's Bay Company exploring expedition, led by John Rae, travelled in Committee Bay and environs in 1846 and 1847 (Cooke and Holland, 1978). Most of the major rivers in western Melville Peninsula are named after members of that expedition.

Charles Francis Hall, who was searching for relics of the Franklin expedition, visited the southern Committee Bay region several times in the years 1864 to 1869 (ibid.).

The first systematic geological mapping in the area was by the Geological Survey of Canada, which mounted Operation Wager in 1964 to map the southern half of Melville Peninsula and the northeastern District of Keewatin, an area of about 88 000 km^2. Results of the bedrock mapping were published in the form of a brief report and a 1:506 880 scale map (Heywood, 1967). Those results provided an invaluable basis for this work. In conjunction with the bedrock mapping, Craig (1965a) investigated the surficial geology of the area.

The findings of Operation Wager, in particular major occurrences of iron formation, aroused the interest of the mining industry. Borealis Exploration Limited prospected extensively in the Prince Albert Hills between 68°N and 68°30'N in the summers of 1968, 1969 and 1970 and mapped the major deposits of iron formation and gossan zones in some detail. Their work was almost exclusively a field study with very little laboratory follow-up, except for assays. Their maps and reports are filed with the Department of Indian and Northern Affairs in Ottawa and a summary paper was published by Wilson and Underhill (1971).

Fryer and Jenner (1978) published the results of a geochemical study of metavolcanic rocks from the Prince Albert Group, collected by Jenner and the author in 1974. Some of their results are reproduced here and, particularly the rare earth element data, supplement this report.

Physiography

Compared with the terrain to the south and east, western Melville Peninsula, named the Prince Albert Hills, is a rugged, heavily dissected region with a relief generally of 300 to 400 m, rising to a maximum of more than 540 m. Deep valleys trending easterly or southeasterly traverse the region. East of the head of Committee Bay, the topography becomes more subdued though still relatively rugged. The south coastal region of Committee Bay is lowland with a relief rarely over 150 m.

The Prince Albert Hills form an extremely rocky terrain of nearly complete bedrock exposure. A beach and coastal plain area, up to 5 km wide, extends from Selkirk Bay south to Lefroy Bay and is the only major area of limited outcrop in the region.

Lakes and streams abound. The largest lake is Folster Lake, 8 km long and up to 5 km wide; most of the others are much smaller and commonly shallow. The larger streams rise in the upland plateau of central Melville Peninsula and flow westward into Committee Bay. Generally shallow, they are marked by numerous rapids. Most of the larger streams have been named and are identified on topographic maps (especially the 1:500 000 scale maps) but the stream flowing into the sea between Cap Sibbald and Barnston Point was named Adamson River too recently for the name to appear on topographic maps.

Climate

Despite its location just north of the Arctic Circle, western Melville Peninsula has a fairly severe climate. Mean monthly temperatures at the Mackar Inlet DEW Line station (as recorded in the "Monthly Records, Meteorological Observations in Canada" published by Environment Canada) for the June - August period was 6°C in 1973 and 4°C in 1974. From December to March mean temperature was -31°C in 1973-74 and 1974-75. However, in the summer months temperatures between 10° and 20°C are not uncommon. Precipitation is low, averaging for the summer period 3.6 cm a month in 1973 and 2.5 cm a month in 1974; snowfall is negligible from December to March. Committee Bay is icebound the entire year, and only narrow ice-free zones appear along the shores in summer.

The season for geological field work begins in early to middle June and ends in late August.

Present work

The field work on which this report is based was conducted in 1972, 1973 and 1974. Most of the 1972 field season was spent in the Prince Albert belt southwest of Committee Bay but about two weeks' work was done in the vicinity of Ross Inlet, southern Committee Bay, and in the Prince Albert belt north of Adamson River.

Two field seasons of about 10 weeks each were devoted to mapping the Prince Albert Hills and the southern Committee Bay area at a scale of 1:125 000, with the emphasis on the former region. Base camp was established in both years at the airstrip of the Mackar Inlet DEW Line station. Geological traversing was done from both the base camp and fly camps, on foot and by helicopter.

Aeromagnetic surveys of the area were flown in the period 1972 - 76 and the results released in 1978 in a series of 1:500 000 maps (Geological Survey of Canada Geophysical Series Aeromagnetic Maps 8309G, 8325G, 8326G, 8327G, 8335G, 8336G, 8337G, 8344G and 8345G). The same data were subsequently released on 1:250 000 maps (7670G, 7671G and 7939G). These maps aided in final compilation of the geological map accompanying this report (Fig. 2).

Determination of plagioclase composition was made on the flat stage and using the charts of Burri et al. (1967). Chemical analyses were performed by staff of the Analytical Chemistry Section of the Geological Survey using 'everyday' methods, except that Rb was measured by the 'screw-rod' method (Abbey, 1979). Analyses of granitic rocks, i.e., rocks of quartz diorite to granite composition, were recalculated to mesonorms according to a procedure developed by Hutchison (1975) and modified by W.N. Houston. All Rb-Sr ages quoted have been calculated using an ^{87}Rb decay constant of $1.42 \times 10^{-11} a^{-1}$.

Acknowledgments

The excellent assistance and companionship in the field of Gregory Dunning in 1972 and 1973, Frank Simons in 1972, and Normand Goulet and George Jenner in 1974 are gratefully acknowledged. Goulet is responsible for a considerable part of the mapping north of 68°10'N and at the head of Committee Bay. Co-operation, advice and information from F.H.A. Campbell, J.E. Reesor and M. Schau, who worked in surrounding or related areas, are appreciated. The expertise of O.R. Eckstrand, who visited the author in the field in 1974, led to the discovery of ultramafic lavas.

The skill of the aircrews contributed much to the successful completion of the geological work and the author is indebted to B. Byl (La Ronge Aviation) in 1972, B. Alards (Viking Helicopters, Ltd.) in 1973, and E. Beaumont, E. Godleski and R. Levack (Viking Helicopters) in 1974. The DC-3 crews of Norcanair Ltd. efficiently cached fuel and equipment at various sites in the spring of 1973 and 1974, often under extremely adverse conditions.

The logistic support, hospitality and numerous courtesies extended by the staff of the DEW Line stations at Hall Beach and, especially, Mackar Inlet, are remembered with pleasure. Thanks are also due Father J. Rivoire and the people of Repulse Bay for help and hospitality.

P. Chernis did fine petrographic work on a large number of samples. W.N. Houston corrected and adapted to the available computer facilities Hutchison's (1975) norm calculation scheme for granitic rocks and arranged for all data processing. A.G. Plant patiently instructed the author in the use of the MAC 400 microprobe and was very helpful in data reduction. A.S. Dyke provided helpful background information on glacial geology.

All isotopic age measurements reported here were made by the Geochronology Laboratory of the Geological Survey of Canada under the direction of R.K. Wanless, who collected some of the samples in company with the author and provided advice on, and interpretation of, the results.

General geology

Bedrock

The map area is underlain entirely by Precambrian rocks of the Churchill Structural Province. Dolomite of Ordovician-Silurian age outcrops on Wales Island, where it presumably forms a cover sequence (of unknown thickness) on the unexposed Precambrian (Heywood, 1967). Wales Island is probably part of a downdropped fault block in which strata of a once extensive Paleozoic marine cover sequence are preserved.

Much of the Precambrian is a granite-greenstone terrane showing many features typical of this worldwide rock association. Linear belts of tightly folded, amphibolite-grade metavolcanic and metasedimentary rocks collectively termed the Prince Albert Group (ibid.), are bordered, and in places intruded, by a variety of granitic rocks, which are massive to gneissic.

The granitic rocks crystallized or recrystallized at depth to form a plutonic terrane that yields few clues to its origin and its temporal relationship to the greenstone belts. No unambiguous evidence of a granitic basement to the Prince Albert Group was found, yet neither can intrusive relations be taken at face value because of common structural concordance at contacts, suggestive of remobilization of pre-existing granitic crust.

In the southern part of the map area, the granitic terrane is traversed by narrow belts of amphibolite-grade schistose supracrustal rocks, which are less well defined and of more limited extent than the greenstone belts to the north.

A sequence comprising minor greenschist-grade metasedimentary schist, conglomerate and marble overlain by weakly metamorphosed arkose, herein named the Folster Lake Formation, rests with angular unconformity on a metaregolith developed on granite and greenstone in the northern part of the area.

Basaltic dykes are of two types. An older type is represented by amphibolite dykes, striking mainly northeast and east, which were metamorphosed and disrupted after intrusion as diabase. They are possibly of more than one age and predate the Folster Lake Formation. The other dykes are of unmetamorphosed diabase; they trend northwesterly and cut all other Precambrian rocks.

A marked northeasterly structural grain dominates the entire map area and the adjacent areas to the north and south. The bulk of the map area lies in the Committee Fold Belt (Jackson and Taylor, 1972).

Results reported here indicate that most, perhaps all, pre-Folster Lake Formation rocks are Archean. The main prograde metamorphism probably occurred in the Archean. The Committee Fold Belt is defined as being of Aphebian age (ibid.) but the age of the main tectonism in the map area is unknown. The Folster Lake Formation appears to have been metamorphosed in middle Helikian time. Low-grade metamorphism of retrograde type (epidotization, sericitization, etc.), which pervades the Archean terrane, may be a manifestation of the Helikian metamorphism or may be earlier.

Surficial deposits

Features of the surficial geology have been detailed by Sim (1960), Craig (1965a, b) and Falconer et al. (1965); the following remarks are based largely on their work and on information supplied by A.S. Dyke.

Striae and glacial landforms indicate that the last major flow of the Laurentide ice sheet across Melville Peninsula was northwestward (Craig, 1965a). A major end moraine extends down the west side of Melville Peninsula from north

TABLE OF FORMATIONS

Eon	Era	Period	Units	Formations	Lithology
Phanerozoic	Cenozoic	Quaternary	Qal		Fluvial, glacial and marine beach sediments
				Unconformity	
	Paleozoic	Ordovician-Silurian			Dolomite
				Unconformity	
Proterozoic					Diabase dykes
				Intrusive contact	
			PFL	Folster Lake Fm. 800 m	(Meta-) arkose, phyllite, metaconglomerate, marble
				Unconformity	
Archean or Proterozoic			md		Amphibolite metadykes
				Intrusive contact	
Archean			Aum		Meta-ultramafite, metamafite
				Intrusive (?) contact	
			Ag		Massive to poorly foliated granitic rock
			Agr		Massive porphyroblastic granitic rock
			Ato		Tonalite
			Asg		Amphibolite, schist
			Prince Albert Group		
			APAgb		Metagabbro
			APAu		Meta-ultramafite
					Iron formation
			APAq		Quartzite
			APAcg		Metaconglomerate
			APAs		Metasedimentary schist
			APAr		Metarhyolite, metadacite
			APAb		Metabasalt, meta-andesite
			APAul		Meta-ultramafic lava
			Agn, Aagn		Granitic gneiss

Stratigraphic order of the Archean units is uncertain. Paleozoic strata outcrop only on Wales Island immediately adjacent to the map area and are here included only for completeness.

of the map area almost to Matheson River. The moraine is preserved in disconnected sinuous segments, whose summits reach at least 440 m above sea level (ibid.); one such segment is shown in Figure 9 of Sim (1960). The moraine marks the outermost demonstrable extent of westward-flowing ice from the Foxe Dome (the part of the Laurentide ice sheet that covered the present Foxe Basin) about 8500 years ago (see Prest, 1970, Fig. XII-15).

The upper limit of the postglacial marine invasion, as determined from the elevation of high-level marine features (raised beaches, shells and the like), appears to have been under 150 m along the west coast of Melville Peninsula (Craig, 1965a).

GRANITIC AND ASSOCIATED ROCKS

Rocks of granitic composition predominate in the map area and unfortunately are the most intractable of the map units. Commonly, contacts are indistinct, lithological differences are subtle, and indicators of origin are few.

In this report the term 'granitic' is used to denote rocks ranging from quartz diorite to leucocratic granite and pegmatite. The rocks are classified according to the IUGS scheme (Streckeisen, 1976), which is based entirely on modal composition (Fig. 3). Two features of this system are particularly pertinent to the present study. 'Tonalite' is the name for all granitic rocks with 20 to 60 per cent quartz and little or no K-feldspar, that is, there is no distinction between leucocratic tonalite, often called trondhjemite, and more melanocratic varieties to which some petrographers restrict the name 'tonalite'. Secondly, 'granite' includes both quartz monzonite (adamellite) and 'true' granite.

A simple chemical classification involving a ternary plot of CaO, Na_2O and K_2O is used by some workers but is here employed only to graphically display relationships of these oxides, particularly ratios of the alkalis.

The elements K, Rb, Sr, Ba, Ti and Zr are plotted on variation diagrams to show compositional peculiarities and trends, chiefly to aid in elucidating the origin of the rocks. Full chemical and modal data may be found in the Appendix.

Also described in this chapter are mafic rocks that are closely associated with the granitic rocks and cannot be readily assigned to other map units, such as the Prince Albert Group.

Tonalite (unit Ato)

Lithology

This unit comprises quartzofeldspathic gneisses characterized by a grey colour and included amphibolite bodies (unit md), outcropping north of Folster Lake and in the Prince Albert Group south of Adamson River. Potassium feldspar being generally absent, these rocks plot on the edge of the tonalite field in the QAP triangle (Fig. 4). They are medium grained, commonly cataclastic and rather homogeneous. Foliation is poorly developed except where the rock is strongly sheared. Their mineral assemblage typically is: oligoclase An_{25-29} quartz - brown biotite - muscovite; green hornblende, chlorite and epidote, if present, are minor constituents. Strongly sheared or cataclastic rocks contain intensely sericitized or epidotized feldspar and more abundant chlorite and discrete epidote—mineralogical features ascribed to retrograde metamorphism.

In thin section, many samples show a pronounced primary 'igneous' texture, comprising well formed plagioclase laths set in a finer grained matrix (Fig. 5). Increasing deformation has resulted in progressive blurring of this texture through recrystallization (Fig. 6) and it is not known if all samples of this unit were originally of igneous texture.

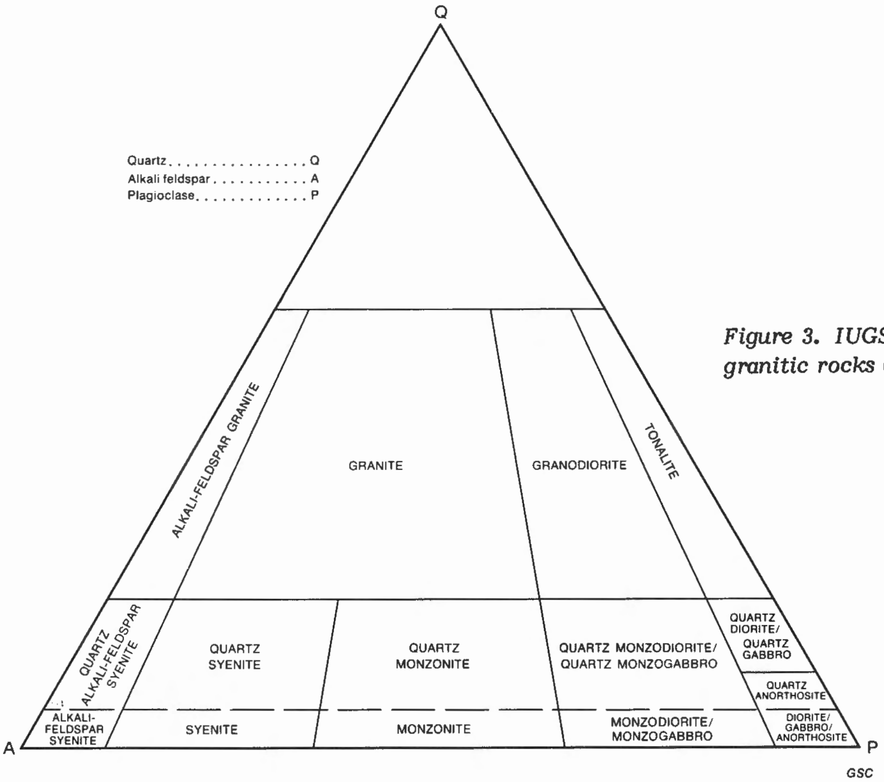


Figure 3. IUGS modal classification of granitic rocks (Streckeisen, 1976).

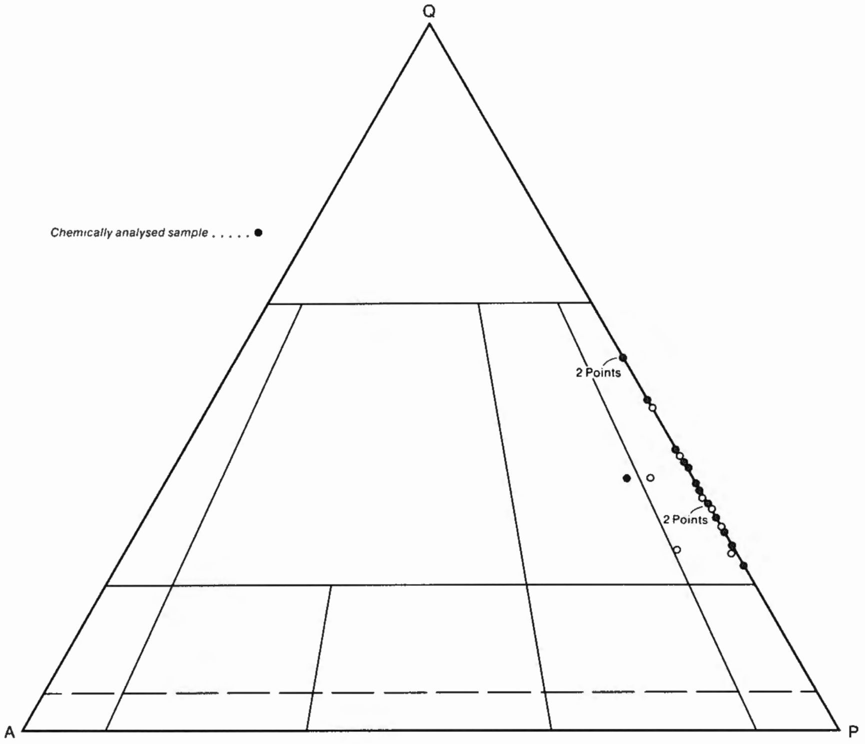


Figure 4. Rocks of unit Ato in the IUGS classification.

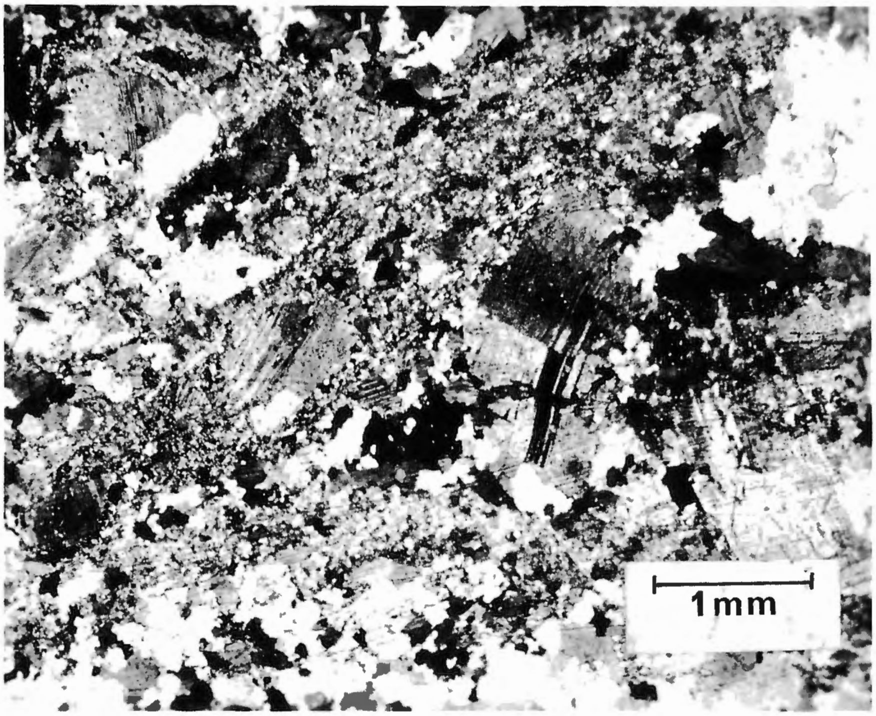


Figure 5. Relict igneous texture in a cataclastic tonalite of unit Ato.

Note: see page 70 for GSC photo numbers.

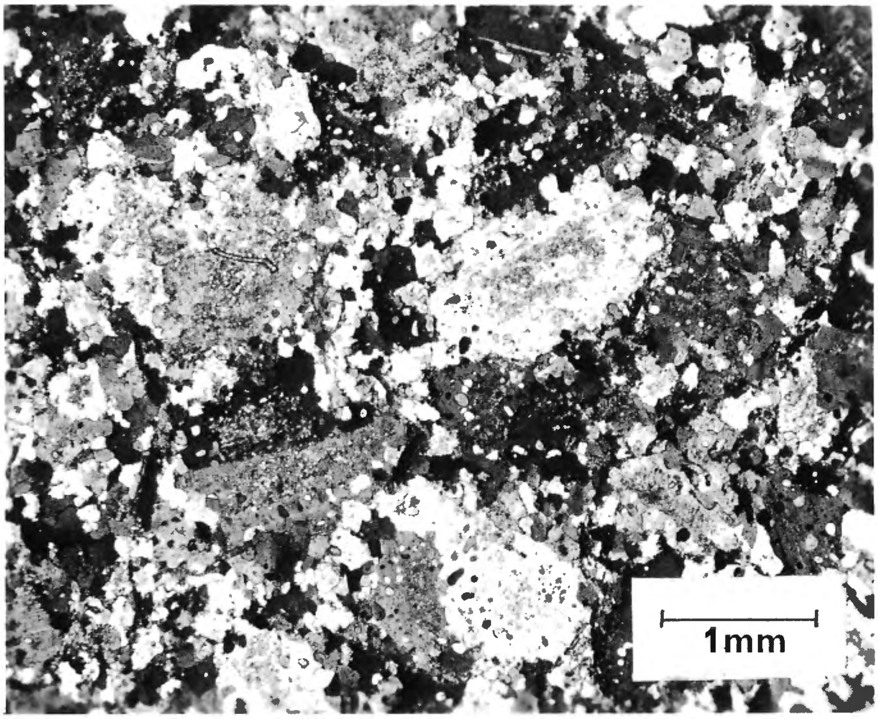


Figure 6. Partly recrystallized relict igneous texture in tonalite of unit Ato.

Chemistry

Chemically (Table 1; see Appendix for tables), as well as petrographically, most of these rocks are tonalites: K_2O/Na_2O ratios are generally less than 0.6 and most samples fall in or near the tonalite field of the CaO-K_2O-Na_2O triangle (Fig. 7). They may further be characterized as low Al_2O_3 trondhjemites in the classification of Barker and Arth (1976) by virtue of an Al_2O_3 content generally less than 15 per cent, low Rb (with one exception, less than 100 ppm) and Sr (less than 300 ppm), and association with mafic magma (now in the form of amphibolite metadykes). Rb and, especially, K contents show a considerable range but relatively good coherency exists between the two elements (Fig. 8). K/Rb ratios tend to be significantly higher than the continental crustal average of 230 (Heier and Adams, 1964) and several are abnormally high (greater than 350; Taylor, 1965), probably a consequence of the dearth of K-feldspar, in which the large Rb ion is normally concentrated. The K-feldspar - poor nature of the tonalites may be the reason for the general trends of Sr enrichment versus Rb and Ba depletion. A plot of Ba versus Rb shows considerable scatter but a rough trend of increasing Ba with increasing Rb emerges (Fig. 8). In contrast, Ti and Zr are strongly coherent.

Contact relations

Contacts of the tonalite with other granitic rocks tend to be gradational or faulted (?) and difficult to delineate, for example in the area due east of Folster Lake. However, contacts with the Prince Albert Group are sharp and commonly concordant. Xenoliths (chiefly amphibolite) of the Prince Albert Group in tonalite are particularly common north of Folster Lake and at one locality, 13 km due east of Cape Lady Simpson, the tonalite clearly has intruded acid metavolcanics, resulting in hybridized rock and abundant partly digested fragments of metavolcanic rock.

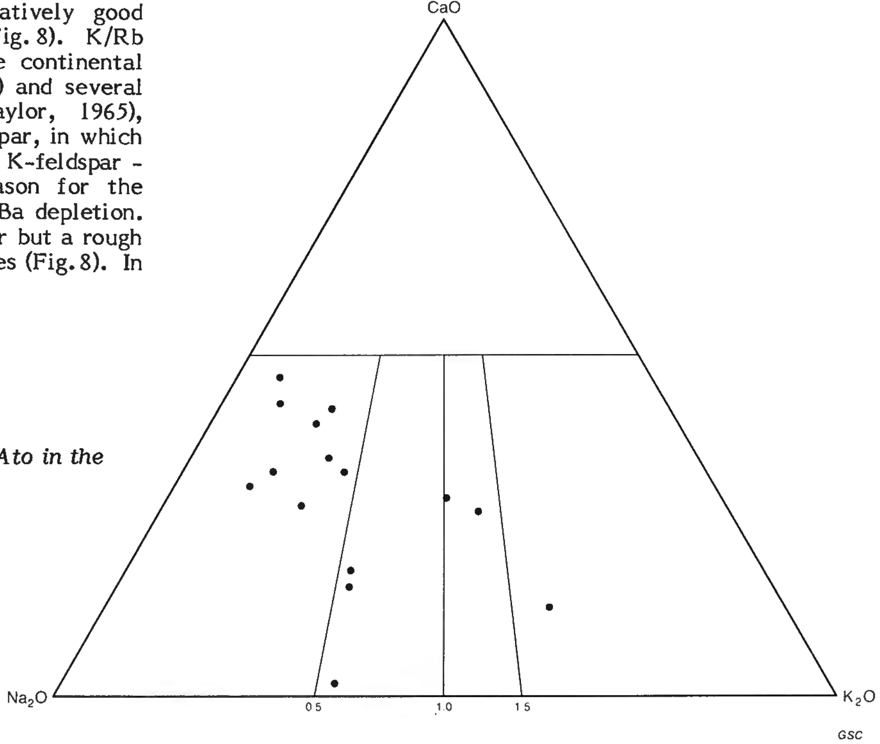
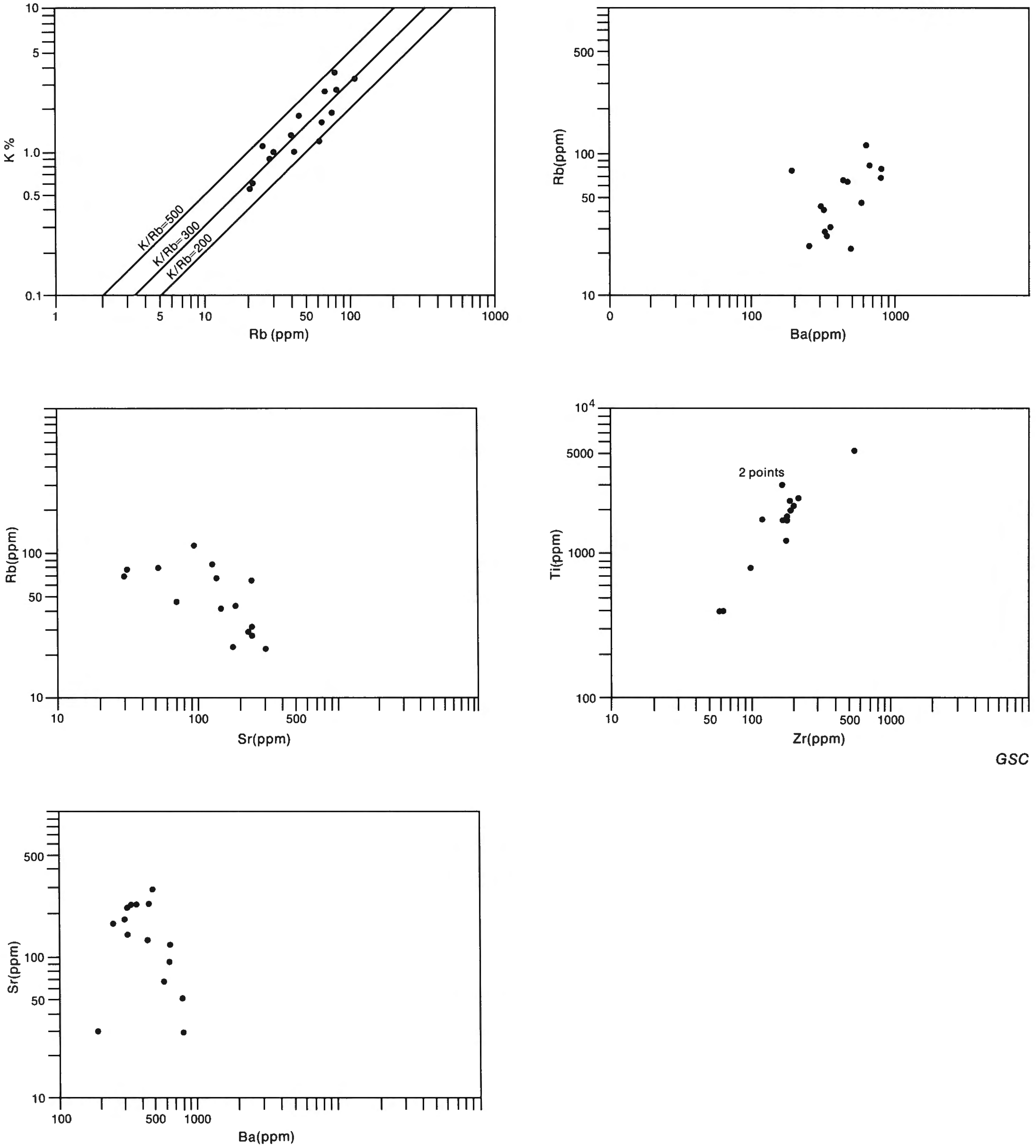


Figure 7. Rocks of unit Ato in the CaO-Na_2O-K_2O triangle.



GSC

Figure 8. Variation diagrams of trace elements in rocks of unit Ato.

Origin

Field relations and textural features of the tonalite suggest a magmatic origin. Chemical evidence supports this interpretation. K/Rb, Sr/Ba, Ti/Zr and, to a lesser degree, Rb/Sr and Ba/Rb form systematic evolutionary trends characteristic of magmatic rocks.

In the normative Q-Ab-Or diagram (Fig. 9) a majority of the rocks plot in an elongate field crudely parallel to the quartz-alkali feldspar cotectic line at 2 x 10^5 kPa water vapour pressure and 695°C, experimentally determined by H. von Platen (Winkler, 1976, p. 293) for a granitic rock with Ab/An = 3.8 (the average Ab/An of the tonalites is 4.0). This may indicate that magmatic differentiation occurred, quartz and plagioclase being removed as the liquid moved toward the minimum melt composition. Normative An decreases, albeit not completely consistently, in the same direction, as it should during differentiation.

Some scatter in trends is to be expected in ancient rocks such as these that have undergone later metamorphism and deformation but the scatter would surely be greater if the rocks were of metasomatic or anatectic origin.

Evidence for remobilization of the tonalite is provided by metadiabase dykes that transect the tonalite but are themselves locally intruded by it. The dykes are discordant to structures in the country rock (Fig. 10), show relict chilled margins, and may be traced into and through the adjacent Prince Albert Group. Dyke margins are commonly straight and sheared (Fig. 11) but may be irregular where movement became sufficiently intense for tonalite to have actually deformed the margin into lobes and cusps. Further movement resulted in breakup of the dyke so that fragments are 'afloat' in tonalite (Fig. 12). The dykes are more fully described in the section dealing with unit md.

Emplacement of the dykes in cool, already consolidated country rock is suggested by their sharp, discordant contacts. The dykes were disrupted in a subsequent event, perhaps long after consolidation of the tonalite. Both tonalite and dyke rock are considered, for lack of evidence to the contrary, to have been metamorphosed together. Quite possibly remobilization and metamorphism were closely related.

However, as pointed out in the discussion of tonalite chemistry, the dykes may be genetically related to the tonalite, in which case emplacement of the two rock types was presumably more or less contemporaneous. A smaller time gap may then separate emplacement of the rocks and their metamorphism and remobilization.

Age

As noted above, the tonalite has invaded the Prince Albert Group but, rather than indicating later emplacement, this may be simply the result of remobilization and the tonalite may well be as old as the Prince Albert Group, or even older.

Ten tonalite samples from north of Folster Lake were processed for whole rock Rb - Sr dating and an isochron based on six of these was obtained, indicating an age of 2678 ± 112 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7022 (Fig. 13). The other four samples deviate markedly from this isochron but for no obvious reason. Two of them (Table 1) are strongly depleted in Sr (21 and 25 ppm) and three are enriched in Rb (75 - 108 ppm) relative to the rest of the tonalite suite---features possibly indicative of post-metamorphic movement of Sr and Rb. The age of 2678 ± 112 Ma falls in the range of zircon U-Pb ages obtained for other rocks in the map area and may give either the time of emplacement of the tonalite or its subsequent metamorphism. The younger ages suggested by samples deviating from the isochron may indicate times of later disturbance when remobilization and cataclasis occurred. Whatever the significance of the Rb-Sr isochron age may be, an Archean age for the tonalite unit is confirmed.

Granitic gneiss (units Agn, Aagn)

Layered gneisses and strongly gneissic granitic rocks form major tracts in all parts of the map area. The majority of the rocks are lumped together as unit Agn, although it is recognized that they may be of different ages. A distinctive assemblage of augen gneisses south of Committee Bay is mapped as Aagn and is described in this section.

Lithology

Unit Agn. This unit is perhaps the most heterogeneous in the map area and includes migmatites and mylonites as well as gneisses.

Most of the rocks are granodiorites and granites but tonalite and plagioclase-rich granite are also represented,

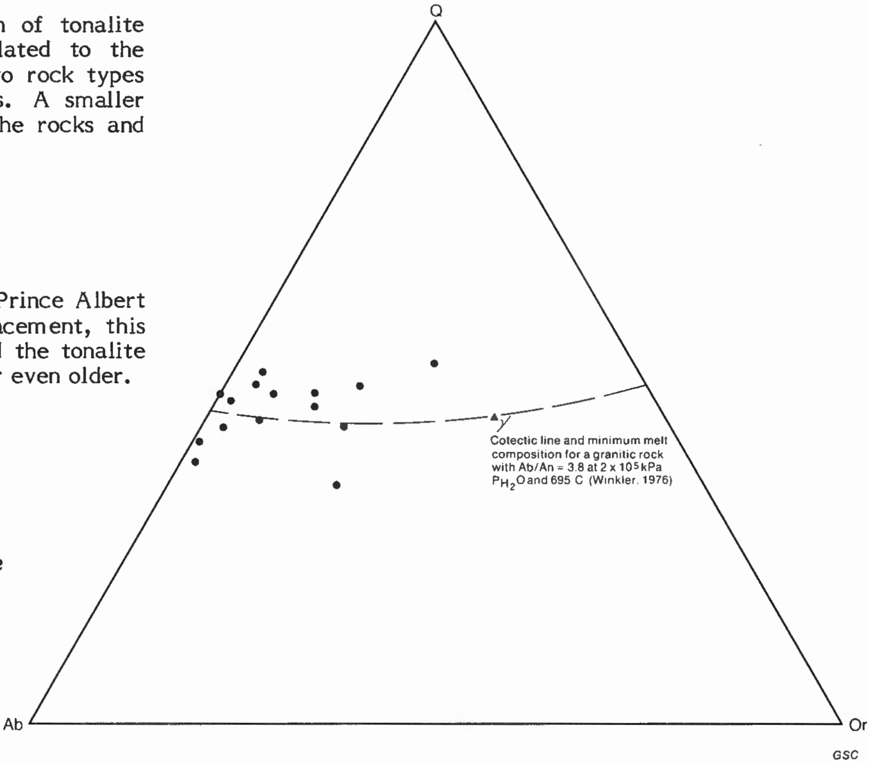


Figure 9. Rocks of unit Ato in the mesonormative Q-Ab-Or triangle.

Figure 10. Amphibolite metadykes of unit md, in foreground and background, cutting tonalite of unit Ato where the Kammaneluk River enters Folster Lake.

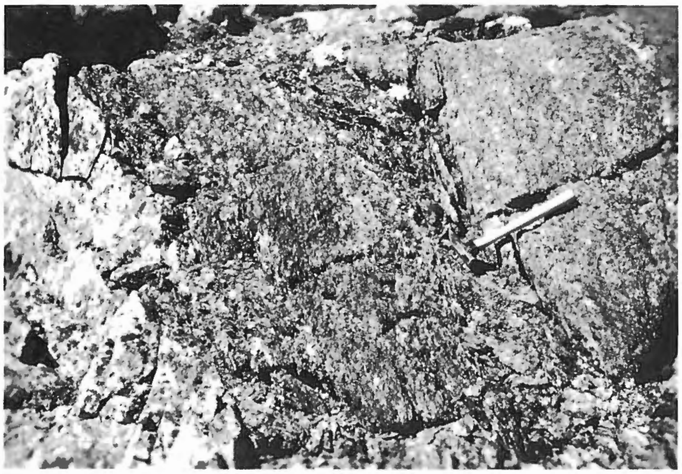


Figure 11. Sheared margin of an amphibolite metadyke in tonalite of unit Ato north of Folster Lake.

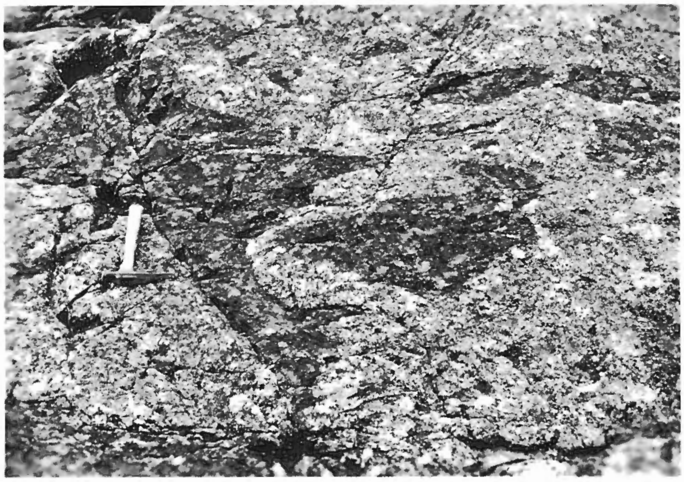


Figure 12. Disrupted amphibolite metadyke in remobilized tonalite, east of Folster Lake.

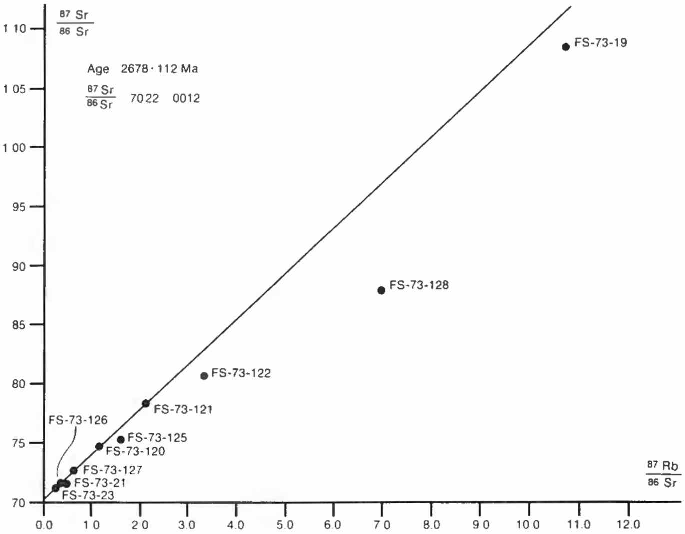


Figure 13. Rb-Sr isochron diagram for rocks of unit Ato. (Data supplied by R.K. Wanless.)

particularly in the northern part of the area (Fig. 14). They are generally grey rather than pink and commonly porphyroblastic, though this texture may be subdued because of flattening and stretching as a result of severe deformation. Layering of pink or white feldspathic material alternating with darker, more mafic material ranges in scale from a few millimetres in gneiss to a metre or so in migmatite. Other rocks are more homogeneous and the gneissic or mylonitic texture is simply an expression of the alignment of particular minerals. In the vicinity of Bagnall Lake, in the northern part of the area, granitic gneisses are intimately mixed with amphibolite (Fig. 15) and the entire assemblage is mapped as unit Agn.

Plagioclase, the chief feldspar in all of these rocks, is slightly more sodic in the granodiorites and granites (An_{21-25}) than in the tonalites (An_{25-29}). Both plagioclase and microcline may form porphyroblasts except in the tonalites, where plagioclase is the sole porphyroblastic feldspar. The plagioclase is usually sericitized and, where heavily altered, may be riddled with epidote. The K-feldspar, invariably microcline, is fresh and generally postdates plagioclase, as shown by inclusions of the latter, particularly in microcline porphyroblasts.

Among the mafic minerals, biotite is predominant and is typically brown; it has a greenish tinge only in a few leucocratic rock types. Grass-green or bluish green hornblende occurs in tonalite gneisses from the northwestern corner of the map area but has only rarely been found elsewhere in unit Agn. Minor pink garnet was noted in granodiorite gneiss from near the eastern margin of the Prince Albert Group. Most of the gneisses contain epidote and many contain chlorite, but these minerals, as well as muscovite, are present in small amounts and are alteration products. The total mafic content in rocks of unit Agn rarely exceeds 10 per cent (by volume).

Cataclasis texture is so common in rocks of this unit that it may be regarded as typical. The matrix of porphyroblastic varieties is generally a fine-grained granular aggregate of quartz and feldspar, which is probably a recrystallized crush. Quartz is invariably strained with sutured borders and, in many rocks, is aggregated in coarser, flattened lenses (*Plättung*). Few rocks seem to have escaped strong deformation.

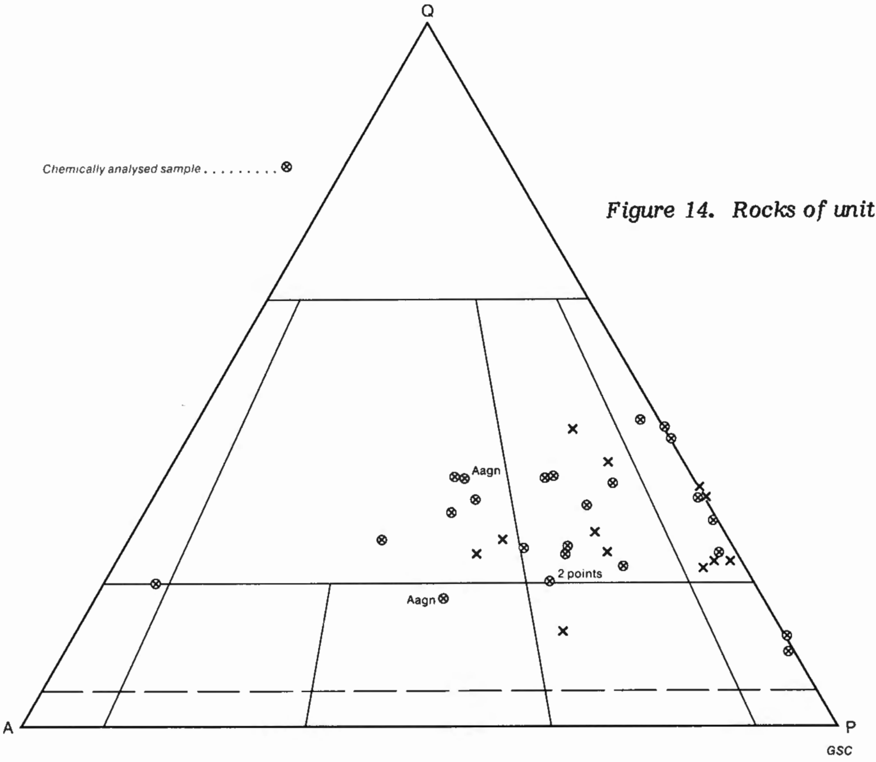


Figure 14. Rocks of units Agn and Aagn in the IUGS classification.

Amphibolites associated with the gneisses are made up of grass-green or blue-green hornblende, oligoclase-andesine, rare biotite and minor sphene. They are generally indistinguishable from amphibolites in the Prince Albert Group and disrupted blocks in gneiss, such as shown in Figure 15, may actually be Prince Albert Group material. The amphibolites may in part represent strongly recrystallized metadykes; they tend to be more coarse grained than the metadykes in the tonalites.

Unit Aagn. A gneiss rich in pink K-feldspar augen and commonly with colour index higher than usual for granitic rock is recognized in the area at the head of Committee Bay. This rock can apparently be traced from Ross Inlet northeastward into the interior of Melville Peninsula east of Mierching Lake (Reesor et al., 1975).

The augen are microcline perthite and range in size from a few millimetres to 3 cm; the larger augen, which may form 20 per cent of the rock, are 1 to 3 cm long. The equigranular matrix comprises zoned plagioclase An_{23-26}, microcline, quartz, grass-green hornblende, deep brown biotite, and sphene as a major accessory in mafic varieties of gneiss. Quartz content varies markedly; some of the gneisses are syenitic. In highly altered specimens, biotite has been completely replaced by chlorite and plagioclase is heavily sericitized.

Amphibolite lenses, more or less chloritized, are common in the augen gneisses near the head of Ross Inlet but are too erratically distributed to be considered as a lithological characteristic of the gneisses.

Chemistry

Chemically, the gneisses fall into two groups, one chiefly tonalitic, the other granodioritic-granitic (Table 2). The two analyzed samples of unit Aagn fall in the latter group. The CaO-K_2O-Na_2O plot (Fig. 16) shows that the analyzed tonalitic rocks consistently have K_2O/Na_2O ratios less than 0.5. For the other group K_2O/Na_2O ratios are, with the exception of one granodiorite, greater than unity. A similar separation of the two groups is evident in the K versus Rb diagram (Fig. 17). The K/Rb ratios of the tonalitic samples cluster between about 200 and 300; the granodiorites-granites show more scatter between about 150 and 350. Ba is generally lower in the tonalitic group. No distinction can be made on the basis of Sr content but, for the tonalitic group, Rb/Sr ratios are below 0.37 (most are below 0.2) and for the

Figure 15. Granitic gneiss with layers and lenses of amphibolite from unit Agn south of Bagnall Lake. Zircons from gneiss of this outcrop gave a U-Pb concordia intercept age of 2919 Ma (Fig. 21).

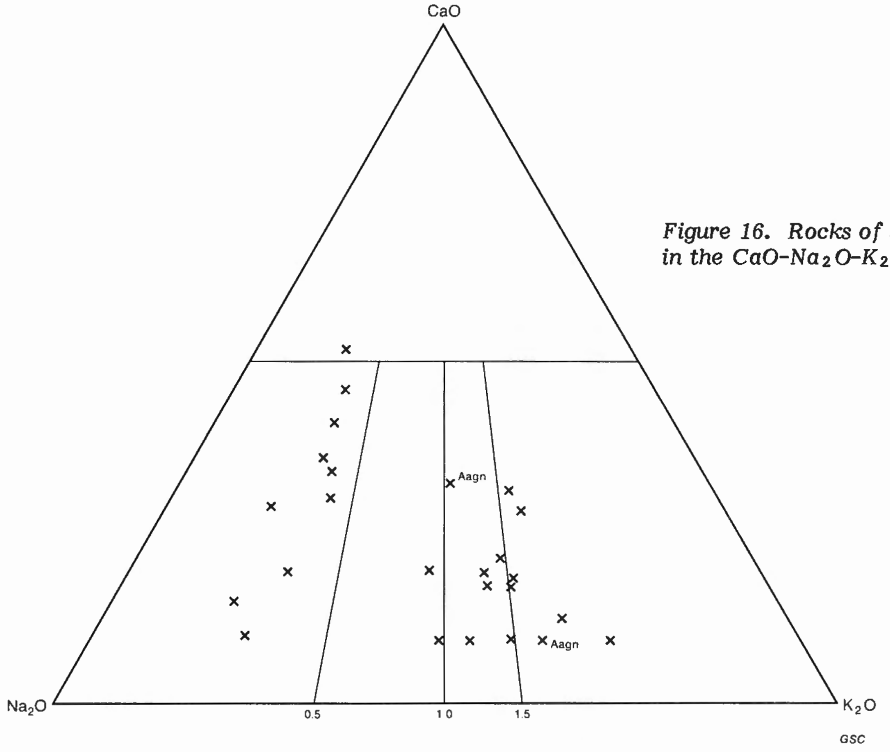


Figure 16. Rocks of units Agn and Aagn in the CaO-Na_2O-K_2O triangle

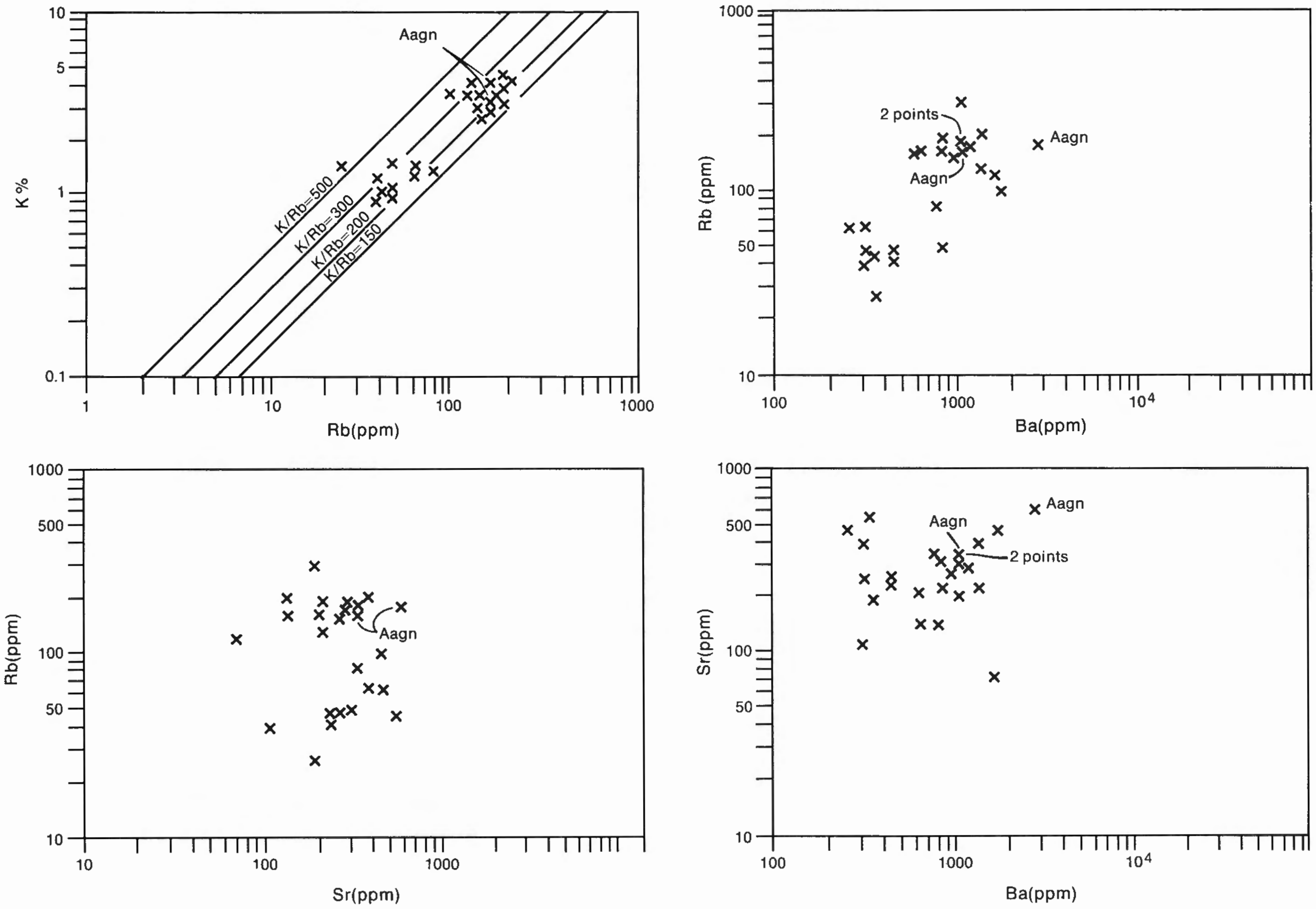


Figure 17. Variation diagrams of trace elements in rocks of units Agn and Aagn.

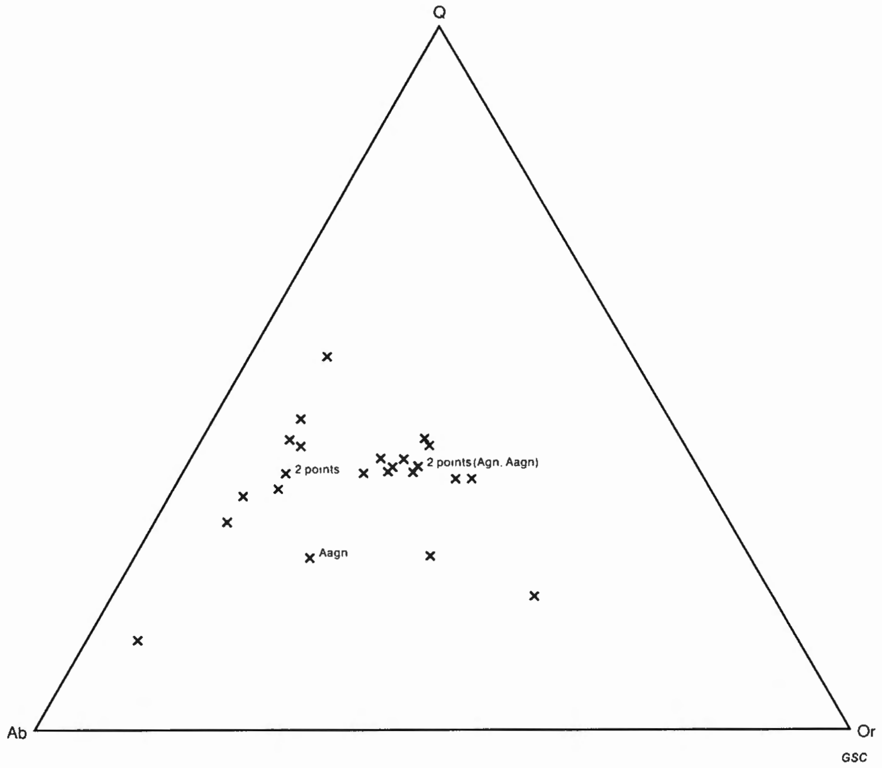


Figure 18. Rocks of units Agn and Aagn in the mesonormative Q-Ab-Or triangle.

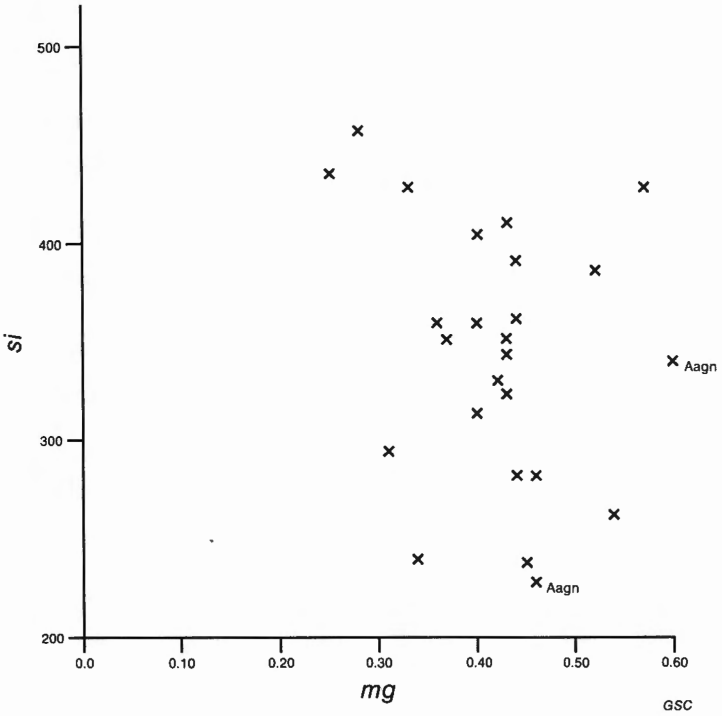


Figure 19. Variation diagram of Niggli si *and* mg *in rocks of units Agn and Aagn.*

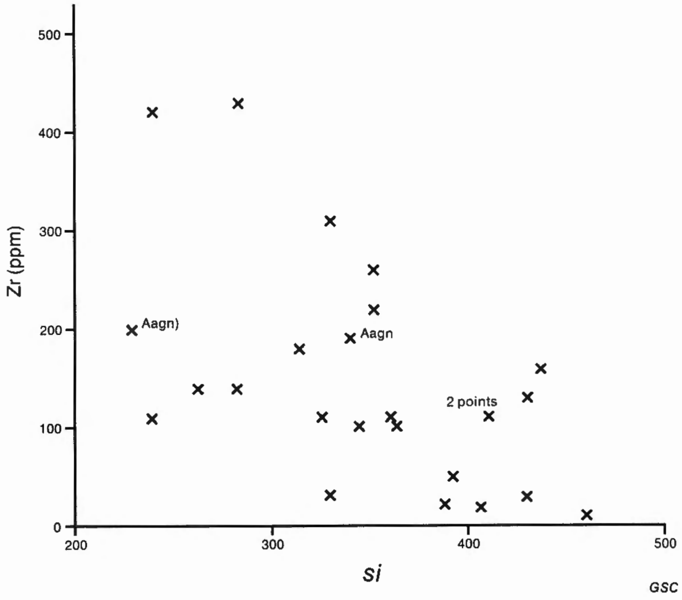


Figure 20. Variation diagram of Zr (ppm) and Niggli si *in rocks of units Agn and Aagn.*

other group, with one exception, the Rb/Sr ratio is about 0.5 or more (mostly greater than 0.6). The exception is sample FS-72-22 from unit Aagn, which has higher Sr and markedly higher Ba (2860 ppm) content than the rest of the gneisses. It seems likely that most of the barium is held in the abundant microcline of this rock.

In terms of SiO_2 and Al_2O_3, both groups overlap to a large extent but the tonalitic rocks, with two exceptions, have 75 per cent or less SiO_2 and more than 14 per cent Al_2O_3. These chemical features, along with low Rb/Sr ratios, are among those shown by the common variety of tonalitic rocks found in terranes ranging from Archean to Tertiary age in various parts of the world, according to Hunter et al. (1978). However, the tonalitic rocks of unit Agn differ chemically from those of unit Ato, which tend to have, for example, more Al_2O_3 and higher K/Rb ratios.

As would be expected in an assemblage as heterogeneous as unit Agn, no coherent trends emerge in the various trace element distribution plots (Fig. 17). The somewhat chemically anomalous sample FS-72-22 of augen gneiss tends to plot apart from the other rocks.

Contact relations

Unit Agn appears to be younger than the Prince Albert Group, as xenoliths of the latter are common in contact zones. Some xenoliths are large enough to be shown on the geological map, for example, the northern end of the domal gneiss body near the northern margin of the map area. These particular xenoliths appear to have been folded into general conformity with the contact between the gneiss and the Prince Albert Group. Two kilometres north, amphibolites of the Prince Albert Group and gneiss have been tightly and isoclinally folded to produce a zigzag but conformable contact. Clearly, intrusion of gneiss into the Prince Albert Group was followed or accompanied by strong deformation. A comparable situation obtains south of Mineau River, northwest of Fraser Bay. Here gneiss and Prince Albert Group amphibolite and metagabbro exhibit a folded, conformable contact, and a narrow zone of interlayered amphibolite and gneiss forms a transition zone between the metagabbro and gneiss.

Contact relations with other granitic units are generally less unequivocal. The gradational contact zone between units Agn and Ag east of Bagnall Lake is described in the section on unit Ag. At the southern end of Committee Bay, gneiss of unit Agn is cut by massive pink granite and pegmatite (unit Agr). Elsewhere, contacts are conformable or gradational and age relations are consequently uncertain.

The augen gneiss of unit Aagn is veined by massive, equigranular and altered pink granite and cut by pegmatite (both rock types are assigned to unit Agr). Contacts with gneisses of unit Agn and with the narrow metasedimentary-metavolcanic belts south of Committee Bay are conformable and generally sharp.

Origin

Neither the lithology nor the geochemistry of the gneisses offers many clues to their origin. None of the rocks appears in the field to be metasedimentary nor are they commonly associated with, or contain relicts of, metasediments. In fact, associated rocks, not counting those assigned to the Prince Albert Group, are of apparent igneous origin, that is, amphibolites, mafic schists and metabasic intrusions.

In the Q-Ab-Or diagram (Fig. 18), the gneisses are segregated into two groups. Twelve samples (mostly granodiorites) cluster in the central region, where late-stage granitic differentiates of igneous origin would plot. Most of the remainder (tonalitic) fall in a linear zone parallel to the Q-Ab sideline. All in all, the pattern strikingly similar to that shown by rocks of the Ancient Gneiss Complex of Swaziland, considered by Hunter et al. (1978), on the basis of major, minor and trace element geochemistry, to be of igneous origin.

A rock differing chemically from the others, such as sample FS-74-65, may be metasedimentary. A sedimentary origin for this particular sample is substantiated by its high Zr content (430 ppm), probably a result of concentration of zircon, though this is not evident in the thin section examined. Again, the anomalous augen gneiss (sample FS-72-22) plots in an isolated position but the high mafic mineral (26 vol. %) and TiO_2 (0.72 wt. %) contents suggest an igneous parentage.

In an attempt to narrow the choice between an igneous and a sedimentary origin for the bulk of the gneisses, chemical criteria proposed by van de Kamp et al. (1976) were studied. These workers pointed to the contrasting trends in plots of the Niggli values *si* and *mg* between igneous suites and psammitic sediments (derived from an igneous-metamorphic terrane): a negative correlation of *si* with *mg* in igneous rocks, a positive one in the sediments. Figure 19 shows a moderately good negative correlation for the gneisses of unit Agn.

A second parameter suggested by van de Kamp et al. (ibid.) is the Zr-*si* relationship. In the differentiation of calc-alkali igneous suites, Zr increases as *si* increases, whereas in sediments, varying degrees of efficiency of sorting detrital zircon leads to much more erratic variation of Zr with increasing silica: the maximum Zr rises markedly and the minimum falls significantly. A variation diagram (Fig. 20) for unit Agn gneisses shows only limited scatter in comparison with the data for sandstones obtained by van de Kamp et al. (ibid., Fig. 5). This is further evidence of an igneous origin for the gneisses.

Van de Kamp et al. (ibid.) also proposed using the variation of Cr and Ni with *mg* as a means of testing the origin of quartzofeldspathic gneisses. This is not possible with the data at hand because the analytical techniques used were insufficiently sensitive at low concentrations.

Age

A sample of the gneiss bearing amphibolite inclusions, shown in Figure 15, has yielded the oldest isotopic age determined in the map area. Two zircon fractions, magnetic and nonmagnetic, define a chord intercepting the concordia curve at 2919 Ma (Fig. 21a) and at 1519 Ma. Combining the data for this sample (WN-36-74) with those for gneiss associated with Prince Albert - type rocks in the Lyon Inlet area, southeastern Melville Peninsula, defines a chord with an upper intercept at 2953 Ma (Fig. 21b).

Biotite from this rock has a ^{40}K-^{40}Ar age of 1723 ± 42 Ma, slightly higher than the typical value of around 1600 Ma for micas from this part of the Canadian Shield. Perhaps this age reflects the presence of excess argon in the sample.

A ^{40}K-^{40}Ar age of 1621 ± 40 Ma has been determined on biotite from gneissic rock of the domal granitic body in Prince Albert Group of the northeastern part of the map area. Migmatitic granodiorite gneiss south of Matheson River, east of Lefroy Bay, gives K-Ar ages of 1647 ± 41 Ma and 1722 ± 49 Ma on biotite and hornblende, respectively. All these ages are typical K-Ar values for the region.

The zircon results indicate that at least part of unit Agn is Archean and that the Prince Albert Group is older than 2900 Ma or so, if the gneisses intruding the Prince Albert have not been remobilized. If there has been remobilization, the great age hints at the possibility of a pre - Prince Albert Group basement. Zircon from the augen gneiss sample FS-72-22 yields a discordant U-Pb age pattern: ^{206}Pb-^{238}U, 2103 Ma; ^{207}Pb-^{235}U, 2273 Ma; ^{207}Pb-^{206}Pb, 2429 Ma. Hence unit Aagn is at least early Aphebian and probably Archean.

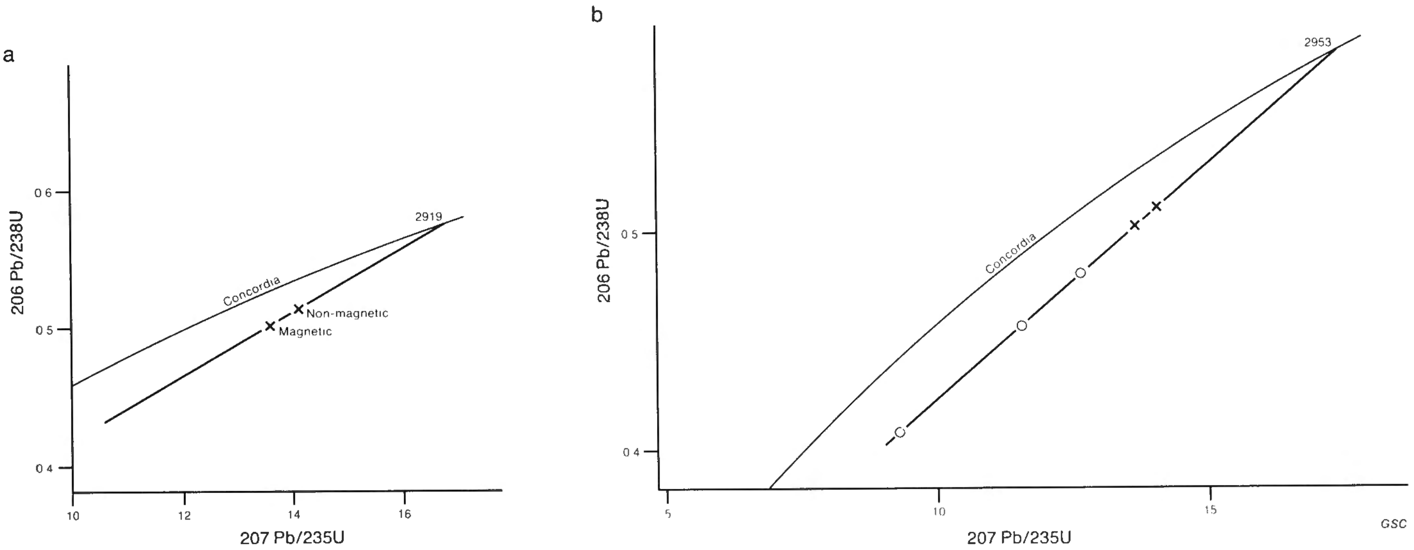


Figure 21. (a) Concordia diagram and U-Pb isotopic ratios for two zircon fractions from gneiss shown in Figure 15 (sample WN-36-74). (b) The same data combined with 'basement gneiss' from Lyon Inlet. (Data supplied by R.K. Wanless.)

Massive to poorly foliated granite and granodiorite (unit Ag)

A variety of granites and granodiorites (Fig. 22) is encompassed by this major unit, which underlies a large part of the map area. The unit is undoubtedly divisible into several smaller units but this requires more detailed mapping. Many of the rocks, however, share certain distinctive features, which are emphasized in the following descriptions.

Lithology

The granites are fine- to medium-grained pink rocks with a poorly developed foliation at best. Most examples of this group are relatively even grained but some are microcline-porphyroblastic. The chief minerals are oligoclase, microcline and quartz; accessory minerals are brown biotite and muscovite. Plagioclase is sericitized or epidotized and biotite is chloritized; quartz shows sutured borders and strong undulatory extinction. In contrast, microcline is fresh and appears to have continued crystallizing to a late stage, as inclusions of sericitized plagioclase are common.

The granodiorites tend to be more foliated and porphyroblastic than the granites and grey overall, rather than pink. Other than showing a preponderance of plagioclase (An_{25}) over microcline, the granodiorites in mineralogy and degree of alteration are similar to the granites.

It must be stressed that the granites and granodiorites grade into each other and may be intimately associated in the field, so that any clear distinction between these rock types is probably artificial and may well be of no significance.

Chemistry

The ten analyzed rocks of unit Ag contain 70 per cent or more SiO_2 and generally less than 14 per cent Al_2O_3 (Table 3). K_2O/Na_2O ratios range from 1.0 to 2.1 (Fig. 23). The high level of potash is accompanied by generally high levels of Rb, as might be expected. In the K-Rb plot (Fig. 24), marked enrichment in Rb is concomitant with only a minor increase in K, resulting in a spread of points across the diagram. Correlations between Rb, Sr and Ba are moderately good. Figure 24 shows a definite depletion in Sr with enrichment in Rb but the trend is marked only at higher Sr levels. Sr and Ba exhibit a regular sympathetic relationship. At higher values of Ba, Rb and Ba show a negative correlation. No trend is evident in a Ti-Zr plot.

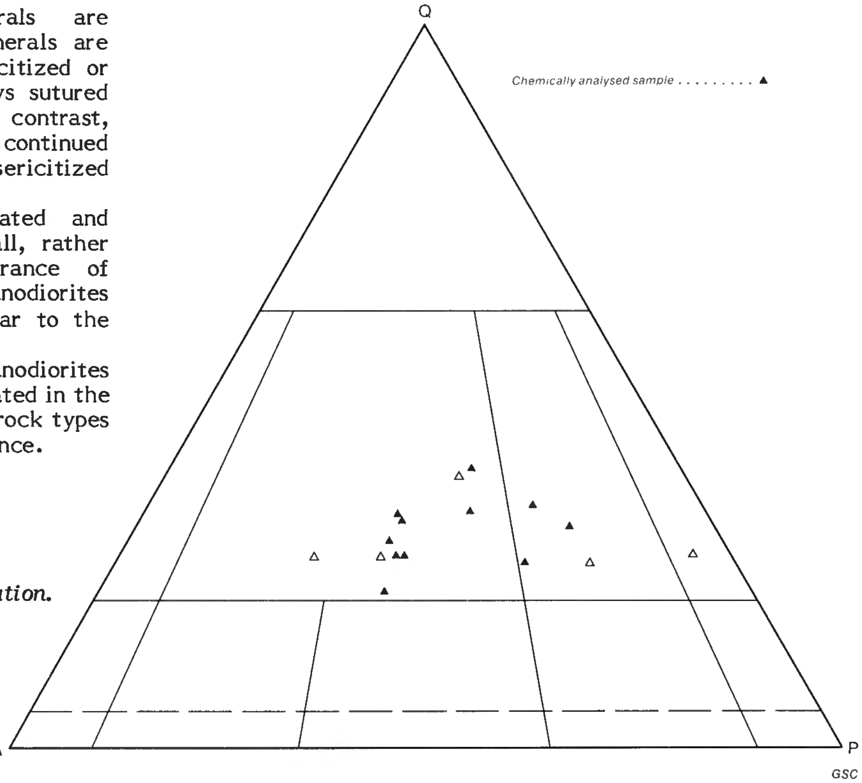


Figure 22. Rocks of unit Ag in the IUGS classification.

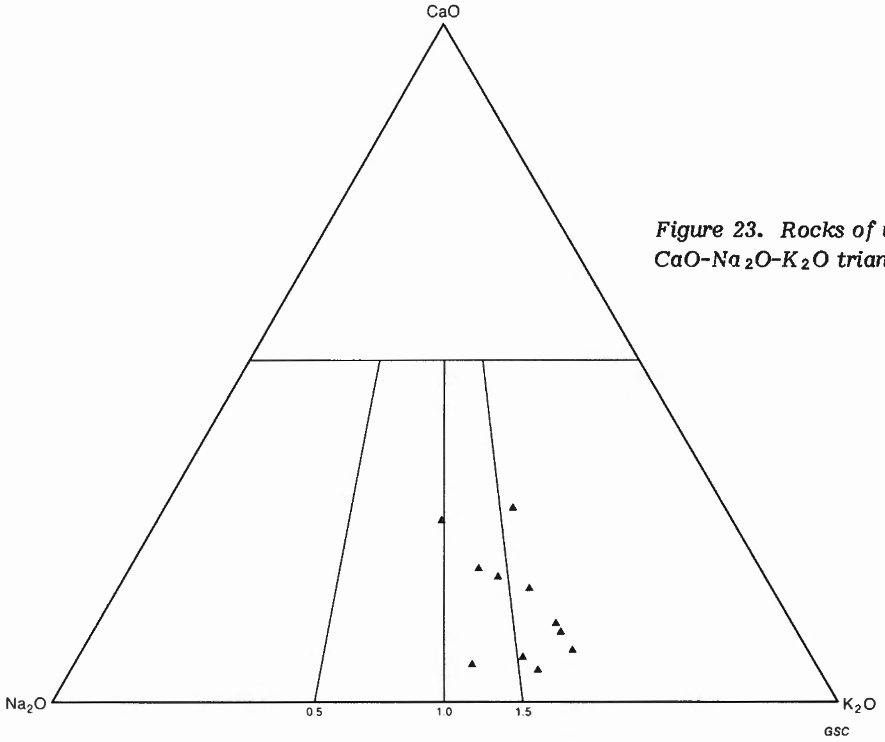


Figure 23. Rocks of unit Ag in the CaO-Na$_2$O-K$_2$O triangle.

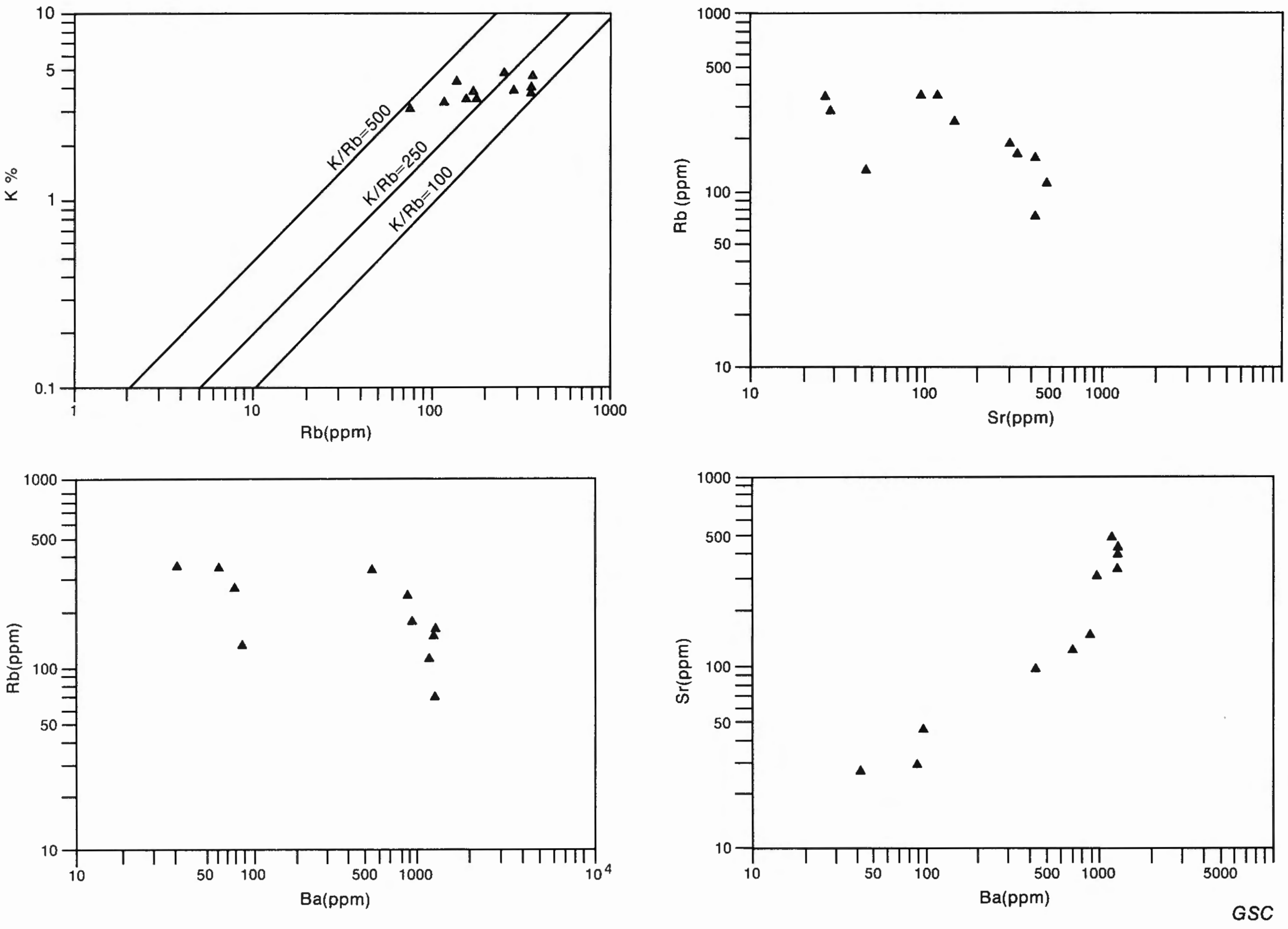


Figure 24. Variation diagrams of trace elements in rocks of unit Ag.

Contact relations

Unit Ag, whether massive or foliated, is intrusive into the Prince Albert Group (Fig. 25). Xenoliths of the latter are particularly common adjacent to the irregular western contact north and south of Adamson River. In fact, south of the river, xenoliths of amphibolite and mafic schists are so abundant that a subunit Agm of Ag can be delineated as far west as the coast between Barnston Point and Cape Finlayson. At this distance from Prince Albert Group outcrops, it is, of course, not possible to be certain that the xenoliths are Prince Albert rocks but this interpretation seems the most likely. If correct, it suggests the presence of Prince Albert Group at shallow depths far to the west of the present exposures.

East and northeast of Bagnall Lake, dominantly massive rocks of unit Ag grade into the foliated rocks of unit Agn over a distance of 1 to 2 km, without any indication of which unit is the younger. Contacts with other granitic units are similarly conformable or gradational.

Figure 25. Intrusive contact between granitic rock of unit Ag and amphibolite of the Prince Albert Group, along the western margin of the Prince Albert greenstone belt, 8 km north of Adamson River.

Origin

Discordant contacts and xenoliths of country rock at the margins of the Prince Albert Group indicate that unit Ag is at least partly of magmatic origin.

The chemical data generally support an origin by advanced fractionation of magma. Marked enrichment in Rb relative to K, evident in Figure 24, is a feature of late-stage granites and differentiates of highly fractionated magmas (Taylor, 1965). The good coherence of Sr and Ba is also well known in progressive differentiation. Igneous rocks show regular trends in Rb-Sr and Rb-Ba relations and, at lower Rb values at least, the trends in unit Ag are moderately well defined. However, since differentiation involving fractionation of plagioclase would produce negative slopes of both Rb/Sr and Sr/Ba ratios, evidence for such a process is contradictory (Fig. 24).

In the normative Q-Ab-Or triangle (Fig. 26) the rocks cluster in a central area, in the thermal trough where late-stage melts in the simple granite system plot, but this is not conclusive evidence of a magmatic origin. Roubault and de La Roche (1973) plotted the analyses of 565 gneisses and migmatites in the Q-Ab-Or diagram and found that their distribution coincided with that of 1190 igneous rocks of granitic composition. They concluded that, it being unlikely that the gneisses and migmatites were all of igneous origin, the area of thermal minima in the Q-Ab-Or system is one where compositions of rocks of different origins converge.

In summary, the field and chemical evidence best supports a late magmatic origin for unit Ag.

Age

U-Pb age data are available for the granitic body east of 'Triangle Lake', south of Adamson River. This body is in contact with the Prince Albert Group but age relations could not be established. It is commonly augen-textured biotite granite or granodiorite, strongly to moderately gneissic; the foliation indicates an antiform. Much of the body closely resembles the granitic rocks along the western margin of the Prince Albert Group north of Adamson River. There, the granitic rocks intrude the Prince Albert Group.

Zircon of a single size fraction from granodiorite (sample FS-73-158) from this body gives the following discordant ages: ^{206}Pb-^{238}U, 1803 Ma; ^{207}Pb-^{235}U, 1996 Ma; ^{207}Pb-^{206}Pb, 2203 Ma. On the concordia diagram (Fig. 27), this sample and three others from various parts of the map area fall on a line intersecting the concordia curve at 2709 Ma. However, there being no obvious relations between these rocks, no particular significance should be attached to the Archean age. Nevertheless, the general similarity of this granodiorite to other granitic rocks on Melville Peninsula known to be of Archean age suggests that it, too, is Archean.

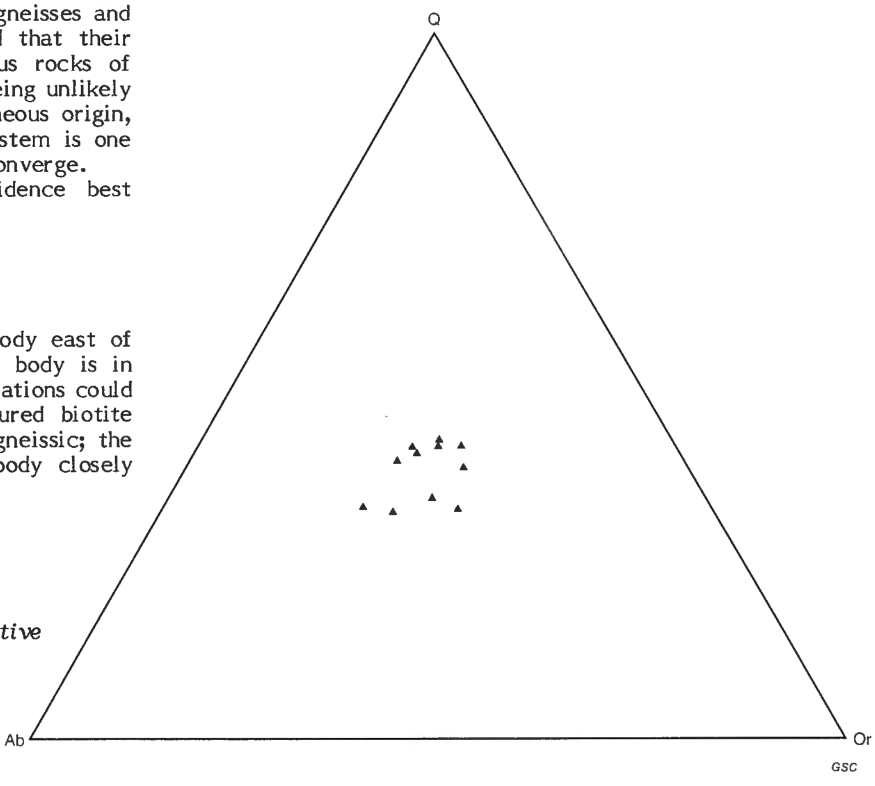


Figure 26. Rocks of unit Ag in the mesonormative Q-Ab-Or triangle.

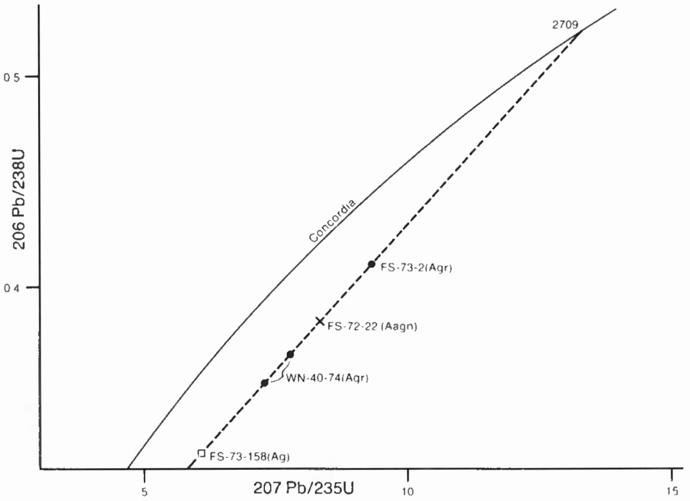


Figure 27. Concordia diagram and U-Pb isotopic ratios for zircons from a granodiorite of unit Ag, two rocks of unit Agr and a gneiss of unit Aagn. The samples may be joined by a line intercepting the concordia at 2709 Ma but the rocks are not necessarily related geologically. (Data supplied by R.K. Wanless).

Massive porphyroblastic granitic rocks (unit Agr)

The major occurrences of this unit are found north of Bagnall Lake, on and near Glen Island, south of Folster Lake, and around Lefroy Bay. Rocks of this unit are characterized by a pink colour and large crystals of potassium feldspar set in a fine- to medium-grained matrix. Similar rocks occur elsewhere in the map area and have generally been included in unit Ag. Rocks of unit Agr are distinguished from these only where they form mappable bodies or large tracts.

Lithology

Most representatives of unit Agr plot in the granite field of the QAP triangle (Fig. 28). They are rich in microcline, both as porphyroblasts and in the matrix, and invariably are pink. Although it may be appropriate to call the larger, commonly well formed crystals of microcline phenocrysts, the term 'porphyroblast' is preferable. These rocks are not separable in age from other granitic rocks in the area and clearly have a similar plutonic history. Thus for consistency they are termed porphyroblastic rather than porphyritic.

These are virtually structureless rocks; any foliation is slight and local and porphyroblasts lack any preferred orientation. The microcline porphyroblasts range in size from less than 1 cm to 3 cm but are generally about 1 to 2 cm long, subhedral to euhedral, and commonly Carlsbad-twinned. Thin sections show that many of the porphyroblasts include small laths of plagioclase (oligoclase) arranged in regular fashion outlining the shape of the host crystal. This plagioclase and that in the matrix are more or less sericitized, indicating that the coarse microcline grew significantly later than plagioclase.

The groundmass is largely quartzofeldspathic and appears to be partly recrystallized. Microcline, unzoned plagioclase (An_{23} to An_{27}) and quartz form subhedral to anhedral grains of variable size. Granular aggregates of these minerals between the porphyroblasts display grain contacts tending toward the Y-shaped, equigranular triple-junction form and hence probably represent recrystallized crush. Major mafic minerals comprise brown biotite that is partly extensively chloritized, epidote and, rarely, grass-green hornblende. Sphene and Fe-Ti oxides are ubiquitous accessories. Minor fluorite was noted from Glen Island, both in the field and in one thin section, and seems to be erratically distributed. Unit Agr is the only one in which fluorite has been observed.

Coarse pegmatites are abundantly developed in the rocks of Glen Island and the neighbouring mainland.

Chemistry

Nine samples of this unit have been analyzed (Table 4). All but a granodiorite (sample FS-74-39) from east of Lefroy Bay have high SiO_2 (more than 71 %), low Al_2O_3 (less than 14 %) and K_2O/Na_2O ratios greater than 1 (Fig. 29). In these respects, unit Agr chemically resembles unit Ag.

However, in the K-Rb plot (Fig. 30) unit Agr samples form a tight cluster of points largely between K/Rb ratios of 200 and 300, within the 'normal' range (Taylor, 1965). In contrast, rocks of unit Ag form a belt across the diagram, as a result of a greater spread in Rb content at the same general levels of K. Rb/Sr ratios are generally close to unity or higher but the highest is 4.22, much lower than some of the elevated ratios of unit Ag rocks. In both units Rb enrichment is concomitant with Sr and Ba depletion (Fig. 30) but these relations are less regular in unit Agr than in Ag. It should be noted that in unit Agr, Sr and Ba contents show a more limited range and are, in general, higher than in unit Ag. A strong, positive correlation exists in both units between Sr and Ba, suggesting an igneous differentiation trend. Plotting Ti against Zr results in large scatter, as for unit Ag.

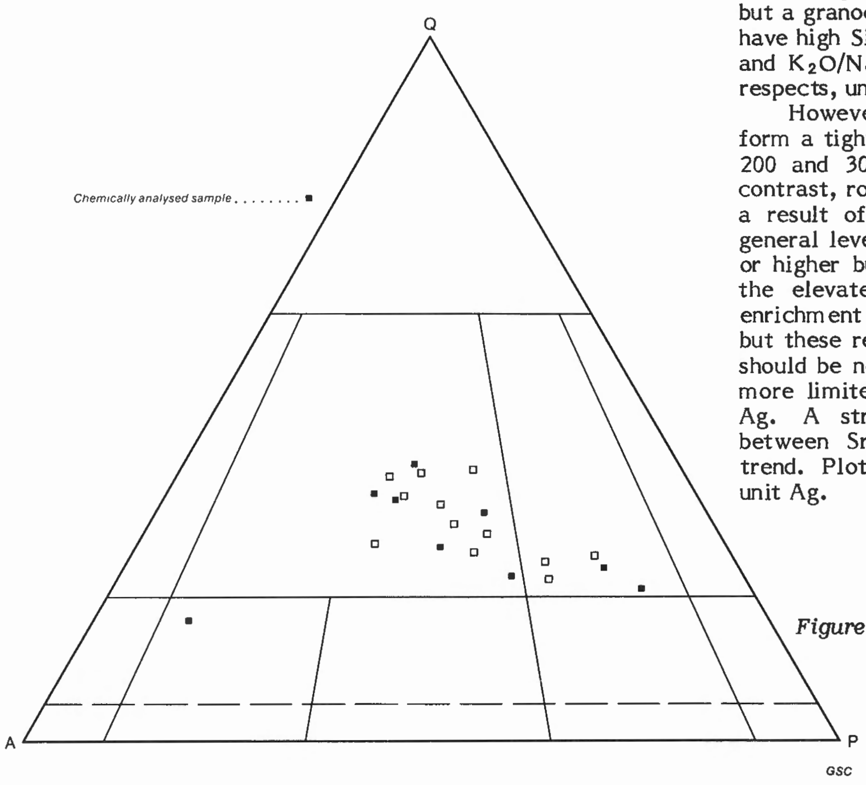


Figure 28. Rocks of unit Agr in the IUGS classification.

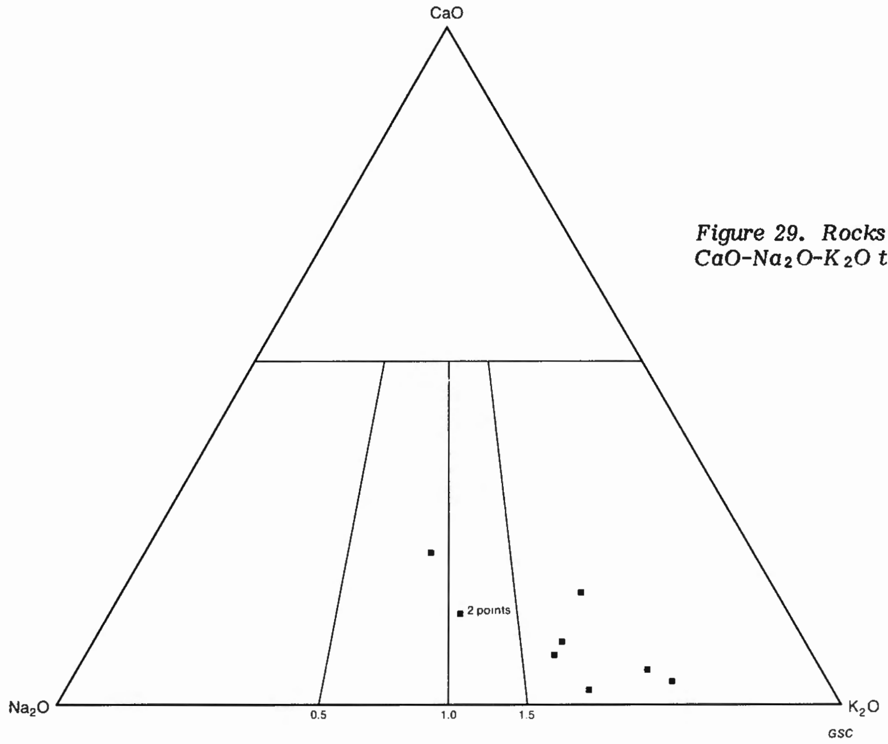


Figure 29. Rocks of unit Agr in the CaO-Na$_2$O-K$_2$O triangle.

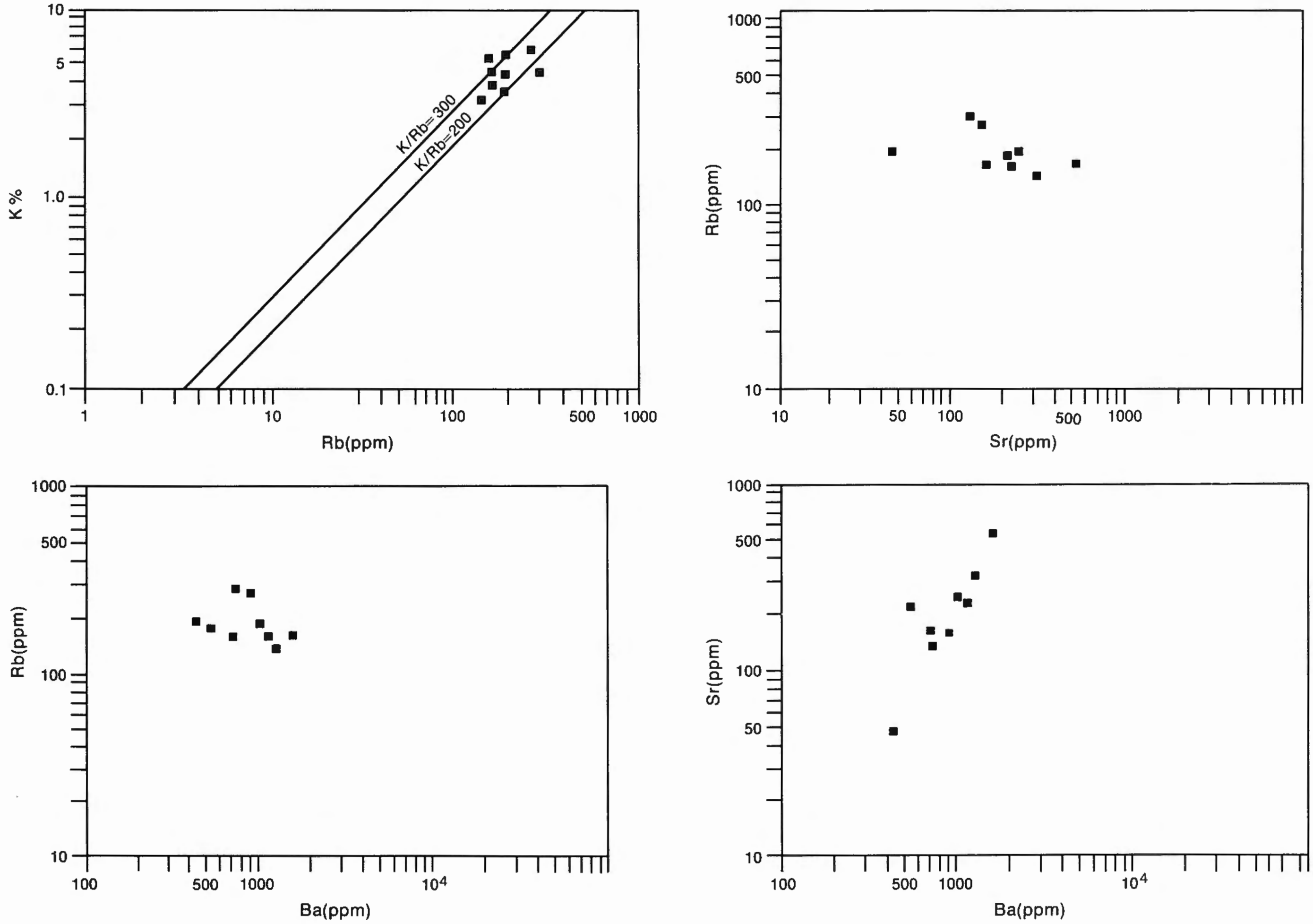


Figure 30. Variation diagrams of trace elements in rocks of unit Agr.

Contact relations

Southeast of Folster Lake, unit Agr is intrusive into the Prince Albert Group (Fig. 31). This contact, however, is not marked by a chill zone. Also in this area, metamafic inclusions up to many metres in size become increasingly common in the granitic rocks as the contact with the Prince Albert Group is approached. Contacts with the tonalites (unit Ato) appear to be gradational or faulted.

North of Mackar Inlet, units Agr and Agn are in contact. Abundant pegmatites in unit Agr cut across the contact in many places and if the pegmatites are genetically related to unit Agr, as seems likely from their distribution, this contact is intrusive.

Elsewhere, contacts with other units are sharp or gradational and their nature is indeterminate.

Origin

The contact relations shown in Figure 31 strongly suggest molten intrusion. The lack of a well developed chill zone may indicate that the granitic melt intruded country rock that was itself hot---in this instance, Prince Albert Group.

Relations between the trace elements Rb, Sr and Ba are consistent with magmatic differentiation, although only in the case of Sr-Ba is the correlation marked. Judged by higher K/Rb ratios (greater than 200) and lower Rb/Sr ratios (generally about 1), unit Agr has fewer highly fractionated rocks than unit Ag.

In the Q-Ab-Or diagram (Fig. 32), unit Agr rocks, two granodiorites excepted, plot in the central, 'granite minimum' area but slightly more to the Or-rich side than unit Ag rocks. The average K_2O/Na_2O ratio of the latter is slightly lower than for unit Agr (1.6 as against 2.1) yet unit Ag rocks appear chemically to be more fractionated. This may mean that potash metasomatism has occurred in unit Agr; certainly the clear evidence of late growth of K-feldspar porphyroblasts does not contradict it.

Figure 31. Granitic rocks of unit Agr intruding dark supracrustal rocks of the Prince Albert Group east of Folster Lake.

In summary, unit Agr is considered to be of probable igneous origin but, like unit Ag, few of its lithological and chemical characteristics are diagnostic. Possible igneous trends may have been modified by potash metasomatism.

Age

U-Pb and K-Ar ages are available from Glen Island and southeast of Folster Lake. Zircon in granite from Glen Island (sample FS-73-2) gives the following discordant age pattern: $^{206}Pb-^{238}U$, 2222 Ma; $^{207}Pb-^{235}U$, 2375 Ma; $^{207}Pb-^{206}Pb$, 2510 Ma.

This granite, therefore, is at least 2510 Ma old. Two fractions (magnetic and nonmagnetic) of zircon from a granite (sample WN-40-74) near Folster Lake give a concordia intercept age of 2675±34 Ma. The three data points for the two unit Agr samples fall on a line intercepting the concordia curve at 2706 Ma (Fig. 33), essentially indistinguishable from the 2675 Ma age. If this is the age of crystallization of the granitic magma from which unit Agr was formed, the Prince Albert Group must be at least 2706 Ma old, as it is intruded by unit Agr. The age also agrees, within error limits, with the Rb-Sr whole rock age of 2678±112 Ma for the tonalite unit Ato.

The lower concordia intercept age of the granite southeast of Folster Lake is 1264 Ma. This date is considerably younger than the $^{40}K-^{40}Ar$ age on biotite from the same sample, that is 1630±48 Ma, which is a typical mica K-Ar age for Melville Peninsula. It is younger even than the K-Ar age (ca. 1450 Ma) of metamorphism of the Folster Lake Formation, which outcrops in the vicinity. Hence the 1264 Ma date cannot be accounted for.

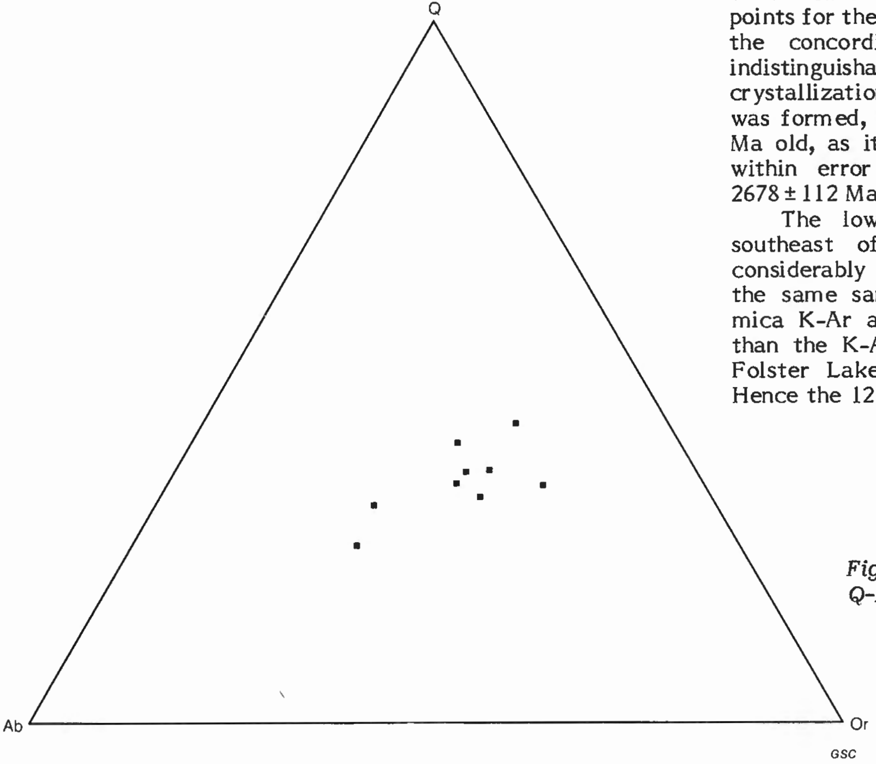


Figure 32. Rocks of unit Agr in the mesonormative Q-Ab-Or triangle.

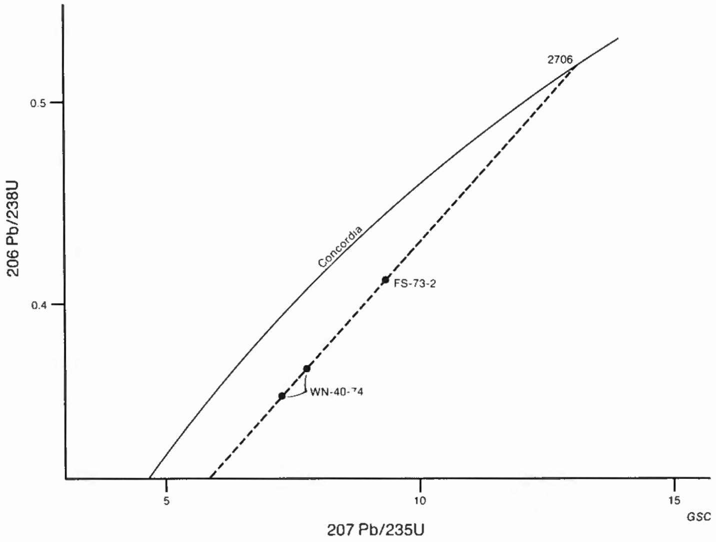


Figure 33. Concordia diagram and U-Pb isotopic ratios for zircons from two rocks of unit Agr. Sample WN-40-74 is from near Folster Lake and sample FS-73-2 is from Glen Island. The two ages obtained overlap within error limits (see also Fig. 27). (Data supplied by R.K. Wanless.)

Amphibolite metadykes (unit md)

Metamorphosed dykes, more or less disrupted, are present in many parts of the map area. They are particularly abundant in tonalite unit Ato (Fig. 10), where they locally may constitute 5 per cent of the outcrop.

The metadykes trend in three directions: northeast, east-west and northwest. Metadykes of the northeast set may be folded (Fig. 34) and have not been seen cutting the Prince Albert Group, so may be older than dykes of the other sets. Only one northwest-trending dyke is known. It is about 30 m thick and is exposed for more than 50 km inland from the vicinity of Corcoran Point. Unmetamorphosed diabase dykes of the Mackenzie swarm have a similar northwest trend in the map area.

Lithology

The metadykes are black or very dark green on both fresh and weathered surfaces and more or less schistose. Inner parts of the northwest-trending dyke have retained much of their gabbroic texture and even the margins are less foliated than those of other dykes. Although now strongly schistose and roughly concordant, amphibolite layers, commonly 2 to 3 m thick, in gneisses (e.g., sample FS-72-21 in Table 5) show fine-grained margins (interpreted as relict chill zones) and are discordant on the scale of an outcrop.

Metadykes in the tonalite are generally about 6 m thick and may be disrupted into disoriented tabular blocks to locally form agmatite. Margins of some east-west metadykes are highly sheared, whereas others show excellent relict chilling: in some dykes, one margin may be sheared whereas the other margin may have a fine-grained chill zone preserved.

Mineralogically, the metadykes are composed of green to blue-green hornblende (the chief mafic mineral), brown biotite, plagioclase (An_{30-40}), minor quartz and accessory sphene, Fe-Ti oxides and sulphides. Texture is commonly decussate but the northwest-trending dyke is notable for its modified diabasic texture, even though original pyroxene has been entirely replaced by hornblende.

Chemistry

The potassium content of the amphibolite layer in gneiss (Sample FS-72-21) is markedly higher than that of average continental and oceanic tholeiites and Archean metabasalts (Tables 5, 9), suggesting that potassium has been introduced. The other samples are from the east-west metadyke swarm in the Folster Lake region and these rocks chemically more closely resemble Archean basalts from the Canadian Shield and oceanic, rather than continental, tholeiite.

Contact relationships

All members of unit md, by definition, are considered to be intrusive into their host rocks. An intrusive relationship is confirmed by numerous examples of relict chilled contacts or discordancy between amphibolite and host rock. The east-west metadykes and the northwest metadyke cut the Prince Albert Group, as well as granitic rocks.

Origin

The metadykes clearly are manifestations of one or more periods of basaltic hypabyssal intrusive activity. The association of amphibolite and tonalite is common in early Precambrian terranes of North America and Africa and may be genetic, the two rock types representing bimodal tholeiitic-intermediate to acid magmatism (Barker and Peterman, 1974; see also the description of unit Ato).

Sugimura (1968) has proposed an empirical relation, the 'theta index', between chemistry and depth of genesis of magma:

$$\text{theta} = SiO_2 - \frac{47\,(Na_2O + K_2O)}{Al_2O_3}$$

where SiO_2 is in weight per cent and the other oxides are in molecular proportions. Typically, young continental

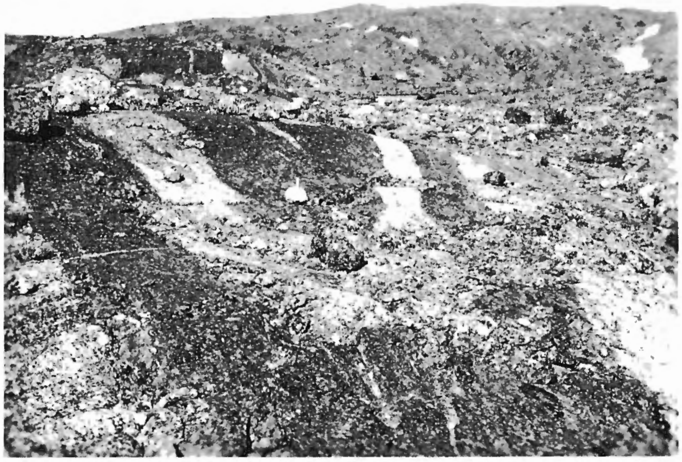


Figure 34. Folded metadykes (unit md) of the northeast-striking set in tonalitic rock of unit Ato east of Folster Lake.

tholeiites have theta indices smaller than 36 and were erupted in crust more than 30 km thick; oceanic tholeiites have theta values greater than 36 and occur in thin crust. Although derived from use in young volcanics, the theta index has been applied to Precambrian rocks as well (see Armbrustmacher, 1977, for examples).

Theta values of the metadykes (Table 5) fall both over and under 36, so that indications of emplacement depth are equivocal. However, some evidence for a thick crust is suggested by the lower values.

Age

The east-west and northwest metadykes postdate the Prince Albert Group and the east-west and northeast dykes predate the Folster Lake Formation (the northwest dyke is nowhere in contact with this formation). Southeast of the map area, amphibolite dykes trending west-northwest in rocks considered to belong to, or be the equivalents of, the Prince Albert Group underlie the Aphebian Penrhyn Group (Reesor et al., 1975). Hence the metadykes are at least Aphebian in age.

If the metadykes in tonalite unit Ato are genetically related to their host, they can be only slightly younger than the tonalite, which gives an Rb-Sr whole rock age of 2678± 112 Ma.

Hornblende and biotite from a metadyke cutting tonalite near Folster Lake were dated by the ^{40}K-^{40}Ar method, giving 1715 ±112 Ma and 1693 ± 50 Ma, respectively (GSC 76-168, 169 in Wanless et al., 1978). These ages agree within error limits and are typical K-Ar values in this region. They reflect the effects of a pervasive Hudsonian thermal event long after intrusion of the dykes and, probably, long after their metamorphism.

Without further data, the metadykes can be classified only as Archean and/or Aphebian.

PRINCE ALBERT GROUP

The Prince Albert Group was the name given by Heywood (1967, p. 5) to "a sequence of Aphebian (early Proterozoic) or Archaean metamorphosed sedimentary and volcanic rocks" exposed mainly in two belts on Melville Peninsula and one belt southwest of Committee Bay. This rather loose definition of the Prince Albert Group was a natural outcome of a reconnaissance mapping project covering a vast region of the Canadian Shield. In practice, it serves its purpose very well and in later, far more detailed work, identification of the Prince Albert Group---at least where it outcrops over an extensive area---has not been a problem. No more rigid definition is given here nor is one needed.

The broad outlines of the Prince Albert belts on Heywood's map (1967) have not been changed as a result of this work. Comparison of Heywood's and the writer's maps shows differences in detail and some additional exposures of Prince Albert Group (north of Bagnall Lake and in the Matheson River area), which Heywood considered to be probably related but for which data were insufficient to assign them firmly to the Prince Albert Group. While these belts lack the iron formation so characteristic of the main belts, they contain metamorphosed ultramafic, mafic to felsic volcanic and sedimentary rocks in associations or accumulations quite unlike those found scattered through the granitic terrane.

On this basis, three belts of Prince Albert Group are recognized in westernmost Melville Peninsula, whereas Heywood's map shows only one. The southernmost of the three is the westernmost extension of a Prince Albert belt that has its main development in eastern Melville Peninsula. Farther south, supracrustal schist belts occur in the granitic terrane south of Committee Bay. They contain mafic schists (probably metavolcanic) and gneisses and have northeasterly trends similar to those of the Prince Albert belts. They may well be coeval with, or even belong to, the Prince Albert Group but are considered as separate and distinct entities because they bear only superficial resemblance to the Prince Albert and knowledge of them is limited.

The largest of the Prince Albert belts extends northeastward continuously for 55 km from northeast of Folster Lake to the Kingora River at the northern boundary of the map area. Its width is generally less than 2 km but it locally reaches a maximum of 10 km. A southern, narrow extension of the belt, separated from the main portion, is exposed south of Folster Lake. If one assumes continuity through or under overlying rock, the entire belt is at least 66 km long in the map area. The shape of the belt is controlled by the distribution of the bordering intrusive granitic rock, in the manner typical of Archean greenstone-granite terranes the world over.

A second belt, newly assigned to the Prince Albert Group in this report, runs northeastward from Mackar Inlet to the map area boundary, where it apparently ends. This belt is up to 4 km wide and is made up chiefly of felsic metavolcanics.

The third belt, which crosses the Matheson River east of Lefroy Bay, is an ill-defined swath of terrane comprising three separate belts of supracrustals, 1 to 2 km wide, separated by granitic rocks. This belt lies on strike with a major Prince Albert belt in eastern Melville Peninsula, which also has a northeast trend. For this reason and because of its lithology, the belt is assigned to the Prince Albert Group.

The entire Prince Albert Group in the map area is metamorphosed in the amphibolite facies or, to use Winkler's terminology (1976), to medium grade, but there may be differences in intensity of metamorphism between areas. Accordingly, the fact that these rocks are, without exception, metavolcanic or metasedimentary is stressed by prefixing 'meta' to rock names. Strong deformation, as well as metamorphic recrystallization, has altered, obscured or even destroyed primary features of many of the rocks, so that chemical composition is used extensively in classifying the metavolcanics.

The discovery of ultramafic lavas (komatiites) during the present work (Frisch and Goulet, 1975) and southwest of Committee Bay (Schau, 1975) suggested an Archean age for the Prince Albert Group and this was subsequently confirmed by isotopic age measurements, as detailed below.

In the following description of the Prince Albert belts, parallels are drawn chiefly with two Archean greenstone-granite terranes, the Eastern Goldfields Province of the Yilgarn Block, Western Australia, and the Rhodesian craton, southern Africa, both of which show many similarities to the Prince Albert terrane of western Melville Peninsula.

Metavolcanic rocks

Nomenclature and classification

The metavolcanic rocks of the Prince Albert Group have been classified chiefly on the basis of their chemical composition. In the field, however, fine-grained grey metavolcanic rock with abundant quartz 'eyes' was mapped as metarhyolite; this identification was confirmed by chemical analysis in many cases. Other rocks are denoted by purely descriptive terms such as amphibolite and plagioclase metaporphyry.

Distinctions based on chemistry, modified from those proposed by Gélinas et al. (1977, p. 293), are as follows: basalt has up to 54 per cent SiO_2 (calculated on a

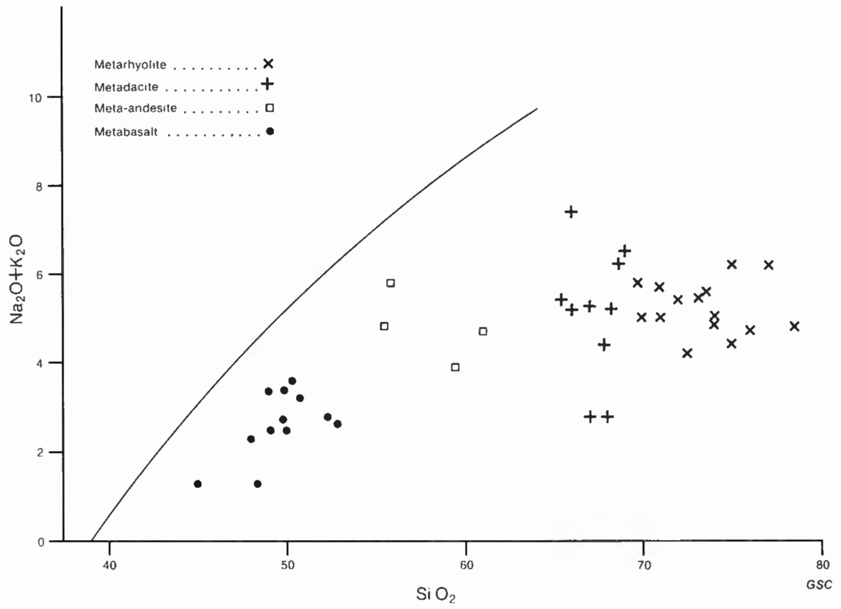


Figure 35. Metavolcanic rocks of the Prince Albert Group in the total alkalis-silica diagram. Curve separates alkaline and subalkaline compositions (Irvine and Baragar, 1971).

volatile-free basis); andesite, 54 to 62 per cent; dacite, 62 to 70 per cent; and rhyolite, more than 70 per cent. The metavolcanic rocks of the Prince Albert Group readily separate into these groups in the alkali-silica diagram (Fig. 35).

Ultramafic extrusive rocks (komatiites) are defined according to criteria established by Arndt et al. (1977).

Use of a chemical classification begs the question of how close the present rock compositions are to those when the rocks were extruded. Clearly altered rocks (for example, those with quartz veins or heavy epidotization) and rocks with excessive H_2O or CO_2 contents were not chemically analyzed. Nevertheless, there seems little doubt that postextrusion processes such as weathering and metamorphism change the chemical composition of volcanic rocks to some degree, at least, and this is why Prince Albert rocks have been only grossly classified, that is, into no more than four major groups. However, as will be shown below, compositions tend to be remarkably close to those of modern, fresh rocks, which suggests that massive migration or redistribution of material has not taken place.

Ultramafic lava (unit *AP Aul*)

Lithology

Metamorphosed ultramafic rocks displaying structures and textures characteristic of Archean ultramafic lavas occur in a restricted area at the western margin of the Prince Albert belt about 9 km east of Selkirk Bay.

Outcrops, up to 50 m high, consist of alternating grey-green - weathering, spinifex-textured rock and orange-brown - weathering, massive meta-ultramafite. The massive layers are generally 0.6 to 1 m thick; the spinifex layers are commonly 0.2 to 0.5 m thick but are locally considerably thicker. Spinifex blades vary greatly in length but 5 to 15 cm is typical; blade size may change gradationally within a given spinifex zone. The two rock types, spinifex and massive ultramafite, are separated locally by a thin zone of spinifex foliated parallel to the contact (Frisch and Goulet, 1975, Fig. 1). Elsewhere, massive and spinifex rocks are in sharp contact (Fig. 36). It should be stressed that weathering accentuates the spinifex texture and, especially, the colour contrasts between the two textural zones.

These textures and structures have been well documented in a remarkably well preserved assemblage of Archean ultramafic rocks in Munro Township, northeast Ontario (Arndt et al., 1977). Features such as lava toes and fractured flow tops recognized in Munro Township, and pillows observed in similar rocks in South Africa and

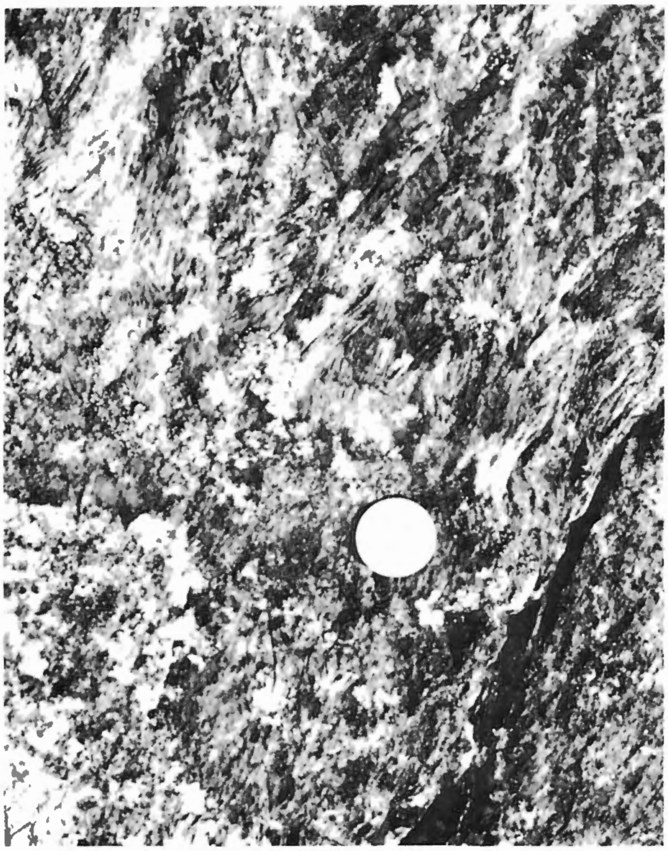


Figure 36. Contact between spinifex and massive cumulate zones of an ultramafic lava flow in the Prince Albert Group east of Selkirk Bay. Diameter of the coin is 2.3 cm.

Zimbabwe attest to the extrusive origin of these unusual rocks. Lesser metamorphism and deformation at the northern Ontario and African localities have resulted in the preservation of much of the original mineralogy, showing that the spinifex texture was formed by bladed olivine or clinopyroxene and that the massive, featureless rock represents an olivine cumulate. In Munro Township the foliated spinifex zone has been shown to lie at the top of the massive zone, which forms the lower part of a flow unit, and the spinifex texture to coarsen downward in the upper part of the same unit (ibid., Fig. 7A).

The lessons learned in Munro Township have been applied to the ultramafic rocks in the Prince Albert Hills. East of Selkirk Bay, at least 12 individual ultramafic flows were recognized. The lavas dip 30° to 40° west but here and there a foliated spinifex zone and 'graded' spinifex indicate that the rocks are overturned. If the stratigraphic order can be extended eastward, the lavas underlie metabasalts and acid metavolcanics. These facing indicators were the only ones recognized in the Archean bedrock of the map area.

Meta-ultramafic rocks that weather a rusty brown like the cumulate zones of the lava flows are common in the Prince Albert Group, particularly north of Adamson River and at contacts with the granitic terrane. Spinifex texture, however, has not been observed outside the restricted area described above. Ultramafic rocks near the '550-metre hill', (named informally for this report) north of Adamson River show green and brown banding similar to that east of Selkirk Bay; Eckstrand (1975) suggested that this evidence is probably sufficient to characterize the rocks as lavas. Intense deformation and metamorphism probably destroyed spinifex texture in the Prince Albert Group in most places. Ultramafic lavas are common in the Prince Albert Group southwest of Committee Bay (Schau, 1977).

Spinifex texture alone cannot be used as proof that the rock is extrusive. Donaldson (1974) has shown that skeletal crystallization of this type results not from rapid cooling but from rapid growth rate caused by high olivine content of the melt and probably also by the very high emplacement temperatures. Some spinifex rocks east of Selkirk Bay are not associated with massive peridotite and may represent high-level intrusive material.

Most, if not all, the minerals of the ultramafic lavas are of metamorphic origin. The spinifex texture is usually not as obvious in thin section as in hand specimen. Blades consist of colourless or very pale green, fine-grained chlorite with an anomalous brownish interference colour, or of chlorite and serpentine, and are commonly bordered by dusty iron oxide. During recrystallization of the original olivine or pyroxene blades, too much iron apparently was released to have gone into chlorite, so that iron oxide formed. The groundmass is magnesian amphibole, commonly colourless tremolite, very fine grained and poorly cleaved.

Chemical data on the minerals of three spinifex rocks have been obtained with the microprobe but analysis is frequently difficult because of intimate intergrowths and fine grain size. Analyses are listed in Table 6 of the Appendix but compilers of analytical data should be aware that they are not of high quality. The chlorites are clinochlore-magnesian pycnochlorite, according to the classification of Deer et al. (1962, Fig. 35), rather poor in alumina compared with other chlorites of this compositional range. In sample FS-74-73 (Table 7) the amphibole is tremolite but in samples 74-76 and 74-79 it is actinolite, in the classification of Leake (1978).

Just as original spinifex texture may remain preserved in relict form, so is a vague cumulate texture still discernible in thin section in the massive metaperidotite zones of some flows. Former rounded, hexagonal olivine grains are pseudomorphed by serpentine aggregates, locally bordered by finely granular iron oxide. A few pseudomorphs show mesh-texture serpentine but generally the serpentine needles are arranged in decussate fashion. Although serpentine dominates the mineralogy, colourless tremolite, chlorite and carbonate also are haphazardly distributed. A minor amount of the iron oxide is chromite, which was not recognized optically but was detected during microprobe analysis.

Chemistry

Chemical analyses of the cumulate and spinifex zones of the two lavas and of a spinifex rock from the same volcanic pile (presumably also extrusive) are listed in Table 7. One cumulate-spinifex analysis pair has been previously published by Fryer and Jenner (1978, Table 2, columns 3 and 4). The other pair was made using slightly different techniques in the laboratories of the Geological Survey of Canada. Analyses of the same samples by the two groups of workers compare well, except in the case of K_2O and Rb, both of which are extremely low in these rocks. In the GSC analyses, K_2O is about 10 times higher, and Rb 3 to 7 times higher, than in Fryer and Jenner's.

The analyses show that, relative to the massive zones, the spinifex samples are enriched in SiO_2, Al_2O_3, CaO, TiO_2 and Cr_2O_3 and depleted in MgO and NiO. Similar changes are found in ultramafic lavas of Munro Township of Ontario and the Eastern Goldfields terrane of Western Australia (Barnes et al., 1974). The chemical variations support the interpretation that the massive metaperidotite zone represents an olivine cumulate derived from a liquid that crystallized quickly to form the spinifex zone.

Although the term 'komatiite' has been variously defined, the ultramafic rocks listed in Table 7 belong to the 'komatiite series' (Arndt et al., 1977) by any definition. They are lavas consisting of both cumulate and noncumulate rock, some with spinifex texture, of ultramafic composition, with low $FeO_t/(FeO_t + MgO)$ ratio and TiO_2 and high MgO, NiO, and Cr_2O_3.

Like many komatiites, notably those of Munro Township and Western Australia, CaO/Al_2O_3 generally is near but less than unity (as low as 0.6). Analyses of ultramafic lavas from Munro Township and Western Australia are provided in Table 7 for comparison. The similarities among the three groups of rocks are obvious. Further evidence that the western Melville Peninsula lavas are typical of the Archean komatiite suite is provided by the Al_2O_3/TiO_2 and CaO/TiO_2 ratios, which hover around 20 (Table 7), a value considered by Sun and Nesbitt (1978) to be characteristic of this suite.

Relations with basaltic rocks

Arndt et al. (1977) have emphasized the common association of a komatiitic series with a tholeiitic series in the volcanic rocks of Archean greenstone belts. In Munro Township, the komatiitic series includes pyroxenitic (MgO 12 - 20 %) and basaltic (MgO less than 12 %), as well as peridotitic, komatiites and it is underlain and overlain by iron-rich (average FeO_t 15 %) tholeiite lavas.

In the Prince Albert Group of the map area the komatiitic series appears to be represented by peridotitic members only and the tholeiitic series is magnesian rather than iron-rich. However, basaltic komatiite is present southwest of Committee Bay (Schau, 1975). Although the Prince Albert basalts are relatively magnesian ('high-magnesium tholeiitic basalts' in the Jensen cation plot of Fig. 40), they are considerably more iron-rich than the basaltic komatiites of Munro Township and the high-Mg metabasalts associated with ultramafic komatiites in the Eastern Goldfields terrane (Williams, 1972). Besides being rich in magnesium, the latter rocks are distinguished by textures indicative of rapid crystallization, which are well preserved because of low metamorphic grade. No such features are seen in the Prince Albert metabasalts but would not be expected, considering the extensive recrystallization of these rocks. The Australian high-Mg metabasalts are broadly equatable with the basaltic komatiites of Arndt et al. (1977) and for the most part fall to the left, that is on the komatiitic side, of the dividing line in the Al_2O_3 vs. FeO_t (FeO_t + /MgO) discriminant diagram (Fig. 37) of Arndt et al. (ibid.). The less aluminous varieties of Prince Albert metabasalt all fall to the right of the line, in the tholeiitic basalt field. At alumina contents of 15 per cent or more this division between komatiitic and tholeiitic basalts cannot be applied. In summary, none of the Prince Albert metabasalts in the map area, with the possible exception of sample FS-72-41 (13.2% Mg), can be called high-Mg or komatiitic basalt.

A distinct gap between ultramafic lavas and basalts of the Prince Albert Group is obvious in the CaO-MgO-Al_2O_3 (Fig. 38), AFM (Fig. 39) and Jensen cation (Fig. 40) diagrams. In the first of these, the uninterrupted trend of Western Australian basaltic rocks, from the MgO corner down toward compositions richer in CaO and Al_2O_3 (Barnes et al., 1974, Fig. 44), contrasts with the Prince Albert rocks; a similar trend is also shown by the Munro Township lavas (Arndt et al., 1977, Fig. 20). This suggests that the tholeiitic metabasalts and ultramafic komatiites of the Prince Albert Group are not genetically related, a conclusion also reached by Fryer and Jenner (1978).

Contact relations and associated rocks

The ultramafic lavas described above are intruded along their southern and western margins by tonalites of unit Ato. Farther from the contact, deformed, almost boudinaged, veins of granitic rock were seen to cut one exposure of spinifex rocks. Immediately to the east, the lavas are flanked by metagabbro, which encloses a layered metaperidotite body 3 m thick. These rocks in turn are bordered to the east by rhyolite, although no contact is exposed.

North of Adamson River, probable ultramafic lavas are associated with both metasedimentary schists and amphibolites (metabasalts). Most of the remaining ultramafic bodies (of unknown origin) in the Prince Albert Group are associated with amphibolite.

Environment of deposition

Judged by their lithological associations, the known and probable ultramafic lavas of the Prince Albert Group in the map area have not formed in a deep oceanic environment but rather in a marginal or even continental one. Schau (1977) concluded that the komatiites of the Prince Albert Group southwest of Committee Bay were emplaced in a stable continental environment, as they are associated with metamorphosed clastic quartzite. Archibald et al. (1978) envisaged the early ultramafic-mafic magmas of the Eastern Goldfields greenstone belts being erupted into a shallow water environment during rifting of sialic crust. An essentially similar origin of ultramafic lavas in the Archean greenstone belts of Zimbabwe has been proposed by Hawkesworth and O'Nions (1977).

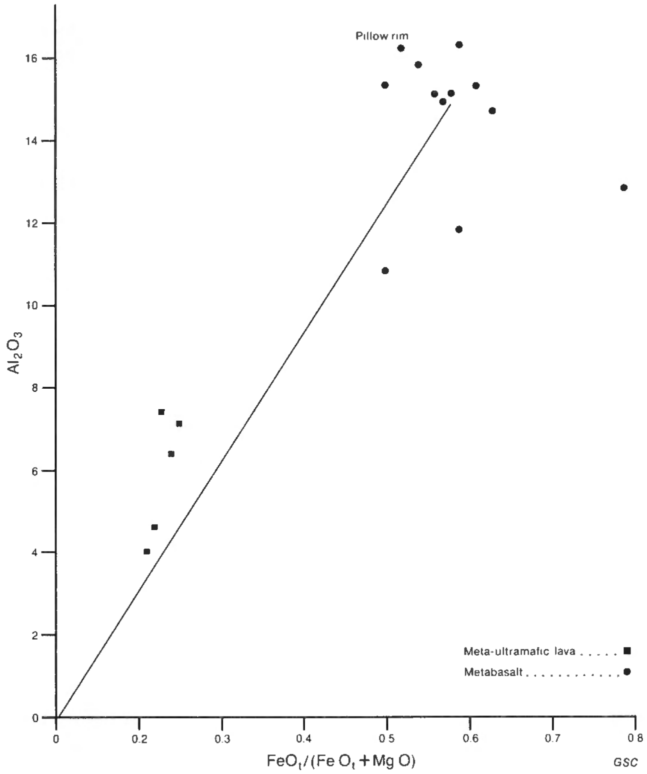


Figure 37. Al_2O_3 vs. $FeO_t/(FeO_t + MgO)$ diagram showing composition of komatiitic and metabasaltic rocks of the Prince Albert Group. Discriminant line is from Arndt et al. (1977, Fig. 23).

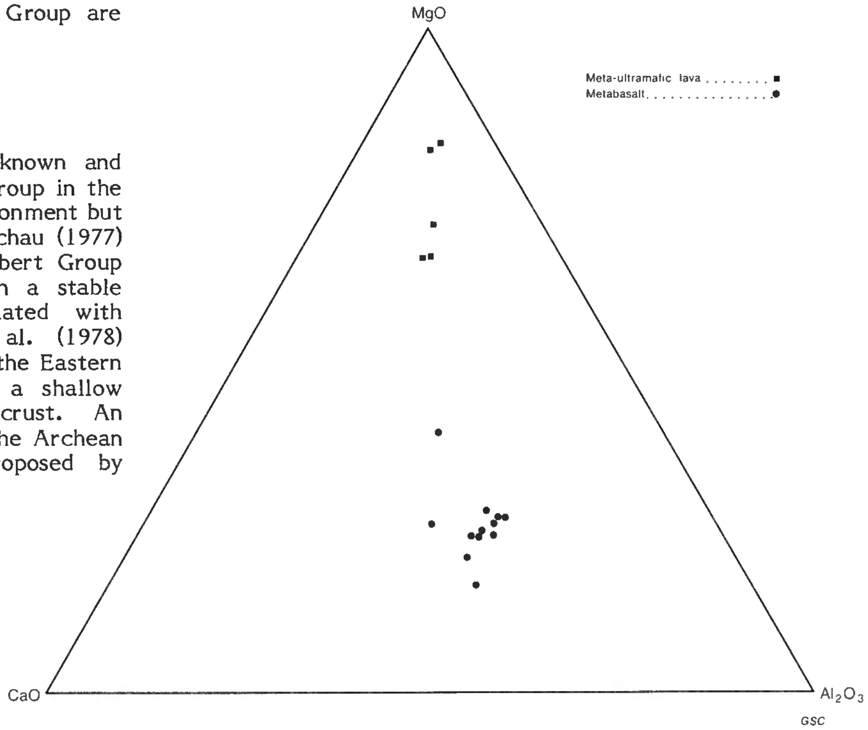


Figure 38. CaO-MgO-Al_2O_3 triangle showing composition of komatiitic and metabasaltic rocks of the Prince Albert Group.

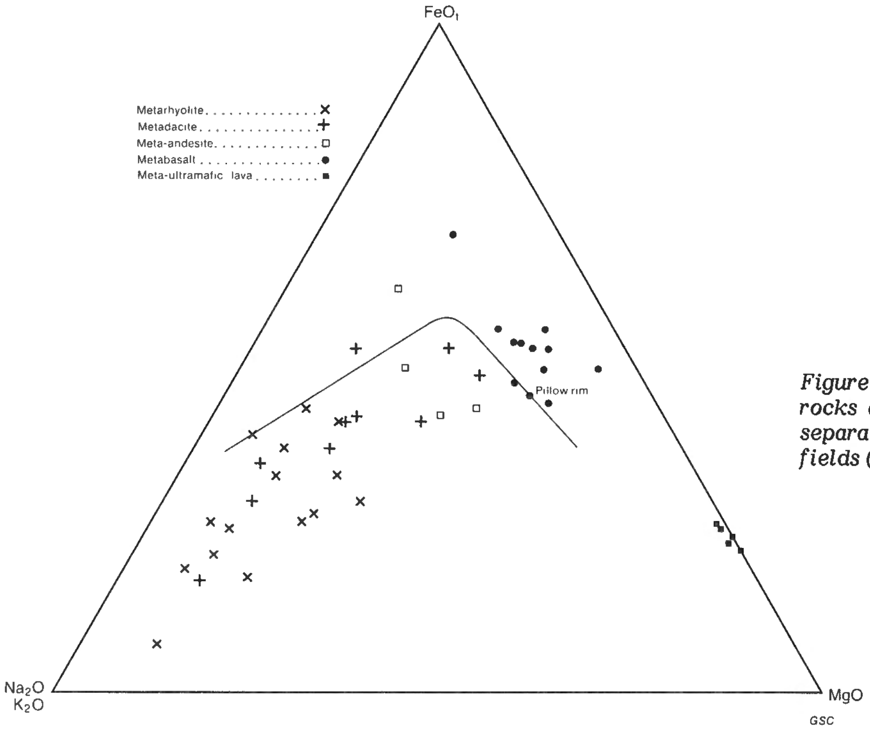
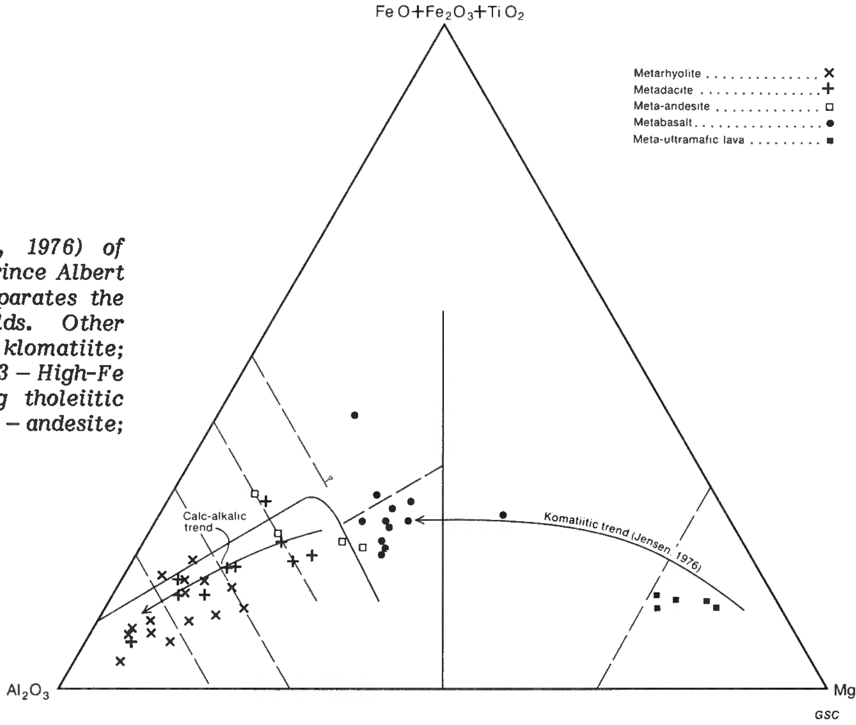


Figure 39. AFM plot of metavolcanic rocks of the Prince Albert Group. Curve separates tholeiitic and calc-alkaline fields (Irvine and Baragar, 1971).

Figure 40.

Jensen cation plot (Jensen, 1976) of metavolcanic rocks of the Prince Albert Group. The vertical line separates the komatiitic and tholeiitic fields. Other fields are: 1 – ultramafic klomatiite; 2 – basaltic klomatiite; 3 – High-Fe tholeiitic basalt; 4 – high-Mg tholeiitic basalt; 5 – basalt; 6 – andesite; 7 – dacite; 8 – rhyolite.



Metabasalt (unit APAb)

Lithology

Dark green to black, massive to foliated, generally fine grained amphibolites constitute the major rock unit of the Prince Albert Group in the map area. Clearly identifiable primary volcanic structures and textures are practically absent but the amphibolites were considered in the field to be metabasalts; chemical analysis showed this assumption to be correct in most cases. Relict pillow structure (Fig. 41) observed at one locality was the only unequivocal volcanogenic feature seen.

Mineralogically, these rocks are simple. Amphibole and plagioclase are invariably the chief constituents and may be accompanied by biotite, epidote, sphene and clinozoisite; Fe-Ti oxide, pyrite and apatite are accessory minerals. Quartz has been positively identified in a few specimens but may be present in other rocks, particularly very fine grained ones.

The amphibole is either hornblende with bluish or grass-green Z or pale green actinolite. In some rocks amphibole, generally actinolite, forms large crystals surrounded by finer grained amphibole needles of apparently sodic composition, which are aligned and wrap around the larger crystals. The latter are interpreted as porphyroblasts that probably were pyroxene before metamorphism. Plagioclase, when measurable, is generally andesine An_{40-45} but oligoclase An_{30} was noted in one sample. It is generally rather fresh and in some specimens is untwinned. The relatively sodic composition, unaltered state and poor twinning indicate that the original plagioclase has been completely recrystallized. Augen-shaped aggregates of fine grained plagioclase are thought to be recrystallized and deformed phenocrysts or glomerophenocrysts. These appear to have been smeared out into thin layers or lenses in the more highly deformed rocks.

Of the less abundant minerals, biotite and sphene are the most important quantitatively. Brown biotite is an accessory constituent except in the sample from a pillow rim, of which it forms 15 per cent by volume. The abundance of biotite in this rock accounts for its high K_2O content of 1.32 per cent (all the other analyzed metabasalts have less than 1% K_2O, Table 8) and it is probably a reflection of potassium enrichment that occurred during secondary alteration of the basalt prior to metamorphism, a process well known in modern basalts (Scott and Hajash, 1976).

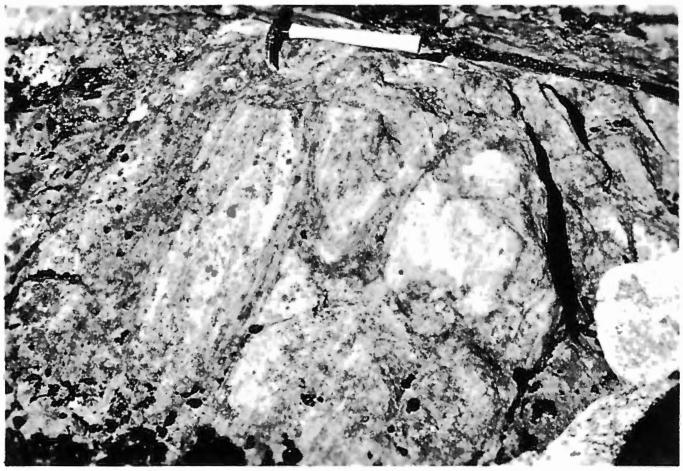


Figure 41. Deformed pillows in amphibolite of the Prince Albert Group, northeast of Bagnall Lake.

Sphene appears to be the main titanium-bearing mineral in many of the metabasalts. It constitutes nearly 2 per cent of sample FS-74-107, which contains 1.90 per cent TiO_2 but no Fe-Ti oxides. In this rock, as well as in many others, sphene forms tiny granules strung out in trains parallel to the foliation and associated generally with amphibole and/or Fe-Ti oxides. Typical fresh tholeiite basalt never contains sphene in more than trace amount. Like the other minerals, sphene appears to be a product of metamorphism.

Chemistry

Analyses of twelve metabasalt samples are presented in Table 8. These include analyses of the core and rim of a pillow. As the pillow rim probably represents a previously altered metabasalt, analysis of sample FS-74-108 has been disregarded in the calculation of the average composition of the Prince Albert metabasalts.

The metabasalts plot in the tholeiitic field in the alkali-silica (Fig. 35), AFM (Fig. 39), and Jensen cation (Fig. 40) diagrams; the average composition is remarkably similar, except in TiO_2, to Le Maitre's (1976) average tholeiite (Table 9). In most respects, the Prince Albert metabasalts chemically resemble basalts of other major Archean terranes, in particular the Eastern Goldfields region of Western Australia (Fryer and Jenner, 1978). The Prince Albert rocks, however, are notably richer in magnesium, a fact clearly brought out in the Jensen cation plot, where most of them fall in the 'high-magnesium tholeiitic basalt' field. On average, the Prince Albert metabasalts also are richer in potassium than those of Western Australia (0.30% compared with 0.18% K_2O) but the latter appear to be unusually K-poor in comparison with other Archean basaltic rocks (Table 9).

The Prince Albert metabasalts are richer in Rb than the other basalts listed in Table 9, and consequently have lower K/Rb ratios. The latter show wide scatter in the K/Rb plot (Fig. 42) and tend to lie below the 'main trend' of Shaw (1968). In other trace elements (excluding rare earths), the Prince Albert rocks are comparable to other Archean basalts. In the Ti-Sr-Zr diagram (Condie, 1976b), most of them plot in the field occupied by typical basalts from the Archean and from mid-oceanic ridges of today (Fig. 43); the average composition is almost coincident with that of the Western Australian suite. Fryer and Jenner (1978) have shown that, in their rare-earth patterns, the Prince Albert metabasalts differ from most other Archean tholeiites in that they display a downward bowing of both the lightest and the heaviest rare-earth elements.

While showing some resemblance chemically to modern ocean-floor basalts, the Prince Albert metabasalts do differ significantly; they are clearly poorer in Al and Ti and richer in K, Rb and Ba. Jahn (1977) suggested that average Archean basalt is chemically more similar to low-K tholeiites of island arcs or marginal basins. Average Prince Albert metabasalt has less Al and Sr and considerably more Mg, Ni and Cr than island arc tholeiites of both the low-K variety and the calc-alkaline type (Table 9). Their resemblance to tholeiite of marginal basins, e.g., the Lau Basin in the Pacific Ocean (Table 9), is greater but the chemical correspondence between this tholeiite class and oceanic ridge tholeiite is well known (Hawkins, 1977). Similar differences exist as with ocean-floor tholeiites, except that Ti content of the Lau Basin basalts is only slightly higher than in average Prince Albert metabasalt.

In summary, the metabasalts of the Prince Albert Group are chemically similar to metabasalts of several other Archean suites and more akin to basalts of mid-oceanic ridge and marginal basin environments than to those of the island arc regime. The Prince Albert rocks are, however, distinctive in their high MgO content and rare-earth element patterns.

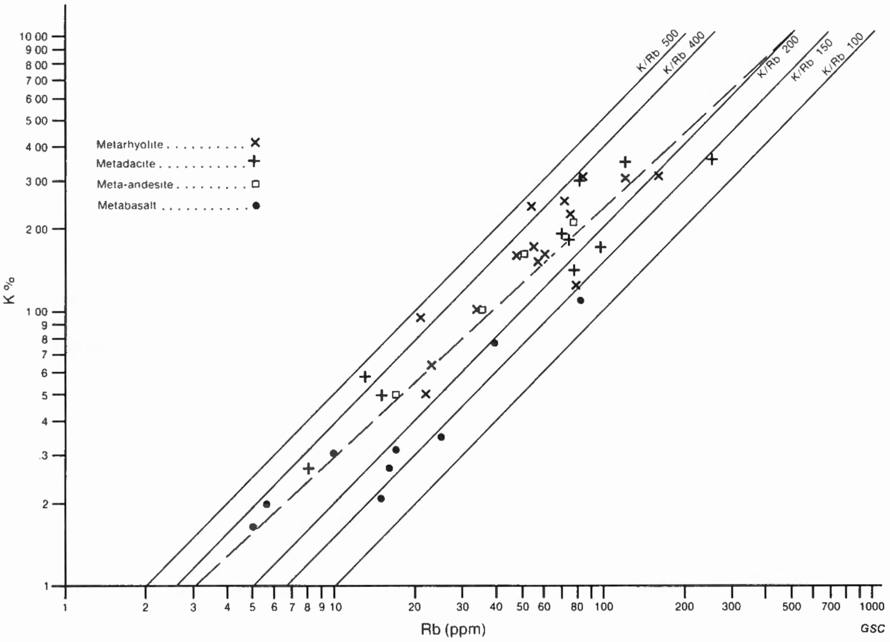


Figure 42. Variation diagram of K and Rb in metavolcanic rocks of the Prince Albert Group. The dashed line is the 'main trend' of Shaw (1968).

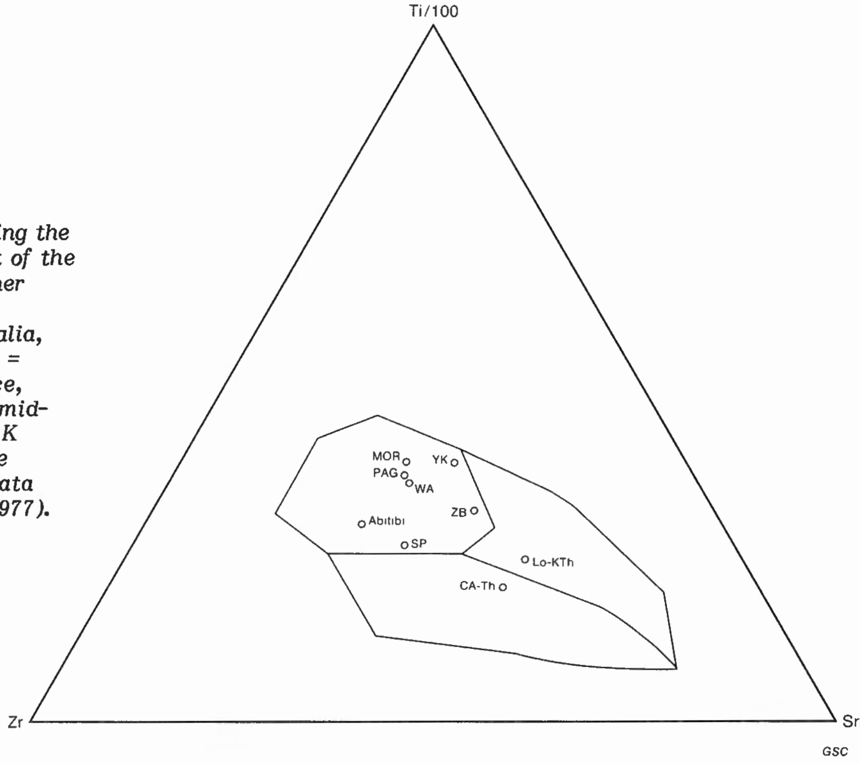


Figure 43. Ti-Sr-Zr triangle showing the composition of average metabasalt of the Prince Albert Group (PAG) and other rocks. Average Archean tholeiitic metabasalts: WA = Western Australia, ZB = Midlands belt, Zimbabwe, YK = Yellowknife, SP = Superior Province, Canadian Shield; average modern mid-ocean ridge basalt, island-arc low-K tholeiite and calc-alkaline tholeiite are plotted in appropriate fields (data from Condie, 1976a, b; Goodwin, 1977).

Associated rocks and environment of deposition

As the predominant rock type of the Prince Albert belts, metabasaltic amphibolite is associated with a wide variety of rocks. Among these perhaps the most important are iron formation and pelitic and conglomeratic metasediments. Associated metavolcanic rocks are chiefly dacitic and rhyolitic.

The rare pillows found in the metabasalts attest to a subaqueous environment but the extent of this environment is unknown. However, the abundant associated pelitic and clastic sediments and iron formation (if analogies to Proterozoic iron formations are accepted) suggest emplacement in a shallow water setting. Scarcity of andesites in the volcanic pile and the chemical data make an island arc environment improbable. A continental margin or a rifted, totally ensialic environment remains as the most plausible locale for deposition of the basaltic rocks of the Prince Albert Group.

Meta-andesite (units APAr, APAb)

Lithology and distribution

In the map area rocks of andesitic composition appear to be of minor significance in the Prince Albert Group; only four samples were identified among the rocks analyzed. Dark, fine-grained varieties, however, are not distinguishable from the lighter metabasaltic and darker metadacitic rocks and may have been mapped as one or the other of these rock types. As no major tracts of meta-andesites were recognized, most rocks of this composition are included in the unit of felsic volcanics (unit APAr), with which they are generally associated. One meta-andesite is interlayered with ultramafic (?) intrusive rock associated with ultramafic lavas (see above); the remainder are included in the amphibolite unit APAb.

The meta-andesites tend to have a grey colour intermediate between the dark shades of the metabasalts and the lighter tints of the felsic volcanics. Original porphyritic texture is commonly preserved although minerals have been completely recrystallized. Plagioclase phenocrysts are represented by rounded, granular aggregates of extremely fine grained plagioclase, ferromagnesian phenocrysts by radiating pale green or blue-green amphibole needles. Greenish brown or dark brown biotite is a second major mafic mineral. The matrix or, in the case of nonporphyritic varieties, the entire rock is made up of tiny crystals of feldspar, epidote, chlorite and possibly quartz. The extremely fine grain size makes point counting impractical in most samples. Laminated or gneissic rocks of this type may well be metamorphosed tuffs.

Chemistry

The four meta-andesite analyses are listed in Table 10. Sample FS-74-35 is the same rock as no. 14 in Table 2 of Fryer and Jenner (1978) but the GSC analysis is reported here. It should be noted that only two andesite analyses were available to Fryer and Jenner; their average "PAG andesite" differs substantially from that reported in Table 10.

In the alkali-silica diagram (Fig. 35), the four meta-andesites form a group well separated from the metabasalts and metadacites. All but one fall in the calc-alkaline field of the AFM plot (Fig. 39) but scatter somewhat in the Jensen cation diagram (Fig. 40), where none of them falls in the andesite field.

Compared with the Prince Albert metabasalts, the meta-andesites are enriched in Si, Al, Na and K and depleted in Fe, Mg and Ca. Most of the trace elements are enriched in the meta-andesites; exceptions are Ni, Cr and V. K/Rb ratios tend to be higher than those of the metabasalts (Fig. 42) and show a restricted range (268 - 316).

The average Prince Albert Group meta-andesite is compared with Archean and modern intermediate rocks in Table 10. Such comparisons are not without their difficulties because of uncertainties as to usage of the term 'andesite'; cautionary comments are made where appropriate.

In major elements, average Prince Albert meta-andesite is similar to average andesite of the Superior Structural Province of the Canadian Shield (Goodwin, 1977) and, except for K, to the average andesite of the Eastern Goldfields Province, Western Australia (Williams, 1975). Goodwin's andesite is defined according to Irvine and Baragar's (1971) scheme, under which two of the four Prince Albert Group samples would qualify as andesite. Williams (1975) did not provide a definition of andesite and his average is based on only three analyses, as intermediate rocks are rare in the Archean of Western Australia. Average andesite (as used in this report and calculated from seven analyses) of the Marda complex, one of the few Western Australian calc-alkaline centres (Hallberg et al., 1976), shows some similarity in major-element chemistry to its counterpart in the Prince Albert Group but is noticeably richer in Sr, Ba, Ni and Cr, and poorer in Cu; K/Rb ratios are virtually the same. Fryer and Jenner (1978) have pointed out significant differences in the rare-earth element patterns between the Prince Albert meta-andesites (two samples) they analyzed and average Marda andesite. When compared with Condie's (1976b) Archean andesites, Prince Albert meta-andesite cannot be readily assigned to either of his two classes, low-alkali and high-alkali, as it shares chemical features with both. Again, its low Sr and Cr contents stand out.

Continental-margin andesites rather than those of island arcs are possible modern chemical analogues of the Prince Albert Group. The higher content of K, Rb, Sr, Ba and Zr and the lower K/Rb ratio of continental-margin (Andean) andesites compare well with the Prince Albert Group rocks. However, it is difficult to choose between the low-K and high-K Andean types and both have much more Sr, though Cr values in low-K and arc andesites are comparable to those in the Prince Albert rocks. Ni is much higher in the latter than in modern andesites and this appears to be a characteristic trait of Archean andesites. While rare-earth element patterns are generally different, Fryer and Jenner (1978) have recognized some remarkable similarities between certain modern andesites of both continental margin and arc types and the Prince Albert rocks they analyzed.

Origin

The apparent scarcity of andesite contrasts with the abundance of mafic (basaltic) rocks in the Prince Albert Group and suggests an origin by differentiation from the basaltic rocks. However, no obvious continuity exists in the alkali-silica or AFM plots between the two rocks groups. Attempts at modelling the magma genesis of the Prince Albert rocks by Fryer and Jenner (ibid.) using rare-earth element patterns, were inconclusive.

The inference that the Prince Albert meta-andesites are of continental margin type supports the supposition that the Prince Albert Group was laid down on continental crust.

Metadacite (units APAb, APAr)

Lithology and distribution

The metadacites cannot be distinguished from meta-andesites or the darker varieties of metarhyolite of the Prince Albert Group in outcrop. Indeed, some of the amphibole-rich varieties closely resemble metabasalt. Most of the metadacites look like the meta-andesites both in hand specimen and in thin section and are associated with metarhyolites. Judged by the number identified by chemical analysis, metadacite appears to be more abundant than meta-andesite in the Prince Albert Group terrane.

Two main varieties of metadacite were found. One is a gneissic or faintly laminated, dark grey to medium grey rock that may or may not be porphyroblastic. The mafic minerals are greenish brown biotite, pale green Ca-rich amphibole and epidote, which commonly shows no sign of being a secondary mineral. Chlorite is general as an alteration product of biotite or amphibole and sphene is a common accessory mineral. The other variety of metadacite is a massive, porphyroblastic or metaporphyritic rock, generally medium grey. Original phenocrysts have been completely recrystallized in most rocks but one (sample FS-73-92) has remarkably well preserved equant plagioclase crystals (An_{24-30}), 1 to 3 mm in size, which are only slightly epidotized. This rock also contains amphibole crystals consisting of colourless cummingtonite or grunerite rimmed by green Ca-rich hornblende. The groundmass is a finely granular aggregate of feldspar, quartz, amphibole, biotite, epidote and chlorite. Most of the massive metadacites consist of a dense feldspathic aggregate with disseminated mafic minerals, similar to the groundmass of the rock just described, and, representing original phenocrysts, scattered clusters of recrystallized plagioclase and amphibole needles or biotite flakes.

Chemistry

Ten analyses of metadacites of the Prince Albert Group are listed and compared with ancient and modern rocks of similar composition in Table 11.

In the alkali-silica diagram (Fig. 35), the metadacites, unlike the metabasalts and meta-andesites, do not constitute a distinct group, as they merge with the metarhyolites. Total alkali content is about the same as in the meta-andesite. Although potash is considerably higher in the medacites, soda in average metadacite is essentially the same as in average meta-andesite, a fact which suggests soda has been lost in post-emplacement processes. Indeed, the great compositional variability among the metadacites may be an indication that original compositions have been changed.

Most of the metadacites are rather siliceous (all but one have more than 66% SiO_2) and potassic. Sample FS-73-71 stands out from the other rocks by virtue of its high Fe and low Al. This rock is a schist rich in epidote and Fe-Ti oxide and is classed as metavolcanic chiefly because of its proximity to an extensive occurrence of metarhyolite. It may be a metamorphosed sedimentary (volcaniclastic?) rock of unusual composition or a metamorphosed igneous rock that was affected by some particular fractional crystallization process. K and Rb in the metadacites show a wide spread and K/Rb ratios range from 150 to nearly 500 (Fig. 42).

Compared with the average dacite (as defined in this report) of the Marda complex, Western Australia, average Prince Albert metadacite has more SiO_2 and less Na_2O but is otherwise similar in major and minor elements. Trace element contents are generally not dissimilar but Prince Albert metadacite is considerably poorer in Sr and Ni (Marda dacite appears to be unusually Ni-rich). The average of 10 analyses of dacite (definition unknown) from the Eastern Goldfields Province (Williams, 1975) shows less SiO_2 and considerably more Na_2O than average Prince Albert metadacite. Superior Province dacite is markedly more sodic, more Sr-rich and less potassic than its Prince Albert counterpart.

Condie (1976b) has divided Archean dacites-ryhodacites (definition unknown) into varieties depleted in heavy rare-earth elements and yttrium (DSV) and undepleted varieties (USV), compared with modern rocks. On the basis of three samples, Fryer and Jenner (1978) have characterized Prince Albert metadacite as the DSV variety. However, in many elements other than the rare-earths, the average Prince Albert metadacite of this study seems more akin to the USV type: lower Na, Sr and K/Rb, and higher K and Zr.

Modern dacites of island arcs are distinguished from those of continental margins (calc-alkaline association) chiefly by lower Rb, Sr and Ba, and higher K/Rb in the former (Table 11). On this basis, average Prince Albert metadacite resembles continental-margin dacite more than island-arc dacite except for its lower Sr.

Origin and environment of deposition

On the basis of rare-earth element patterns and results of experimental petrology, Fryer and Jenner (ibid.) postulated a low degree of partial melting of basaltic material (such as amphibolite) under lower crustal conditions as the preferred origin for the Prince Albert metadacites they analyzed. This process would yield a dacitic to rhyodacitic liquid with a low Na/K ratio. The latter value for the three rocks Fryer and Jenner analyzed was 0.6. Average Na/K for the 10 samples reported here is 1.2---somewhat higher but still low. On the assumption of a similar rare-earth element distribution, the partial melting model could be extended to all the Prince Albert metadacites analyzed.

As in the case of the meta-andesites, the chemical evidence favours a continental margin, rather than an island arc, setting for the metadacites of the Prince Albert Group.

Metarhyolite (unit APAr)

Lithology and distribution

Metarhyolite is found in many outcrops of the Prince Albert Group in the map area but is especially abundant in what appears to be a major felsic volcanic centre northeast of Folster Lake. Narrow belts of metarhyolite extend north and south from this centre but they are volumetrically insignificant in comparison with the metabasaltic rocks. Although many varieties, particularly 'quartz-eye porphyries', are readily recognizable as metavolcanic siliceous rocks, others are strongly recrystallized and gneissified and are identified as metarhyolite only with difficulty. Still others undoubtedly went unrecognized.

The Prince Albert metarhyolite most easily identified is a medium grey to pale grey, fine-grained, massive rock with quartz metacrysts a few millimetres in diameter. The quartz metacrysts are made up of irregular quartz grains with strongly sutured borders and are interpreted to be recrystallized quartz phenocrysts. The matrix consists of quartzofeldspathic material (quartz, plagioclase and K-feldspar, although the feldspars are not always distinguishable) and flakes of brown biotite and muscovite, accompanied by epidote, chlorite and accessory zircon and apatite. Whereas the chlorite in some rocks has clearly formed by the alteration of garnet, in others chlorite appears independently of biotite.

More commonly, metarhyolite is deformed, resulting in foliation of mica or layering of quartzofeldspathic material. The latter consists of thin trains or lenses of recrystallized quartz with sutured borders. These elongate aggregates are considered to be stretched and recrystallized phenocrysts of the type described above. Plagioclase is oligoclase An_{25} but its composition is generally indeterminable, because of fine grain size. Potassium feldspar shows the grid twinning of microcline.

A few specimens of metarhyolite contain recrystallized or altered phenocrysts of plagioclase as well as quartz. These rocks illustrate a remarkable difference in the way the two minerals have reacted to the same stress. The plagioclase is heavily sericitized and contains oriented muscovite laths but has retained its (presumably original) subhedral shape. The quartz phenocrysts, in contrast, are now aggregates of sutured grains, some of which are fringed by finely crushed quartz.

Garnet is sporadic in the metarhyolites as an accessory mineral. It is pink, subhedral to anhedral, and shows no granulation even in a well foliated rock. A 'bleached' zone free of mafic minerals generally surrounds each garnet grain. Thus it appears that the garnet is a metamorphic, not an original igneous, mineral and its chemical composition supports this view. Microprobe analyses of two garnets in sample FS-73-93 are given in Table 12. The garnet is slightly zoned chemically, edges being poorer in Mn and richer in Fe than cores, but it is a spessartine-bearing almandine throughout, unlike the almandine found in calc-alkaline rocks and the very Mn-rich almandine-spessartine of cavities in lavas (Green and Ringwood, 1968).

Chemistry

Fifteen analyses of metarhyolite, four of which have previously been published by Fryer and Jenner (1978), are listed in Table 13.

In the alkali-silica diagram (Fig. 35), the metarhyolites merge with the metadacites and are not conspicuously richer in total alkalis; in fact, two metadacites have higher alkalis. In the AFM plot (Fig. 39) the metarhyolites overlap the metadacites to some extent. As in the case of the metadacites, there is a distinct possibility of post-eruptive loss of volatiles.

Fryer and Jenner (ibid.) have divided their metarhyolite analyses into two groups according to silica content---the first with 70 to 75 per cent SiO_2, the second with over 75 per cent SiO_2---and found other chemical differences between them. Rocks of the first group have more Ti, Al, Fe, Ca, Na, P and Sr than those of the second group, which exhibit a very large negative Eu anomaly. As none of these differences can be related to occurrence or appearance of the rocks, no such distinction is made here.

K/Rb ratios of the metarhyolites are similar to those of the metadacites: they fall between 150 and 500, with an average of 298 (Fig. 42).

The Prince Albert rocks are on average more mafic and less alkali-rich (Table 14) than Archean rhyolites elsewhere. Rhyolites from the Eastern Goldfields Province of Australia have been divided into sodic and potassic types and average compositions available are not readily comparable with the Prince Albert average. Judged by the much larger number of analyses (50 as against 15) presented in Williams (1975), sodic rhyolite greatly exceeds potassic rhyolite in abundance in this part of the Western Australian shield. The situation appears similar in the Prince Albert Group. Rhyolites from the Marda complex, Eastern Goldfields Province, show, in addition, more Rb and considerably more Ba than the Prince Albert metarhyolites but overall the rocks from the two areas are very comparable (see also Fryer and Jenner, 1978). The similarity is even greater in the case of the average Superior Province rhyolite, which differs significantly only in having lower Ca and higher Na. Of Condie's (1976b) two Archean rhyolite types, heavy rare-earth element - depleted (DSV) and undepleted (USV), the latter is more akin to the Prince Albert metarhyolite (Table 14; and Fryer and Jenner, 1978), though there are major discrepancies in the Ba content and K/Rb ratio.

Condie's average modern rhyolite is not unlike its Prince Albert counterpart but is richer in alkalis, Sr and Ba, and poorer in Mg, Zr and Y.

Origin and environment of deposition

Arguing chiefly on the basis of REE distribution, Fryer and Jenner (ibid.) considered the Prince Albert metarhyolites to have originated by melting of sialic crust. They also suggested that the more siliceous metarhyolites were derived from the less siliceous ones by fractional crystallization.

The abundance of rhyolitic rocks in the Prince Albert Group of the map area is significant. Modern volcanic belts with major concentrations of felsic rocks are more characteristic of continental margins than of island arcs (Jakeš and White, 1972). As in the case of the andesites and dacites, the evidence suggests that the rhyolitic rocks of the Prince Albert Group were emplaced in a continental-margin (Andean), rather than an oceanic, environment. Such a setting would provide the sialic crust required by the partial melting model proposed by Fryer and Jenner (1978) for the origin of the metarhyolites.

Age

Metarhyolite of the type represented by sample FS-74-95, a 'quartz-eye' metaporphyry, and collected at the same locality, has yielded a U-Pb age of 2879 Ma. The age has been obtained by analyses of three size fractions of zircons and results are plotted on the concordia diagram of Figure 44. Assuming the metavolcanic rocks of the Prince Albert Group to be coeval and that a primary igneous event has been dated, 2879 Ma is accepted as the age of the Prince Albert Group. However, as metabasaltic and metaultramafic rocks underlie the metarhyolite dated, 2879 Ma is, strictly speaking, a minimum age for the mafic volcanic rocks of the Prince Albert Group. Further, the author acknowledges that it may be no more than a metamorphic age, although he does not favour this interpretation.

Metagabbro (unit APAgb)

Medium- to coarse-grained, largely massive, feldspathic amphibolite forms a major portion of the Prince Albert Group just east of Fraser Bay near the northern margin of the map area.

The chief minerals of the amphibolite are blue-green hornblende and well zoned and well twinned plagioclase An_{28-33}. Brown biotite has replaced some of the hornblende and the cores of some plagioclase grains are saussuritized. Quartz is present in minor amount (less than 5 %) and sphene and epidote are common accessory minerals. The colour index of the amphibolite may be as low as 65, clearly distinguishing this rock from the typical metabasaltic amphibolite. The rock is rarely slightly foliated.

The outcrop area of the feldspathic amphibolite is irregular and the contact between it and the foliated metavolcanics and metasediments interfingers. The nature of the contact and the petrography suggest that the feldspathic amphibolite is a metagabbro of intrusive origin. Metagabbroic sills, apparently better preserved, are common in the Prince Albert Group in eastern Melville Peninsula (Schau, 1975). Schau considered that they were emplaced at a relatively late stage of deposition of the Prince Albert Group.

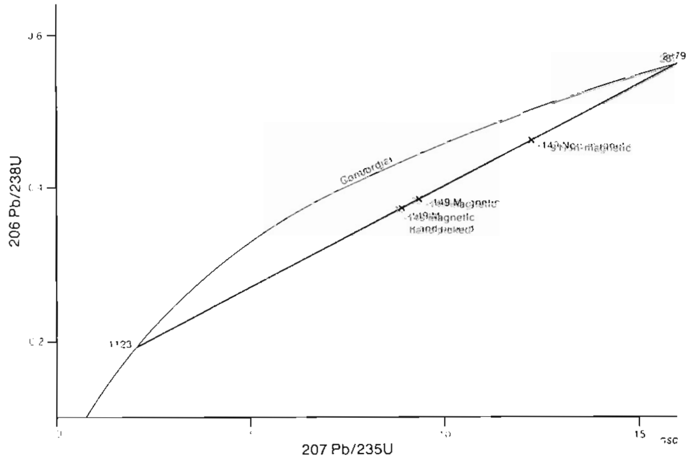


Figure 44. Concordia diagram and U-Pb isotopic ratios for three fractions of zircons from metarhyolite of the Prince Albert Group south of Adamson River. (Data supplied by R.K. Wanless.)

Meta-ultramafic rocks of intrusive or uncertain origin (unit APAu)

Rocks of ultramafic composition are a characteristic feature of the Prince Albert Group and those known to be lavas have already been described (unit APAul). This section deals with varieties deemed to be intrusive or whose origin is not clear.

Distribution and lithology

A few dykelike ultramafic bodies cut across the trend of foliation of the enclosing rocks in the Prince Albert Group of the map area. A major example is found on the northeastern slope of the '550-metre hill' due east of the DEW Line station, where a folded, dykelike mass of meta-ultramafite, 15 m wide, transects garnet-biotite schist and amphibolite. Strongly schistose and dark green on the fresh surface, the rock has a rough, brown to rusty brown weathered surface. The appearance of the fresh and weathered surfaces is typical for ultramafic rocks of the region. In places, the outcrop surfaces assume a distinctly orange cast, whereby the rocks are easily identified from a distance as ultramafic.

Other ultramafic dykes found in the Prince Albert Group are no more than 3 m thick and are sparsely and erratically distributed.

Immediately east of the ultramafic lava pile described earlier, a layered meta-ultramafite lens is enclosed by coarsely recrystallized amphibolite or metagabbro. The lens is up to 4 m thick and several tens of metres long and comprises alternating regular layers, 5 to 8 cm thick, of black and green amphibole-chlorite rocks.

Ultramafic rock in the Prince Albert Group occurs most commonly as lenses or pods, up to several tens of metres long, at or near the contact with granitic country rocks. These bodies are concordant with structures in the enclosing rock and have been so deformed as to lose all evidence of their origin.

An unusually continuous but narrow and in part highly altered belt of ultramafic rock extends eastward from the vicinity of the ultramafic lavas for about 2 km before turning northward to parallel the main trend of the Prince Albert belt. The rocks constituting the ultramafic belt are highly sheared and, in places, fragmented, but can be readily followed for at least 7 km. Along much of this length, the rocks have been altered to carbonate. Indeed, these outcrops make up the only known unit of carbonate rock in the pre-Folster Lake Formation, Archean basement of western Melville Peninsula. In the most highly sheared rocks, carbonatization proceeded to completion but sparse relict minerals such as tremolite, chlorite and biotite are ubiquitous even in these rocks. In less altered meta-ultramafite of this belt, carbonate is confined largely to crosscutting veins. Carbonatization of this extent was not seen elsewhere in the Prince Albert Group and appears to be attributable to intense deformation and attendant alteration in what was essentially a shear belt.

Mineralogy

The meta-ultramafic rocks of unit APAu are mineralogically variable. Most consist chiefly of pale green or blue-green Ca-amphibole or colourless tremolite, brown biotite, epidote and chlorite; amphibole is generally the most abundant mineral. Other varieties show conspicuous amounts of tremolite and carbonate. Still others consist entirely of chlorite, calcite and accessory pyrite. In no rock was olivine or pyroxene observed; the mineralogy of the ultramafites is considered to be entirely metamorphic.

In the carbonated meta-ultramafites, the chief carbonate mineral is ferroan dolomite; calcite is subordinate. Minor quartz present was probably introduced during metamorphism or alteration. The chief silicate minerals are one or more of tremolite, chlorite, biotite and talc, all of which decrease in abundance as carbonate content increases.

Origin and age

The crosscutting dykelike bodies and the layered mass described above are interpreted to be minor hypabyssal intrusions coeval with mafic-ultramafic volcanism. Such bodies are found, usually much better preserved, in the Archean greenstone belts of Munro Township, Ontario, and southern Africa (Arndt et al., 1979) and Western Australia (Williams, 1975).

The origin of the meta-ultramafic lenses along the margins of the Prince Albert belts is problematic. They may be remnants of a once-continuous layer of intrusive and/or extrusive ultramafic rock at the base of the volcano-sedimentary pile; such a layer is considered by many to characterize Archean greenstone belts. Alternatively, the lenses may represent material preferentially intruded along a zone of weakness (the contact between Prince Albert Group and basement country rocks), in which case they would be relatively young rocks later metamorphosed.

Metasedimentary rocks

Iron formation

One of the most significant results of Operation Wager (Heywood, 1967) was the discovery of major belts of iron formation in the Prince Albert Group. The deposits are associated chiefly with metavolcanic amphibolites and attain their greatest extent where these rocks are most abundant, on Melville Peninsula near the western and eastern coasts. The eastern Melville occurrences lie outside the map area and will not be considered here.

Considerable exploratory work on the iron formation has been done by private industry (Wilson and Underhill, 1971) and much of what follows is based on that work.

Distribution and lithology

Iron formation in the Prince Albert Group is concentrated in three regions of the map area: around 'Triangle Lake' south of Adamson River; in the '550-metre hill' due east of the DEW Line station; and at the western edge of the Prince Albert Group east-northeast of Bagnall Lake. The first two deposits are joined by a nearly continuous belt of iron formation.

Typically, the iron formation is a well laminated rock with small folds and consists predominantly of recrystallized magnetite and white quartz (Fig. 45); specular hematite is an important constituent in places and iron silicates are abundant is some of the leaner varieties of iron formation. By analogy with unmetamorphosed Proterozoic iron formation, the quartz represents recrystallized chert. Weathered surfaces are commonly steely black or, where hematite is present, rusty red. Pyrite, locally abundant, may cause some rusty weathering.

Much of the iron formation is composed essentially of iron oxide and quartz. Where magnetite and hematite coexist, both oxides appear to be stable, as there is generally no evidence of one replacing the other. Occasionally magnetite appears to have partly altered to hematite ---probably a weathering process. More commonly, the iron formation contains, in addition to the main minerals, silicates such as amphiboles, micas and chlorite, which together may form up to 40 per cent of the rock. Both calcium-rich and calcium-poor amphiboles are found, often in the same rock. Coexisting amphibole assemblages comprise grunerite and

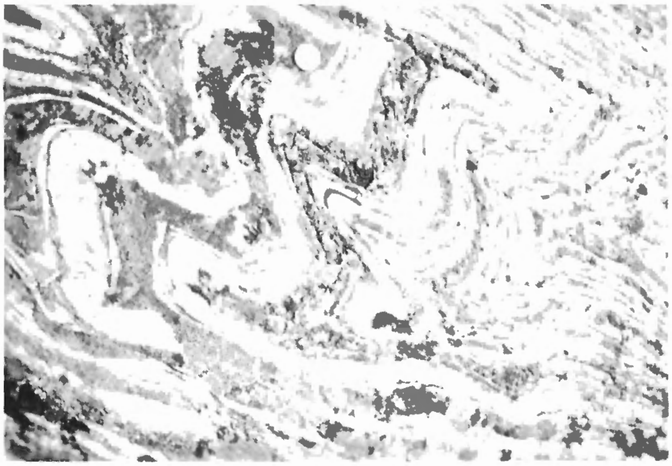


Figure 45. Weathered surface of an outcrop of magnetite-quartz iron formation in the Prince Albert Group, 6 km north of Adamson River. Diameter of the coin is 1.9 cm.

actinolite or hornblende, in discrete or zoned grains. These zoned grains invariably consist of colourless grunerite cores mantled by green Ca-rich amphibole. Lamellar intergrowths of the two amphiboles are common. Chlorite is an important minor constituent and biotite and muscovite may also be present. Watkins (1972) found stilpnomelane (which he considered to be secondary) in two samples and clinopyroxene in another. As accessory minerals, apatite is common and calcite and epidote are rare.

Watkins (ibid.) provided optical and chemical data for several silicate minerals from the iron formation. Grunerite (three analyses) shows the compositional range $Ca_{1-2}\,Fe_{62-83}Mn_{1-2}\ Mg_{14-24}$; analyzed amphiboles are hornblende $Ca_{31}Fe_{54}\ Mg_{15}$ and actinolite (two analyses) $Ca_{11-27}\ Fe_{35-68}\ Mg_{21-38}$ (all values based on 23 oxygens per half-unit cell and total iron as Fe^{+2}). On the basis of chemical and optical data, most of the chlorites are iron-rich with Fe/(Fe + Mg) around 0.8. In an assemblage that includes magnetite, hematite, quartz and calcite, salitic clinopyroxene $Ca_{51}Fe_{16}Mg_{33}$ coexists with actinolite $Ca_{29}\,Fe_{19}Mg_{52}$.

Intense folding of the major deposits of iron formation has repeated and thickened the original accumulation. The belts of iron formation bracketing 'Triangle Lake' are the limbs of a major antiform-synform pair, dipping and plunging steeply. The western limb is commonly 250 to 300 m wide and, though offset by two major transverse faults, can be followed for several kilometres. The eastern belt is about 75 m wide and equally persistent along strike. South of 'Triangle Lake', the two belts gradually converge in a major fold nose. There, hematite is a major component of the iron formation. Thin lenses of iron formation, up to several hundred metres long, occur between the two major belts. Erosion along the two major transverse faults has resulted in valleys up to 150 m deep on whose sides the iron formation is magnificently exposed.

North of Adamson River and directly east of the DEW Line station, coarse magnetite iron formation forms the west flank and summit of the highest hill (the '550-metre hill') in the map area, whose summit lies more than 540 m above sea level and whose slopes are up to 250 m high. The iron deposit occurs as an S-shaped fold, with vertical contacts and a very steep southwesterly plunge. The deposit is up to 500 m wide and has the remarkable peak aeromagnetic signature of 95,000 gammas.

Eight kilometres due north of the deposit just described lies the third major occurrence of iron formation. This, too, is an isoclinal fold, irregular in outline and plunging steeply northward. The deposit is about 3 km long and between 180 and 390 m wide.

Contact relations

Most of the iron formation in the Prince Albert Group of the map area is associated, on a regional scale, with mafic metavolcanic rocks (amphibolite). In detail, however, a thin bed of pelitic schist (generally garnet-biotite ± sillimanite schist, locally rusty) separates iron formation from amphibolite in many places. In the northernmost deposit, metaconglomerate borders iron formation. South of Adamson River, iron formation and metarhyolite are juxtaposed. Typically, iron formation follows a particular stratigraphic horizon for a considerable distance and abrupt deviations can probably be ascribed to tectonic disturbance.

Granitic rock shows intrusive contacts with iron formation in the northern two deposits, where fragments of magnetite-quartz rock in granitic rock are common. Heywood (1967) mentioned blocks of iron formation up to 12 m long in granite east of Erlandson Bay.

Environment of deposition

The iron formation is entirely of the oxide facies and Algoma type. Kimberley (1978) has recently classified iron formations according to their environments of deposition and has assigned the deposits of western Melville Peninsula to a major group he called "metazoan-poor, extensive, chemical-sediment-rich, shallow-sea iron formation (MECS-IF)." This assignment was made chiefly on the basis of great areal extent and varied mineralogy of the iron formation and its common association with sedimentary rocks. Kimberley (ibid.) envisaged MECS-IF to have been deposited, typically, on a "shallow continental shelf with minimal relief adjacent to a low-lying continent with intervening terrigenous-sediment traps or a nearly flat oceanic platform." Such an environment is consistent with that deduced for the majority of the volcanic rocks of the Prince Albert Group in the map area.

However, classification of the Prince Albert iron formation as MECS-IF fails to take into account its regional association with volcanic rocks. This association is the key element of Kimberley's "shallow-volcanic-platform iron formation (SVOP-IF)." Certain characteristics of SVOP-IF are shown by the Prince Albert iron formation but others are not. SVOP-IF is a deposit laid down on a volcanic platform, commonly Archean, banded magnetite (or siderite) and chert, and richer in sulphide than other types of iron formation. On the other hand, SVOP-IF is generally of limited and highly variable areal extent, very thin (usually less than tens of metres thick), and shows evidence of sedimentation at or near wave base. Whatever the category to which it belongs, MECS or SVOP, the Prince Albert iron formation clearly was formed in shallow water.

Associations of banded iron formation, volcanic rocks and sediments similar to those in the Prince Albert Group are found in the Archean shields of Western Australia (Williams, 1975) and Zimbabwe (Milner, 1979). In both these areas there is abundant evidence that greenstone belt formation took place in a shallow marine environment (Archibald et al., 1978; Nisbet et al., 1977).

Metasedimentary schist (unit APAs)

Thoroughly metamorphosed pelitic and psammitic rocks constitute relatively minor amounts of the Prince Albert Group, and are commonly associated with iron formation.

Many of these beds are too thin or discontinuous to be shown on the accompanying geological map. Metamorphism and deformation have largely destroyed evidence of the original nature of the rocks but the rocks are important for their metamorphic index minerals, which provide information on pressure-temperature conditions during their formation. In addition, they locally contain abundant sulphide minerals.

Distribution and lithology

The major accumulation of metasedimentary schists is in the Prince Albert belts north of Adamson River, where their close association with iron formation is apparent. Elsewhere in the Prince Albert Group of the map area, schists are generally limited to thin beds or lenses intercalated with metavolcanics or iron formation. They have not been found associated with known ultramafic lavas.

Depending chiefly on muscovite content, the schists range from pale grey to dark grey or brown. Almost invariably, foliation surfaces are crinkled. Porphyroblastic schists tend to be strongly knotted, and porphyroblasts with inclusion trains out of alignment with the foliation attest to complex deformation.

Perhaps the most striking rocks are andalusite-biotite schists, which are adjacent to metavolcanic amphibolite and iron formation north of Adamson River. Pale purplish, poikiloblastic andalusite occurs as crystals up to 15 cm in diameter and densely packed with inclusions of quartz and biotite; some show a narrow rim relatively free of inclusions. Light or golden brown, strongly pleochroic biotite and quartz are constant and abundant associates of the andalusite and are accompanied by one or more of the following: muscovite, plagioclase, garnet, chlorite, staurolite, cordierite and sillimanite. Tourmaline, epidote and Fe-Ti oxides are common accessory minerals. Complete mineral assemblages are listed under "Metamorphism".

Staurolite and cordierite have been found only together, with pink garnet (almost certainly almandine). The cordierite is slightly pinitized but otherwise seems stable, whereas the staurolite crystals are highly skeletal and appear to be breaking down, possibly indicating the reaction

$$\text{staurolite} + \text{quartz} = \text{andalusite} + \text{almandine} + \text{cordierite} + H_2O$$

Sillimanite is present in only trace amounts as needles in quartz or intergrown with biotite. Although some of the chlorite is clearly an alteration product of biotite, a greenish grey variety looks to be stable in certain rocks where it has grown late, across the main foliation trend. Plagioclase, present in most of the andalusite schists (including andalusite-staurolite-garnet-cordierite schist), is oligoclase An_{15-20}.

Garnet has been granulated and may be rich in inclusions of quartz but is unaltered.

The other metasedimentary schists of the Prince Albert Group are generally medium to coarse grained and all contain biotite, chlorite and quartz; most contain muscovite and plagioclase (oligoclase) as well. Pink garnet is common but not abundant. Watkins (1972) reported X-ray and partial chemical data for "metamorphosed pelitic rocks" from the vicinity of the iron formation, all indicating almandine composition. However, no proof exists that all these rocks are metamorphosed pelites, since some of the mineral assemblages listed by Watkins could as well correspond to metavolcanics. The chlorite appears as an alteration of biotite and muscovite. Quartz forms up to 75 per cent of some rocks.

Local concentrations of pyrite and, less commonly, pyrrhotite weather bright orange or rust in the mica schists. None of these occurrences appears to be of economic significance but their presence suggests a possible favourable environment for ore deposition.

No unequivocal sedimentary structures were observed in any rocks of unit APAs. Gradational changes in abundance of a particular mineral such as biotite or garnet in some of the finer grained schists may reflect original graded bedding.

Origin

The rocks comprising unit APAs clearly are metamorphosed clastic sediments, part of which may be volcanogenic. Wilson and Underhill (1971) implied that they are metagreywackes but there seems to be no firm evidence of this. Judged by relative mica and quartz contents, both argillaceous and sandy sediments existed prior to metamorphism and their intimate association with mafic metavolcanics and iron formation suggests deposition contemporaneous with these rocks. This rock association is a familiar one in Archean greenstone belts (Windley, 1977).

Metaconglomerate (unit APAcg)

Strongly metamorphosed and commonly highly deformed conglomeratic rocks form a minor part of the sedimentary component of the Prince Albert Group. They are found in the interior of the Prince Albert belts, not at contacts with the granitic country rocks. Metaconglomerate is most extensively developed around the northernmost deposit of iron formation, northwest of Bagnall River. This metaconglomerate is separated from the granitic rocks by a narrow zone of schistose rocks, generally metasedimentary. Metaconglomerate is also associated with iron formation, amphibolite and mica schists in the Prince Albert belt south of Adamson River.

In the less deformed metaconglomerates, pebbles vary greatly in shape and size; they are generally ovoid and from less than 1 cm to 12 cm long. The pebbles consist chiefly of quartz but also of granitic rock, iron formation and mica schist or gneiss; all types may be present in one conglomerate bed. In thin section, the quartz pebbles are seen to be sutured aggregates of quartz grains. The matrix is generally schistose to gneissic and rich in brown biotite, chlorite, plagioclase and quartz.

Both northwest of Bagnall River and south of Adamson River the metaconglomerate is spatially associated with iron formation and other metasediments. This relationship suggests deposition of iron formation in shallow water.

Metaquartzite (unit APAq)

Bright white metaquartzite consisting essentially of quartz and subordinate muscovite is characteristic of the Prince Albert Group southwest of Committee Bay (Heywood, 1967; Schau, 1977). In western Melville Peninsula, however, only one occurrence is known, associated with iron formation and metarhyolite on the '550-metre hill' due east of the DEW Line station. The metaquartzite underlies a rectangular area about 400 m by 150 m.

The metaquartzite is a medium-grained, foliated (sheared?) rock composed of lensoid aggregates of sutured quartz grains with irregularly spaced laminae of muscovite. Muscovite flakes disseminated between the laminae are also aligned parallel to the foliation.

This rock is similar to metaquartzite southwest of Committee Bay. Schau (1977) reported crossbedding from that general area and concluded that the metaquartzite was originally a clastic sedimentary rock rather than a chert or highly siliceous volcanic rock. By analogy, a similar origin is proposed for the metaquartzite in the Prince Albert Hills.

Age of Prince Albert granite-greenstone terrane: Summary of new results

The Archean or minimum late Aphebian ages obtained for several major granitic and supracrustal units in western Melville Peninsula establish this region as an Archean crustal block. The ages indicate a major thermal event at around 2900 Ma ago, followed by a second one at around 2700 Ma. The 2900 Ma event may possibly be subdivided into an earlier period of (early basement?) gneiss formation (2919 or 2953 Ma) and later volcanism (2870 Ma) but the age difference is so small that to postulate two separate thermal events seems unrealistic. Only 200 Ma later, major granitic plutonism took place and the essential lithological constitution of the Prince Albert granite-greenstone terrane was perhaps already established around 2700 Ma ago.

The Churchill Structural Province was long regarded, partly on the strength of regionally consistent K-Ar and Rb-Sr age determinations, as being younger than the Superior and Slave provinces. More recent work in restricted areas of the province has documented Archean events and further evidence is provided by Sm-Nd geochronology of composite samples from Baffin Island and Saskatchewan (McCulloch and Wasserburg, 1978). The Sm-Nd data suggest that Churchill Province, as well as Superior and Slave provinces, formed as a crustal segment between 2700 and 2500 Ma ago. The ages reported here indicate that the Churchill crust actually began to form at least 2900 Ma ago.

MISCELLANEOUS METAMORPHIC AND IGNEOUS ROCKS

Metamorphosed supracrustal rocks south of Committee Bay (unit Asg)

Narrow belts of chiefly schistose, layered rocks of supracrustal aspect occur in the granitic terrane south of Committee Bay. They were examined in less detail than the Prince Albert belts.

One belt, a few hundreds of metres wide and at least 7 km long, lies between augen gneiss (unit Aagn) and granitic gneiss (unit Agn) east of Ross Inlet. The belt trends slightly north of east and is parallel to the regional foliation. Chief rock types in the belt are biotite and amphibole schists and interlayered milky quartz sheets. The uniform configuration and great extent of the latter suggest they are recrystallized sedimentary quartzite beds. Contacts of the supracrustal belt with the gneissic country rocks are sharp. The most reasonable interpretation of the belt is that it represents a package of sedimentary and volcanic rocks that were metamorphosed and strongly deformed.

Farther east, within the augen gneiss terrane, lies another belt of supracrustal aspect that is sufficiently well defined to be approximately delineated on the geological map. This belt, about 800 m wide and at least 18 km long, also trends north of east and comprises chiefly biotite schist and amphibolite with blue-green hornblende. The belt is bordered on both sides by highly foliated gneiss, much of which is augen gneiss (unit Aagn), and contacts are transitional rather than sharp. The mafic rocks presumably represent metamorphosed volcanics.

The distribution of known outcrops of such mafic schistose rocks and of linear aeromagnetic anomalies (Geological Survey of Canada Map 7671G), which appear to be related to these rocks, strongly suggests that the supracrustal belts once were more extensively developed but have been severely modified and disrupted by granitic intrusion and deformation.

These supracrustal belts may well be Prince Albert Group or its equivalents but, because of a lack of characteristic lithological assemblages such as iron formation and ultramafics, and of a direct connection with Prince Albert belts to the northeast, they are provisionally considered as separate units of probable Archean age.

Minor meta-ultramafite - mafite (unit Aum)

Two elongate bodies 1.5 km long, consisting of metamorphosed ultramafic-mafic rock in the northwestern part of the map area, were examined. Both bodies trend northeasterly, parallel to the gross structural grain of the area.

The larger and more complex of the two bodies occurs 6 km southeast of the mouth of Adamson River. This body is about 1.5 km long and up to 400 m wide and comprises a southern meta-ultramafic zone and a northern metagabbroic to metadioritic zone, which is intruded by massive granite rock of unit Ag. The ultramafic zone consists of coarse-grained, massive biotite amphibolite, composed essentially of grass-green hornblende crystals up to 7 cm long, brown biotite and minor epidotized plagioclase An_{35-40} or interstitial calcite. Much of the biotite is an alteration product of hornblende.

The more felsic parts of the body contain abundant plagioclase and quartz, as well as microcline near the granite contact. The plagioclase, about An_{30-35}, is strongly zoned and riddled with epidote granules. The mafic minerals are blue-green hornblende and brown biotite. Some rocks carry abundant coarse sphene (2 - 4 mm), others are markedly pyritiferous. One metagabbro contains abundant pale green clinopyroxene, which is partly altered to blue-green hornblende, and large (4 - 6 mm), well formed crystals of brown hornblende partly altered to green hornblende. Apart from the salite-bearing iron formation reported by Watkins (1972), this metagabbro is the only metamorphosed rock with pyroxene found in the Archean basement in the map area.

Some rocks with the appearance of metamorphosed diorite contain unaltered pink microcline in addition to abundant, slightly strained quartz. The microcline and quartz are considered to represent contamination by the granite. Veins of pink granitic country rock are common in the metamafite body. A fine-grained zone localized at the contact with the country rock suggests that the metamafite body is an original intrusion that was subsequently veined by remobilized granite or perhaps back-veined during intrusion. Igneous differentiation gave rise to distinct ultramafic and mafic zones.

The other mafic body is in the coastal cliffs west of the DEW Line station, where it is exposed in a prominent cleft about 100 m wide and 1.5 km long in layered gneisses of unit Agn. The body consists of coarse-grained amphibolite, comprising chiefly grass - green hornblende in subhedral crystals 5 to 15 mm long and epidotized plagioclase zoned from An_{35} in cores to An_{27} in rims; greenish brown biotite, sphene and scattered quartz are subordinate constituents. Granitic veinlets cut the amphibolite mass parallel to its length; the quartz is probably the result of contamination from this intrusion. This mass is similar to the more mafic parts of the larger body to the south and is interpreted as a recrystallized igneous body emplaced prior to intrusive granitic activity.

Diabase dykes

As Heywood (1967) noted, in an areally much wider sampling, diabase dykes are not abundant in this part of the Canadian Shield. Most are not particularly well exposed and some appear to be segmented, though the discontinuity may only be apparent because there is no outcrop.

Ranging from 20 to 40 m wide, the dykes are irregularly exposed for up to 22 km. One of the two dykes paralleling Matheson River is probably a northwest extension of the one sampled and dated near the head of Lyon Inlet, at least 80 km southeast (Geological Survey of Canada, 1970).

The dykes are brown on weathered surfaces and dark grey to black on fresh surfaces, and have fine grained chilled margins. Textures in thin section range from ophitic to intersertal and the main minerals are very pale brown clinopyroxene and labradorite An_{55-60}. Fe-Ti oxide is a ubiquitous accessory and hornblende, biotite and chlorite are common alteration products of pyroxene. The first dyke northwest of the '550-metre hill' east of the DEW Line station is unusual in that it is the only one found to bear olivine. This rock has both clinopyroxene and orthopyroxene, the latter mantling iddingsitized olivine in the reaction relationship that characterizes tholeiite.

None of the dykes sampled is very fresh and alteration is significant---alteration of pyroxene to sheet silicates, interstitial chlorite and clay minerals (altered glass?), and calcite veining and replacement.

The major dyke that cuts the Folster Lake Formation and meets the coast between Barnston Point and Cape Finlayson has been chemically analyzed (Table 15). The CIPW normative composition of this rock, as derived from the analysis, which includes significant water and CO2, recalculated volatile-free, shows that it is a tholeiitic basalt of the K-rich series (Irvine and Baragar, 1971). The theta index is 34, as befits a basalt intruded into continental crust.

The diabase dykes are undoubtedly Precambrian and, being unmetamorphosed and intrusive into the Folster Lake Formation, are the youngest pre-Paleozoic rocks in the map area. However, the dykes are not necessarily all of the same age. The Isotopic Age Map of Canada (Geological Survey of Canada, 1970) shows, in the area south and east of Committee Bay, two dykes with whole rock ^{40}K-^{40}Ar ages of 941 and 964 Ma and a third (mentioned above) 606 Ma old. Hence no assignment of the diabase dykes to any particular dyke swarm such as the Mackenzie or Franklin is made in this report.

FOLSTER LAKE FORMATION (unit PFL)

Around Folster Lake and in the area to the northeast, the Archean rocks are unconformably overlain by gently folded, low-grade metamorphosed to unmetamorphosed sedimentary rocks (see Frontispiece), formally defined as the Folster Lake Formation. These strata were first recognized in 1964 during Operation Wager and briefly described as map unit 16 by Heywood (1967, p. 13). Additional outcrops about 20 km south of Cape Weynton, on the opposite shore of Committee Bay, were discovered in 1973 by F.H.A. Campbell of the Geological Survey of Canada.

The lithology, origin and age of the Folster Lake Formation are discussed here; its metamorphism and structure are deferred to the separate sections on these topics.

Thickness

The type section of the Folster Lake Formation has been chosen at locality 1 (base of section) in Figure 46, where the thickest sequence is exposed. Unfortunately, this section does not include the lowermost beds but these are excellently exposed nearby. A covered interval of 18 m separates the lowest exposed Folster Lake rocks from the Archean; the top of the unit is not exposed. Thus the measured thickness of 793 m is a minimum.

Lithology

The Folster Lake Formation rests on a Precambrian pediment developed on the Archean basement of granitic and metavolcanic rocks. This surface of deposition, though affected strongly by metamorphism, is well preserved east of Folster Lake. As the basal contact of the Folster Lake Formation is approached, the appearance of the basement changes markedly: granitic rocks commonly take on a vaguely 'clastic', rather than a denser, gneissic texture, and a brighter pink hue; lenses of deeply weathered calc-silicate rock become abundant; and, adjacent to the contact, a metamorphosed regolith may occur. The metaregolith is formed of rounded, chiefly granitic boulders up to several metres in size, in a matrix of pale greenish, commonly crenulated biotite-muscovite phyllite (Fig. 47). Here and there between the boulders, quartz-pebble conglomerate, considered to belong to the Folster Lake Formation (see below), is preserved. At locality 2 (Fig. 46) the metaregolith has a horizontal width of 25 m. Williams (1969) has described a somewhat similar but unmetamorphosed ancient erosion surface from northwest Scotland, where late Precambrian Torridonian sediments overlie Archean Lewisian basement.

The Folster Lake Formation can readily be divided into lower and upper members. The lower member comprises a heterogeneous assemblage up to 50 m thick, consisting of schists, conglomerates, marble and iron formation; the upper member consists of more or less calcareous arkose.

Lower member

Nine sections were measured in the lower member. Although heterogeneous, it shows a broadly consistent stratigraphy from place to place; a typical section is shown in Figure 48.

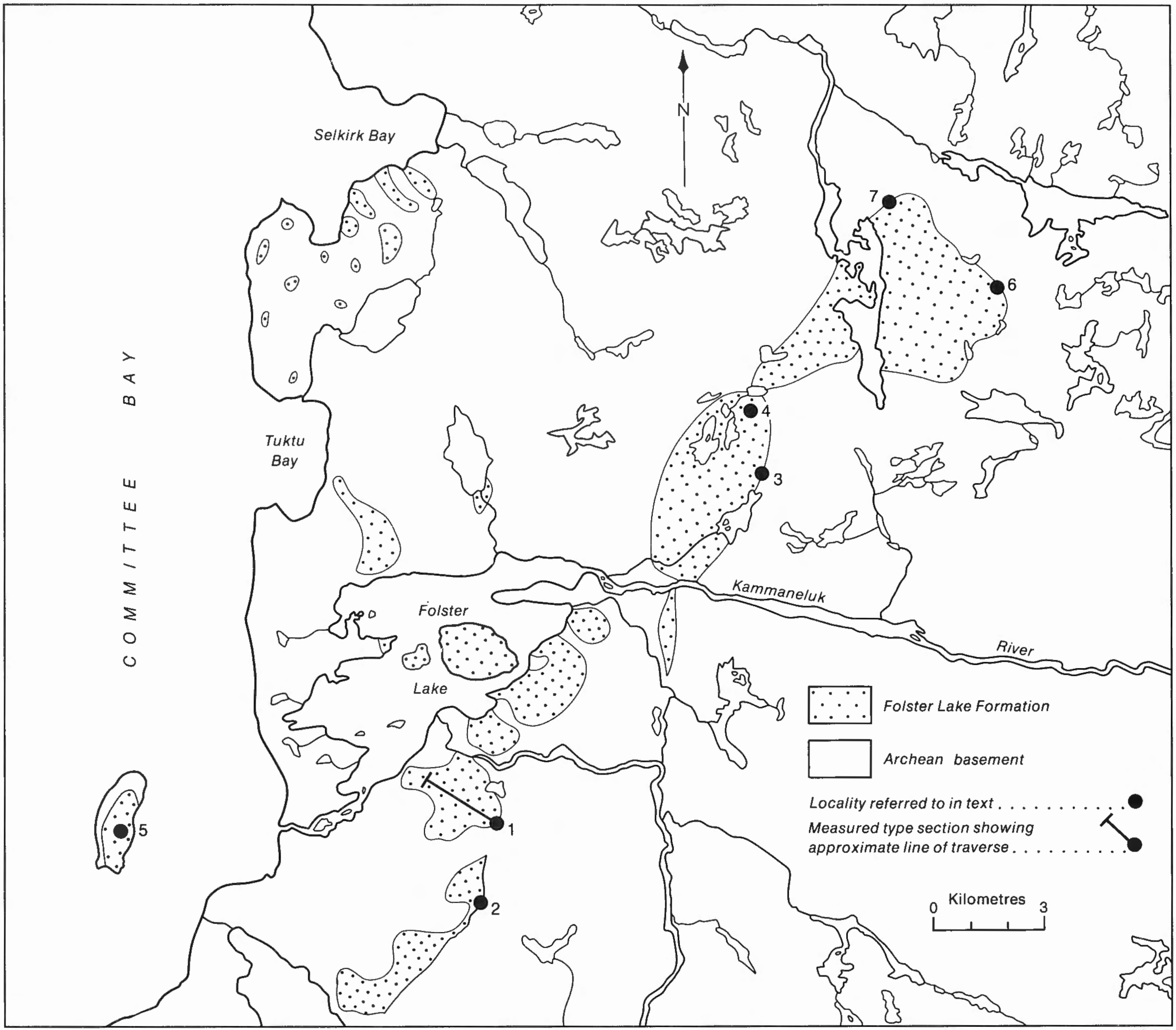
The basal rocks (unit A, Fig. 48) of the lower member are quartz-pebble conglomerates largely confined to depressions in the Archean pediment, which mark the site of former stream channels (Fig. 49). The conglomerate consists chiefly of well rounded, white quartz pebbles and much less abundant granitic and metavolcanic pebbles in a green matrix of phyllite identical to that in the metaregolith. Rarely, the conglomerate forms a more continuous layer 1 to 3 m thick immediately above the contact with the basement.

Typically, the lowermost layered rocks (unit B, Fig. 48) which commonly rest on the metaregolith, comprise dark schists with thin lenses of ferruginous quartzite (Fig. 50). Unit B is commonly 1 to 3 m thick but at one locality it is nearly 7 m thick. The schist matrix consists of very finely granular feldspar, quartz, epidote, muscovite, biotite and calcite, and, disseminated throughout, finely particulate hematite; euhedral magnetite is a common accessory but in places is abundant. The lenses, whose length:width ratios are generally 10, are made up of sutured quartz grains with hematite disseminated and in ragged grains and stringers.

These schists grade into rocks of unit C (Fig. 48), typically 3 m but up to 10 m thick. Abundant quartzite lenses are generally 35 cm long and 7 cm wide but may attain lengths of 90 cm and widths of 17 cm. Average length:width ratios of the lenses are 6 and rarely exceed 10. The larger lenses tend to be concentrated in the lower layers of unit C. Other than containing larger quartzite lenses, the rocks resemble those of unit B.

Although clearly metamorphic, these rocks preserve a major sedimentary feature---lenticular bedding containing isolated lenses that are flat in the lower layers and thick in the upper ones, in the terminology of Reineck and Singh (1975, p. 101). The original sediment comprised mud or silt (now schist) with lenses of sand (now quartzite).

The next unit in the succession (unit D, Fig. 48) consists of greenish calcareous phyllite commonly with thin lenses or recrystallized white quartz parallel to the foliation. The thickness of this unit varies from 5 to 45 m, but rarely exceeds 20 m. The phyllite is made up chiefly of epidote (cored by allanite), muscovite, greenish brown biotite, feldspar and quartz; hematite occurs in tiny flakes and is a major constituent of some rocks. Calcite tends to be



GSC

Figure 46. Distribution of the Folster Lake Formation and localities mentioned in text.

patchily distributed in relatively coarse grained (1 - 2 mm) aggregates, which weather preferentially, giving the rock a pitted surface. Calcite also fills veins, cutting the foliation. In general, these rocks resemble the lower beds of unit B and the white quartz lenses are thought to have an origin similar to that of the ferruginous lenses in that unit.

Locally, skarnlike assemblages including andradite, hedenbergite and grunerite are present in unit D. Near locality 2 (Fig. 46), a well layered calcareous rock, rich in magnetite, epidote, feldspar and quartz, carries 1 mm needles of pale green grunerite and highly sieved, elongate (2 – 4 mm) porphyroblasts of andradite. The grunerite is found throughout the rock but the andradite is confined to discrete layers depleted in magnetite. At locality 3 (Fig. 46), one rock comprises coarsely recrystallized lenses of calcareous grunerite-andradite-epidote quartzite in a dark green matrix of hedenbergite, grunerite, calcite, quartz and epidote. Unlike andradite, which has assumed a ragged, skeletal form, hedenbergite has crystallized in subhedral grains 1 to 5 mm in size. Since the two minerals are not found together, they appear to be incompatible.

Unit E, 2 to 29 m thick, comprises marble that is predominantly conglomeratic, especially in the lower part, but grades upward into nonconglomeratic calcareous arkose of unit F. The conglomeratic marble is composed of elongate pebbles of granitic rock, hematitic quartzite (of a composition identical to that in the underlying units) and white quartz, and lensoid clasts of buff or grey marble in a medium-grained matrix of buff or grey marble rich in pale green tremolite. The pebbles vary in size from 1 to 25 cm but most are 6 to 15 cm long, are moderately well rounded, and make up less than 10 per cent of the rock. In contrast to the pebbles, the marble fragments are compositionally identical to the matrix and are therefore considered to be

Figure 47. Metamorphosed regolith developed on Archean granitic basement beneath the base of the Folster Lake Formation. The large granitic boulders lie in a phyllite matrix.

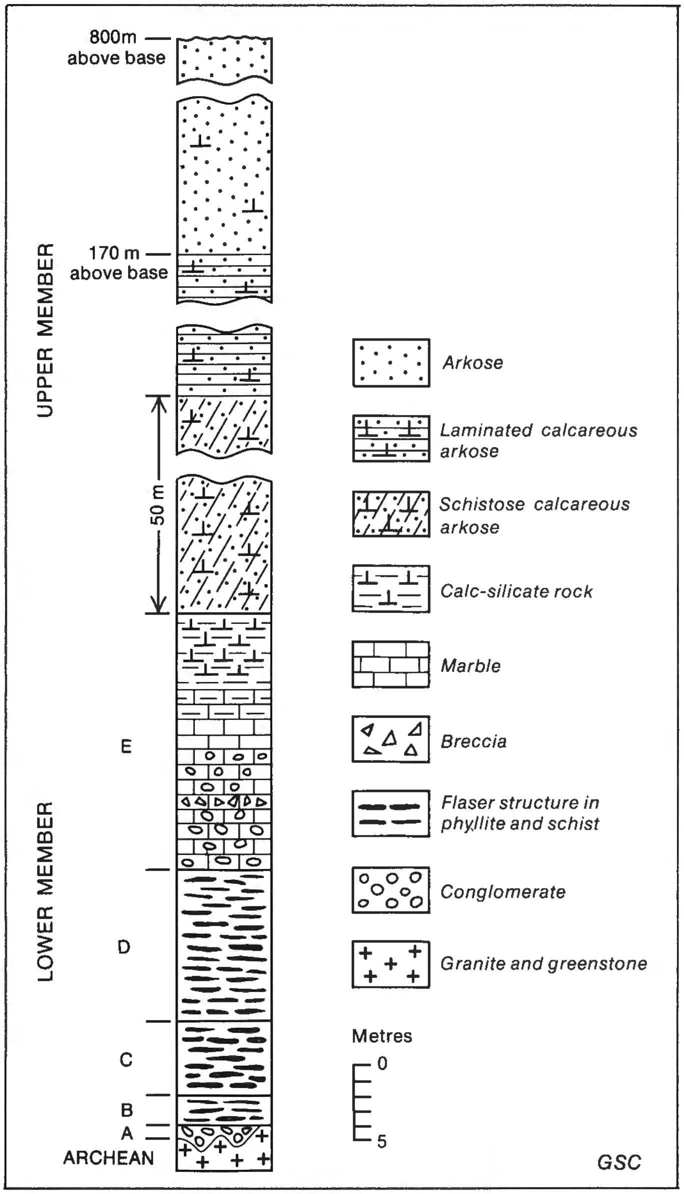


Figure 48. Stratigraphic section of the Folster Lake Formation. Vertical scale applies to lower unit only.

intraclasts; where these are abundant, the rock is a true intraformational conglomerate or breccia (Fig. 51). Both fragments and matrix are composed of strongly recrystallized calcite, pink or yellow on fresh surfaces, with minor interstitial phlogopite and talc and major late tremolite growing, often in rosettes, across all earlier structures.

Much of the less conglomeratic and the tremolite-poor marble is well laminated (Fig. 52).

The marble of unit E shows the effects of a disturbed depositional environment. In addition to being conglomeratic, the rock is deformed locally into slump folds and the entire unit thickens and thins rapidly, for example at one locality, from 0 to 2 m over a distance of 50 m.

Unit E becomes increasingly silicate-rich toward the top, grading into, successively, siliceous marble, calc-silicate rock and calcareous arkose. The transition to calcareous arkose is taken as the top of the lower member of the Folster Lake Formation.

The rocks of the lower member are cut by the occasional vein of white quartz. None of the veins could be traced into the underlying basement and it seems virtually certain that they are related to the metamorphism of the Folster Lake sediments.

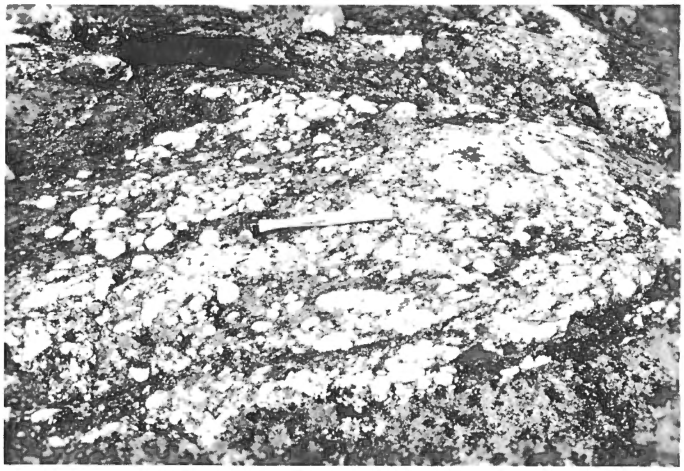


Figure 49. Quartz-pebble conglomerate of the basal Folster Lake Formation filling a depression in the underlying Archean pediment, east of Folster Lake.

Figure 50. Flaser bedding in unit B near the base of the Folster Lake Formation. The lenses consist of ferruginous quartzite and lie in phyllite. Diameter of the coin is 1.9 cm.

Figure 51. Angular fragments of marble in conglomeratic marble of unit E of the Folster Lake Formation. The length of the tape is 15 cm.

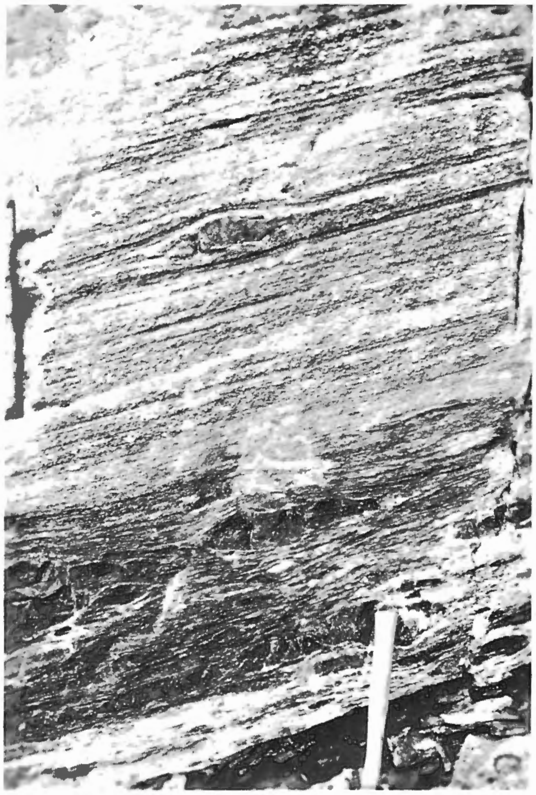


Figure 52. Laminated marble of unit E of the Folster Lake Formation. Length of the hammer shaft is 29 cm.

Upper member

The entire upper member of the Folster Lake Formation, nearly 800 m thick at locality 1 (Fig. 46), consists of arkose. 'Arkose', as used here, is defined in terms of quartz, feldspar and sheet silicate content in Figure 53. Although adapted from Figure 5-5 of Krumbein and Sloss (1963), the diagram differs in that the sheet silicates end-member does not necessarily include the matrix component. In all but the least metamorphosed rocks of the Folster Lake Formation, any matrix that may once have existed has been destroyed by recrystallization. However, where recognizable, the matrix consists chiefly of sericite and is therefore included in the mica component. Identifiable rock fragments are absent from the Folster Lake arkoses. Representative samples of upper member rocks are plotted in Figure 53.

Typically, the upper member is more calcareous at the base than at the top, as evidenced by pronounced carious weathering of the lower beds (the lower 160 m of the section at loc. 1). Bed thickness varies between 0.6 and 1.2 m and weathering colours are pink (GSA Rock-Color Chart colour 5R 6/2), grey (5Y 6/1) or pale brown (10YR 6/3). Characteristic of these rocks are planar-tabular crossbeds up to 1 m thick, indicating a consistent transport direction from the east and southeast, that is, off the Archean basement (Fig. 54). Paleocurrent data are sparse for Folster Lake Formation rocks that are bordered both east and west by Archean terrane (as at loc. 4, Fig. 46) but, there being no

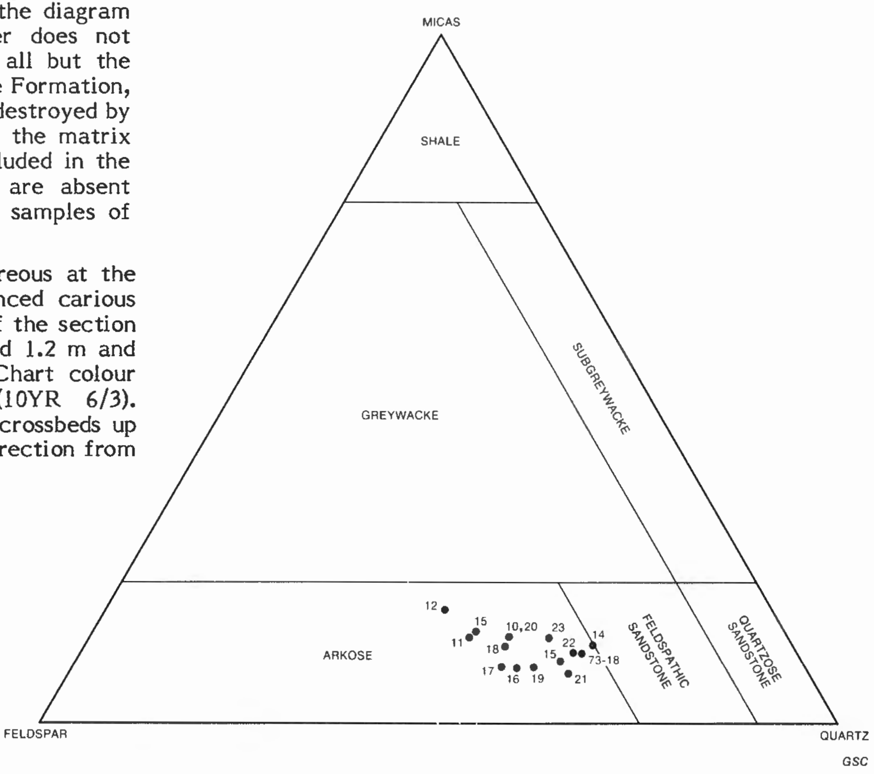


Figure 53. Rocks of the upper member of the Folster Lake Formation in the quartz-feldspar-mica triangle (adapted from Krumbein and Sloss, 1963, Fig. 5-5). Sample numbers, excluding 73-18, increase with height in the section.

indication of sediment transport from the west, it appears that the 'intracratonic' position of these rocks is the result of later tectonism and does not mark the site of an original depositional 'micro-basin'. Small-scale slump folds with amplitudes up to 0.7 m are common in the calcareous lower beds and also indicate a west-northwest direction of transport. The effects of alternating transgression and regression are seen in numerous outcrops displaying overlap and offlap relationships (Fig. 55). Much rarer sedimentary structures are sand-filled scour channels up to 10 m across and 2 m deep, and poorly developed ripple marks.

The upper member of the type section shows a remarkably gradual progressive diminution in metamorphic grade from bottom to top. The lower arkoses are metamorphosed rocks; they are layered, even schistose, and the layers are defined by muscovite, brownish green biotite, and epidote in parallel elongate grains. The mica is generally fresh and well crystallized and, although well aligned overall, individual flakes are commonly discordant to the foliation,

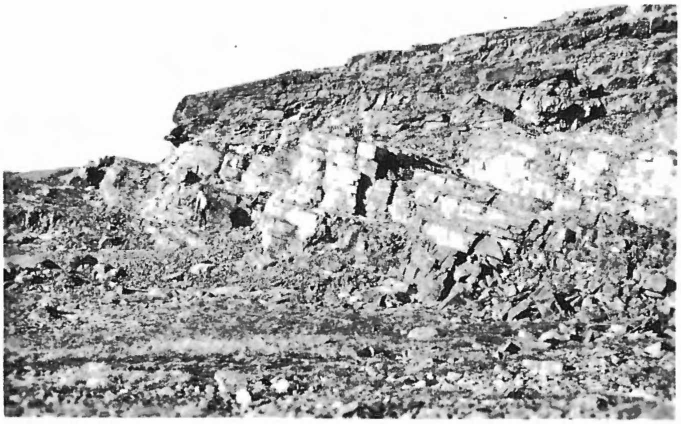


Figure 55. Overlap and offlap in arkose of the Folster Lake Formation.

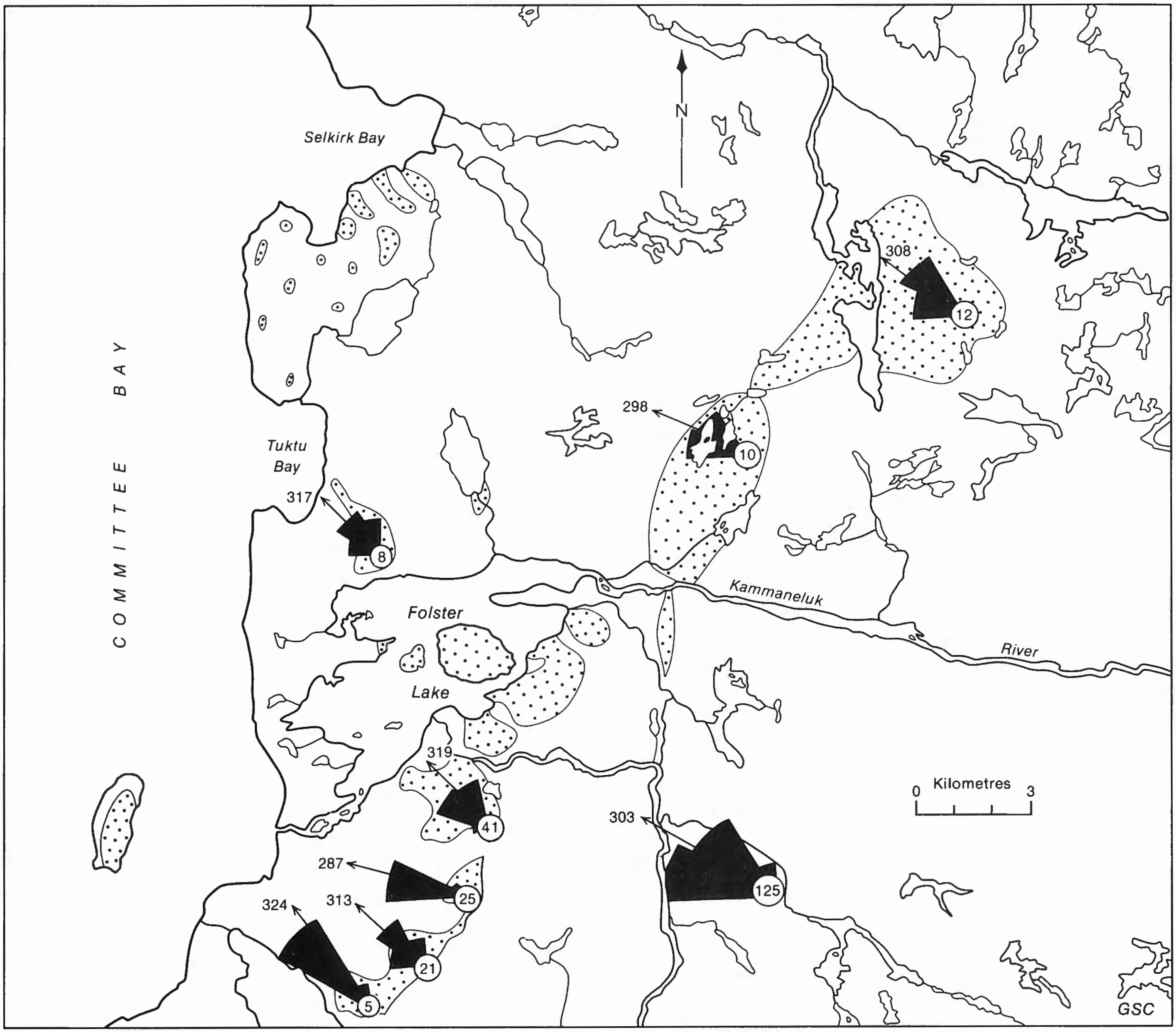


Figure 54. Paleocurrent directions as determined from crossbedding in the upper member of the Folster Lake Formation. Numbers of readings and azimuths of average current directions and of a grand average direction are shown.

suggesting that the mica grew during metamorphism before and after the deformation that gave rise to the foliation. Quartz and feldspar are finely granular (grain size up to 0.3 mm) and quartz has sutured borders. Because twinning is scarce and grain size is small, distinction between Na- and K-feldspar and determination of An content are frequently difficult. However, the plagioclase generally has a refractive index less than that of quartz, and is almost certainly albite; it is partly altered. On the basis of rare grid twinning, the K-feldspar is all thought to be microcline; it is fresh. Both feldspars are subhedral to euhedral and, although originally clastic, are thoroughly recrystallized. Calcite tends to be concentrated in ragged lenses, made up of 15 mm grains, which parallel the layering. Preferential weathering of these lenses gives a pitted surface to the rock.

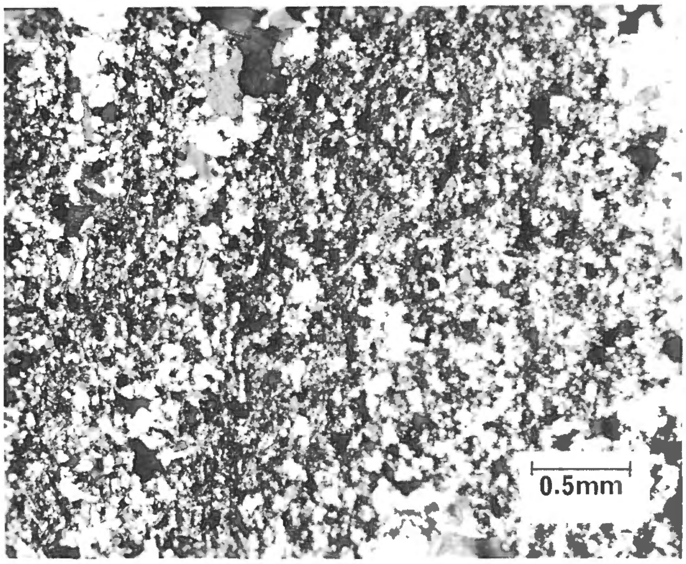


Figure 56. Photomicrograph of laminated calcareous arkose from the lower beds of the upper member, Folster Lake Formation. Note the roughly parallel, recrystallized muscovite flakes.

Higher in the section (from roughly 50 m above the base of the member), epidote is less common and the rocks are laminated rather than schistose, with rare exceptions. The laminations are generally a few millimetres thick and result from variation in the amount of micas + chlorite and quartz + feldspar, mimicking an original bedding. Grain size rarely exceeds 0.3 mm and the preferred orientation of elongate quartz and feldspar grains so characteristic of the schistose lower arkosic rocks is no longer very evident. On the other hand, there is little sign of matrix material and relatively coarse (0.7 mm) metamorphic muscovite is abundant; calcite is disseminated throughout the rock (Fig. 56).

Above a height of 170 m in the type section, the rocks have an increasingly pronounced clastic texture, a discernible matrix of sericite, and oligoclase in place of albite (Fig. 57). The amount of matrix rarely exceeds 10 per cent of the rock. Quartz and feldspar grains are generally more angular and uneven in size (0.1 - 0.4 mm) than in the lower arkoses. Scattered flakes of relatively coarse (0.2 - 0.3 mm) muscovite and greenish brown biotite, and disseminated calcite are ubiquitous but there is little suturing of quartz. Figure 58 shows a rock from the westernmost outcrop of the Folster Lake Formation (loc. 5, Fig. 46), presumably near the top of the upper unit, as Paleozoic strata are exposed nearby on Wales Island. The strongly clastic, undeformed texture of this specimen represents an end-stage in the gradual diminution of metamorphism upward in the Folster Lake Formation.

Fifteen rocks from the upper member of the type section are plotted in the sheet silicates-quartz-feldspar diagram of Figure 53. Five of the seven samples with 58 per cent or more quartz come from above 170 m, indicating maturity increasing upward in the section.

Contact relationships

The contact between the Folster Lake Formation and the underlying Archean basement is exposed at several localities east and northeast of Folster Lake (Fig. 59). The quartz-pebble conglomerate that commonly forms the basal beds of the Folster Lake Formation fills depressions in the

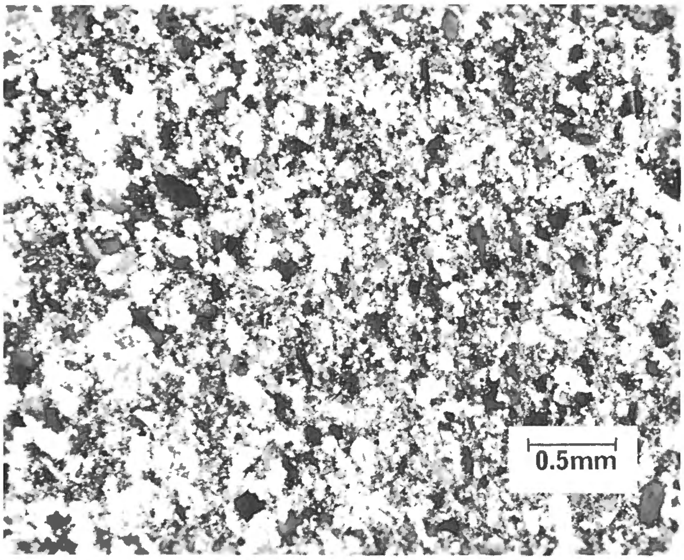


Figure 57. Photomicrograph of calcareous arkose from about 180 m above the base of the Folster Lake Formation. Note the clastic appearance and sericitic matrix.

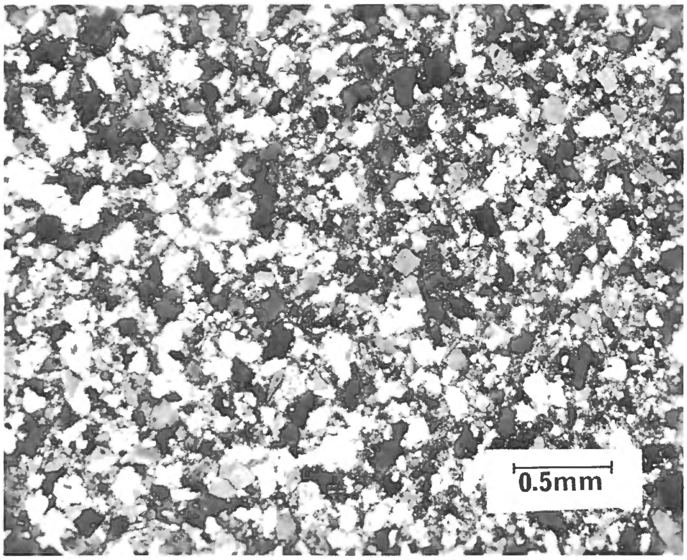


Figure 58. Photomicrograph of arkose from the upper beds of the Folster Lake Formation (loc. 5, Fig. 46). This is a clastic rock virtually unmetamorphosed.

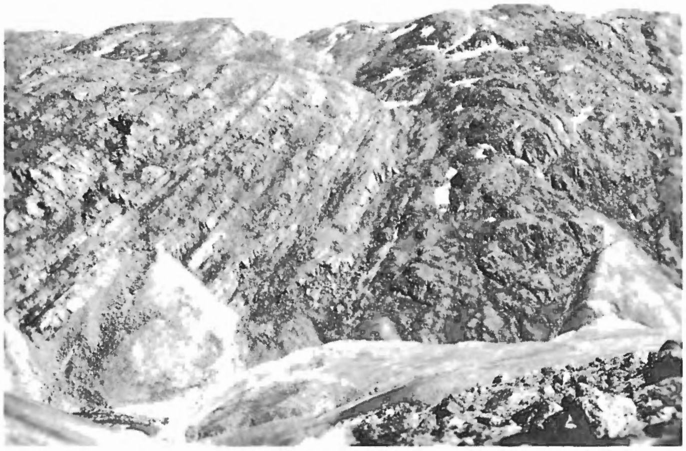


Figure 59. Contact of the Folster Lake Formation (left) and the Archean basement, north side of Kammaneluk River valley.

pediment developed on the basement surface. As noted above, this conglomerate is missing in places and dark schists of unit B rest directly on granitoid or metavolcanic rock (Prince Albert Group) of the basement.

A marked divergence exists between dips of bedding in the Folster Lake Formation and of foliation in the basement rocks, for example, up to 50° east of Folster Lake and 115° at locality 5 (Fig. 46). The contrast between the regularly bedded metasediments and the underlying highly deformed metamorphic-plutonic terrane, coupled with the lack of major deformation along the contact, makes the break between the Folster Lake Formation and the basement a classic nonconformity.

Environment of deposition

Preservation of original sedimentary features permits a reasonably good reconstruction of the environment in which the Folster Lake Formation was deposited. Such features are, from bottom to top in the succession: (a) quartz-pebble conglomerates filling depressions in an eroded bedrock surface; (b) lenticular bedding in a psammite-pelite mixture; (c) hematite metaquartzite; (d) laterally discontinuous conglomeratic and laminated carbonate rocks; and (e) abundant, land-derived calcareous arkose with tabular planar crossbedding.

The quartz-pebble conglomerate is probably a deposit in stream channels cut into the Archean pediment. Lenticular bedding originates when sand deposits (laid down by current or wave action) alternating with mud or silt deposits (from quieter water) are reworked by currents or waves, typically in tidal flats (Reineck and Singh, 1975). The abundance of iron formation in the basement resulted in iron-rich waters that readily precipitated hematite in the well oxygenated, shallow-water environment of a tidal flat (see Drever, 1974). Laminated carbonate rocks and intraformational carbonate conglomerates characterize many tidal flats, both ancient and modern (Pettijohn, 1975; compare Fig. 9 of Laporte, 1967 with Fig. 52 of this report). Uniformity of rock type, absence of conglomerates and abundant signs of transgression and regression suggest deposition of the arkosic sands in a nearshore, shallow-water environment dominated by bimodal offshore currents. Much of the sand is confined to channels perpendicular to the ancient shoreline, through which sediment was transported from a granitic terrane probably of moderate to high relief.

Age and correlation

As detailed above, the Folster Lake Formation rests on a paleo-erosion surface of the Archean basement and was not seen to be intruded by any granitic rocks. It is cut, however, by a diabase dyke (at loc. 7, Fig. 46), which is unmetamorphosed, trends west to northwest, and is probably of Hadrynian age.

A sample of epidote-biotite-muscovite-feldspar-quartz phyllite from unit B at locality 2 (Fig. 46) was dated by the ^{40}K-^{40}Ar method. Because of intergrowth of the micas, it proved impossible to separate the biotite from the muscovite and a mixture of the two micas was dated. In addition, a sample of the bulk rock was processed. The ages obtained were 1477 ± 37 Ma for the micas and 1416 ± 44 Ma for the whole rock. Agreement of the ages is to be expected within error limits, since most, if not all, of the argon would reside in the micas.

The relatively low temperature and shallow depth at which metamorphism of the rock took place (see "Metamorphism") should result in retention in the micas of most of the argon after metamorphism, that is, the K-Ar age should approximate the age of metamorphism. If valid, the age obtained is the first indication of a late Paleohelikian (Elsonian) event on Melville Peninsula.

There are no rocks known with certainty to be correlative with the Folster Lake Formation. Heywood (1967) tentatively suggested correlation with the Penrhyn Group but the contrasts between the two are striking. The Folster Lake Formation consists almost entirely of arkose, postdates all granitic rocks, is weakly deformed, and appears to have been metamorphosed in the greenschist facies about 1450 Ma ago. The Penrhyn Group, on the other hand, comprises paragneisses, pelitic schists, marble, calc-silicate rocks and orthoquartzite, is commonly intruded by granitic rocks, is intensely deformed, and appears to have been metamorphosed in the middle to upper amphibolite facies about 1800 Ma ago (Reesor, 1974; Reesor et al., 1975).

Blackadar (1963) described quartzitic sandstone and minor shale and conglomerate of probably late Proterozoic age from Fury and Hecla Strait but these rocks petrographically do not resemble those of the Folster Lake Formation and are unmetamorphosed.

It is interesting that near Baker Lake, 600 km southwest of Folster Lake, sediments of the Proterozoic Dubawnt Group appear to have been affected by a late Paleohelikian diagenetic or thermal event, according to Rb-Sr dating by Bell and Blenkinsop (1974). These investigators obtained two isochrons for whole rock sediments of the Kazan Formation, one at 1749 ± 50 Ma, the other at 1511 ± 60 Ma, and interpreted these as corresponding to the age of deposition and the age of a later event. Perhaps the latter is related to the greenschist-facies metamorphism of the Folster Lake Formation.

METAMORPHISM

Information on the physical conditions of metamorphism in the map area must be sought primarily in the supracrustal rocks, particularly the metasediments, where diagnostic mineral assemblages are most likely. As far as the Archean terrane is concerned, data obtained from the Prince Albert supracrustal rocks should be applicable to the surrounding granitic rocks, both components of the terrane apparently having undergone the same metamorphism.

Metamorphic mineral assemblages in the Prince Albert Group are listed below. Minerals are listed without regard to their stability or abundance. Minerals in parentheses occur in only trace amounts.

Pelites (and psammite?)

Biotite-muscovite-plagioclase-quartz
Biotite-muscovite-epidote-K-feldspar-plagioclase-quartz
Biotite-muscovite-chlorite-epidote-K-feldspar-plagioclase-quartz
Biotite-chlorite-muscovite-plagioclase-K-feldspar- quartz
Biotite-chlorite-muscovite-epidote-K-feldspar-quartz
Garnet-biotite-chlorite-muscovite-plagioclase-quartz
Garnet-biotite-chlorite-quartz
Andalusite (-sillimanite)-biotite-chlorite-muscovite-epidote-quartz
Andalusite-biotite-chlorite-muscovite-epidote-plagioclase-quartz
Andalusite (-sillimanite)-garnet-biotite-chlorite-plagioclase-quartz
Andalusite-garnet-biotite-muscovite-quartz
Andalusite-garnet-biotite-staurolite-cordierite (-chlorite-muscovite)-plagioclase-quartz

Psammite

Muscovite-quartz

Basalt and andesite

Blue-green hornblende-plagioclase
Blue-green hornblende-biotite-plagioclase (-quartz)
Blue-green hornblende-epidote-plagioclase
Blue-green hornblende-biotite-epidote-plagioclase (-quartz)
Pale green amphibole-biotite-plagioclase
Pale green amphibole-epidote-plagioclase-quartz
Pale green amphibole-epidote-plagioclase
Pale green amphibole-plagioclase

Dacite

Biotite-epidote-muscovite-chlorite-plagioclase-quartz
Biotite-epidote-chlorite-plagioclase-K-feldspar-quartz
Biotite-epidote-plagioclase-quartz
Ca-amphibole-Ca-poor amphibole-biotite-epidote-chlorite-plagioclase-quartz

Rhyolite

Biotite-muscovite-quartz
Biotite-muscovite-plagioclase-quartz
Biotite-muscovite-K-feldspar-plagioclase-quartz
Biotite-muscovite-epidote-plagioclase-quartz
Biotite-muscovite-chlorite-plagioclase-quartz
Biotite-muscovite-chlorite-epidote-K-feldspar-plagioclase-quartz
Almandine-biotite-chlorite-feldspar quartz

Ultramafic

Tremolite-chlorite-serpentine
Actinolite-chlorite-serpentine
Tremolite-biotite-epidote-chlorite
Blue-green hornblende-biotite-epidote-chlorite
Pale green amphibole-biotite-epidote-chlorite
Altered (carbonated) ultramafic: Fe-dolomite-tremolite-chlorite-biotite-talc (-quartz)

The chlorite and epidote in most of the assemblages are generally the products of a later, lower grade metamorphism and not the main metamorphism. The latter is considered to have been effected in a single event, no evidence to the contrary having been discovered, but it is recognized that this may be an oversimplification. Metamorphic zonal nomenclature follows that of Winkler (1976).

Metamorphic grade of the Prince Albert Group ranges from that of the biotite and muscovite zone (Winkler's low grade) to that of the (cordierite-almandine) medium-grade zone. The prevalence of andalusite and absence of kyanite constrain the fluid pressure to values below 4×10^5 kPa, if the aluminosilicate phase diagram of Holdaway (1971) is used. Metamorphism, then, took place at depths of less than 13 km. Occasional sillimanite in minor amounts suggests that maximum temperatures of around 600°C were approached; the lack of migmatites and other evidence of a granitic melt phase in Prince Albert metapelites indicates temperatures well below 700°C (Fig. 60). The presence of Ca-rich pyroxene (salite) in iron formation is further evidence that metamorphism reached a relatively high grade, according to Klein (1978), who found that pyroxene does not appear in Proterozoic iron formations of the Labrador Trough until well into the amphibolite facies.

It is not known if these metamorphic conditions prevailed over the entire Archean map area. Andalusite, cordierite and staurolite were not found in the Prince Albert belts that cross Matheson River in the southern part of the area but richly garnetiferous schists with abundant reddish brown biotite and oligoclase are common there, which suggests amphibolite-grade metamorphism. South of Committee Bay diagnostic assemblages are rarer still but the common abundance of blue-green hornblende may be cited as evidence for medium-grade or amphibolite-grade metamorphism.

Finally, with regard to the Archean terrane, it is important to note that no direct relationship between grade of metamorphism and proximity to intrusive granite is evident. In other words, no obvious contact metamorphism exists. The conclusion follows that supracrustal and granitic rocks were at a similar temperature at the time of metamorphism, with a consequent implication that granitic intrusion and metamorphism were contemporaneous processes.

The Folster Lake Formation was metamorphosed at much lower grade than were the Archean rocks on which it rests. The common assemblages, quartz-albite-muscovite-biotite-epidote (-chlorite) in pelitic rocks and quartz-calcite-talc-tremolite in calcareous rocks, attest to low-grade or greenschist-facies metamorphism of the lower part of the Folster Lake Formation. The experimentally determined equilibrium curve for the reaction

$$\text{talc} + \text{calcite} + \text{quartz} = \text{tremolite} + CO_2 + H_2O$$

lies a little over 500°C over a wide range of CO_2/H_2O ratios (Winkler, 1976, Fig. 9-2). In

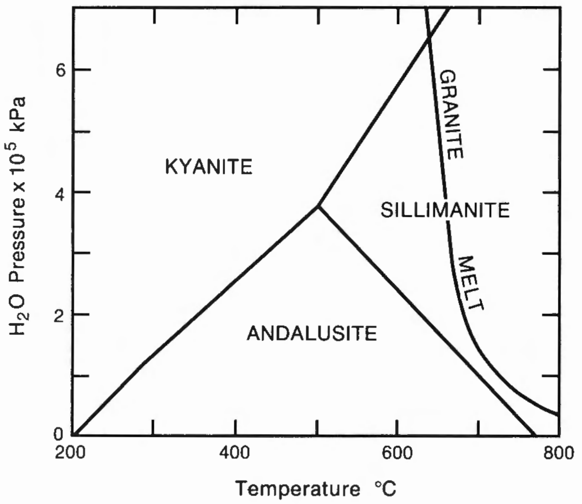


Figure 60. Aluminosilicate stability diagram and melting curve of granite (after Holdaway, 1971, Fig. 7).

the laboratory slight increase in temperature results in the formation of diopside followed by forsterite. As neither of these minerals is present in the Folster Lake Formation, temperature of metamorphism at the base was unlikely to have been much in excess of 500°C. Pressure is more difficult to estimate, since the thickness of the sedimentary pile is unknown, but as nearly a kilometre of rock is preserved, the pressure at the base was at least 3×10^4 kPa (see Turner, 1968, p. 59). It seems probable, however, that load pressure did not exceed 1 or 2×10^5 kPa.

Throughout the petrographic descriptions in this report, reference has been made to secondary, low-grade metamorphic features such as epidotization and sericitization of plagioclase, growth of late chlorite and alteration of mafic minerals. In many instances, these can be attributed to deformation, particularly cataclasis, and hence are clearly indicative of retrograde metamorphism. The remaining examples cannot readily be related to any particular process or event. Retrograde metamorphism on a regional scale is to be expected during uplift and cooling of a plutonic terrane following metamorphism. The numerous ^{40}K-^{40}Ar mineral ages of 1600 to 1700 Ma in this part of the Canadian Shield could well reflect this regional cooling event. Alternatively, the low-grade metamorphism could be related to the greenschist-grade event that affected the Folster Lake Formation.

These considerations lead naturally to the question of the timing of metamorphism in the map area. We have no direct evidence for deciding whether the main amphibolite-grade metamorphism occurred in Archean or Aphebian time. The regional K-Ar age pattern sets a limit of around 1600 Ma as a minimum age of metamorphism but this fact is hardly helpful. Jackson and Taylor (1972) assigned an Aphebian (Hudsonian) age to the main metamorphism and deformation but this contention rests partly on their belief that the majority of the rocks in the Committee Fold Belt are Aphebian. The author favours an Archean age for the main metamorphism because of the preponderance of Archean and minimum early Aphebian U-Pb and Rb-Sr ages obtained (since publication of Jackson and Taylor's paper) on a variety of plutonic, granitic and supracrustal rocks.

The metamorphic grade and style of the Prince Albert Group show similarities to those of the Archean greenstone belts of Western Australia and the Rhodesian craton in Zimbabwe. In the Eastern Goldfields Province, andalusite is the characteristic aluminosilicate, indicating generally low-pressure metamorphism; even in areas of intense deformation, pressures probably did not exceed 5×10^5 kPa (Archibald et al., 1978). Saggerson and Turner (1976) emphasized that low-pressure mineral assemblages are diagnostic of the Zimbabwe greenstone terrane, where andalusite and cordierite are common.

Archibald et al. (1978) related the metamorphism in the Eastern Goldfields Province directly to one thermal event that initiated both greenstone volcanism and granite plutonism, and he believed that the entire granite-greenstone terrane was born, deformed, metamorphosed and stabilized within a relatively short period of about 150 Ma. The limited isotopic data from the Prince Albert terrane are in agreement with this thesis.

DEFORMATION

A northeast regional trend predominates throughout Melville Peninsula and continues both north and south. The several parallel belts of Prince Albert Group running from southwest of Committee Bay to eastern Melville Peninsula illustrate this major trend.

Although broadly linear, the Prince Albert belts in detail have irregular, locally arcuate borders, where they are intruded by granitic bodies in the style so characteristic of Archean greenstone-granite terranes.

Dips of foliation, bedding and gneissic layering are generally steep (greater than 45° and commonly nearly vertical) in the basement throughout the map area. Gneissic trends and the northeasterly regional trend are remarkably parallel on a broad scale, and macroscopic fold or dome structures and related contortions are rarely apparent in the granitic terrane (in contrast to the Penrhyn Group of southeastern Melville Peninsula).

Folding

Two phases of folding are evident in Prince Albert Group rocks and granitic gneisses. The second phase is dominant.

Evidence for an earlier period of folding is provided by moderately tight mesoscopic folds (F_1), commonly accompanied by a penetrative axial planar schistosity (S_1),which trend northwest and plunge steeply north and south. S_1 is locally parallel to the plane of flattening of clasts in metaconglomerates and of pillows at one locality in metabasalts. In granitic gneisses, an early foliation, commonly parallel to lithological layering (bedding?), is discernible beneath the overprint of an axial planar foliation in the noses of many folds. Early structures in the gneisses, however, are not as consistently oriented as in the Prince Albert rocks.

Second-phase folds (F_2) dominate the map pattern and are clearly the manifestation of the main phase of deformation. They trend northeast, are tight to isoclinal and plunge moderately to steeply south and north; axial planes are nearly vertical. These folds were seen at all scales from microscopic to macroscopic. A penetrative foliation (S_2), parallel to the axial planes of F_2 folds, is a major structural feature throughout the map area. It is in the hinges of major F_2 folds that examples of overprinting of S_2 on S_1 may be seen to advantage in many places. Locally in the metavolcanics, planes of flattening of pillows are folded about S_2. However, it must be emphasized that, because of the severity of the main deformation, S_1 has commonly been transposed into coincidence with S_2.

The lack of facing indicators makes the complete characterization of the structures difficult. Representative examples of major folds are provided by the Prince Albert Group in the area of 'Triangle Lake' south of Adamson River, and the folded metadyke shown in Figure 34. At 'Triangle Lake', a south-plunging antiform, whose nose as defined by iron formation is covered by a lake, is associated with a south-plunging synform farther east. Granitic rocks are folded with the supracrustals.

Fold structures have also been created by the intrusion of granitic bodies into the Prince Albert Group. The large granitic mass (unit Agn) flanked by narrow belts of Prince Albert Group in the northern part of the map area is a doubly plunging body of diapiric aspect, with internal structures concordant with structures in the surrounding Prince Albert rocks.

To what extent the rise of granitic bodies (or sinking of the mafic supracrustals) influenced the structural development of the Prince Albert belts is unknown. Because the dips are isoclinal and facing indicators are absent, the Prince Albert belts cannot be recognized as synclinal keels created by the compression due to granitic intrusion---a common concept in Archean greenstone belt theory (Windley, 1977).

The superposition or interplay of these three fold phases or effects has given rise to very complex interference patterns. It seems unlikely that the orientation of the first folds signifies an original northwest trend of the Prince Albert belt, that is, at right angles to the present northeast trend, and that the latter (a major feature of the northern Churchill Province) is merely the result of wholesale transposition due to large-scale fold interference (see Hobbs et al., 1976, p. 252 ff.). There being no evidence that the two deformations were separated by a major interval of time, F_1 and F_2 folds may have developed essentially contemporaneously in one major period of folding. Certainly the consistency in trend of each set of folds militates against any interpretation that either was produced by compressive forces exercised by intruding granitic bodies.

It is also apparent that the bulk of the intrusive granitic material must have been emplaced prior to, or coevally with, the main deformation, as most of the granitic terrane clearly shows the effects of this deformation.

After (probably long after) the main deformation of the granite-greenstone terrane, gentle folding occurred in the Folster Lake area, where the Folster Lake Formation is weakly deformed. The structural style of the Folster Lake Formation is simple. In the outcrops around the lake the rocks dip generally westward, away from the basement, and flatten in the same direction (commonly from about 40° to about zero). Folding about northeast-trending axes of the rocks immediately east of the lake resulted in minor swells but a well developed southerly plunging, open syncline, bordered on both sides by basement, occurs to the northeast. Farther northeast, the axis of this syncline appears to swing eastward, suggesting that compressive forces were directed north-south as well as northwest-southeast.

Faulting

The major faults in the map area are transverse structures trending west-northwest, marked by major valleys in which streams flow westward to Committee Bay. Two chief examples are the valleys of Adamson and Kammaneluk rivers in the northern part of the map area.

Movement in the Adamson valley was left-lateral, as shown by displacement of Prince Albert strata. South of 'Triangle Lake', two faults parallel to Adamson River, one left-lateral, the other right-lateral, cut the Prince Albert Group; strike-slip movement of up to 500 m is indicated.

Extensive shearing and cataclasis mark the Kammaneluk River valley as a fault zone, but no significant offset of the basement - Folster Lake contact is apparent. Faults or fault zones of this type are common in the map area.

The major transverse faults are probably long-lived structures that were initiated in Archean time or, at least, prior to deposition of the Folster Lake Formation. Evidence for this is: (i) the lack of offset of Folster Lake strata along the Kammaneluk River fault and (ii) parallelism of foliation and fault trend in the immediate vicinity of the northwest-trending fault that heads towards Erlandson Bay.

Diabase dykes commonly trend northwest, paralleling many of the transverse faults, and were even intruded into the Erlandson Bay fault zone. The distribution of the dykes is further evidence that these northwesterly trending structures are fundamental zones of weakness.

The northern part of the map area shows evidence of late block-faulting. Outcrops of Folster Lake Formation are preserved between basement horsts north of Folster Lake; Wales Island, with its Paleozoic cover, appears also to belong to a downdropped block.

Timing

As with the metamorphism, evidence for the timing of the main deformation is no better than circumstantial. The close causal relationship between greenstone belt deformation and granitic intrusion implies that since the rocks are Archean this particular deformation is also Archean. The northeasterly regional trends, however, may be a later imprint. The author prefers to consider the main deformation to be Archean but admits that this belief is no more than intuitive.

ECONOMIC GEOLOGY

Operation Wager, the Geological Survey of Canada's reconnaissance mapping project in 1964 (Heywood, 1967), revealed a promising economic potential for Melville Peninsula. Spurred by the discovery of major deposits of iron formation and numerous gossans, Borealis Exploration Ltd. began exploratory work in 1968 and conducted significant mapping, prospecting and sampling in 1969 and 1970.

Borealis concentrated its efforts on evaluating the iron deposits and results have been reported by Wilson and Underhill (1971); supplementary details are given by Laporte (1974). Wilson and Underhill stated that the deposits in the map area grade from 32 to 38 per cent soluble iron and 29 to 37 per cent magnetic iron and that magnetite concentrate with 68 to 70 per cent soluble iron can be produced at a grind of about 85 to 90 per cent minus 325 mesh. The concentrate was found to be essentially free of undesirable elements.

Wilson and Underhill (ibid.) divided the main iron formation south of Adamson River into three deposits, using the two major transverse faults as dividers. The two northern deposits were estimated to hold 1.22×10^9t of magnetite iron ore. The southern deposit includes considerable hematite associated with magnetite and is excluded from the ore reserve estimates.

Of the two deposits north of Adamson River, the southern was estimated to contain 549×10^6t, and the northern, 1.38×10^9t of magnetite iron ore.

Wilson and Underhill considered all the deposits to be amenable to open-pit mining and tentatively proposed a rail link with a planned shipping facility at Roche Bay on the east coast of Melville Peninsula.

Borealis also examined for base metals and silver nearly 50 sulphide occurrences in the present map area, most of them gossan zones in metavolcanics of the Prince Albert Group. The most common sulphide minerals are pyrite, pyrrhotite and chalcopyrite; bornite is uncommon and galena rare. Highest copper value determined was 0.42 per cent but Cu, as well as Pb, Zn and Ni values are generally much lower. No significant concentrations of gold and silver were found.

In the course of the field work that forms the basis of this report, gossans were encountered, many of which had been examined previously by geologists of Operation Wager and, especially, Borealis Exploration. Most of the gossans are associated with metavolcanics and iron formation of the Prince Albert Group. The actual rock type of the larger gossans is difficult to identify because of intense alteration and weathering. Indeed, some of the gossans are no more than areas of loose rusty soil.

The majority of the gossans appear to be pyritic, quartz-rich zones in schistose biotite-chlorite rocks of mafic to felsic composition. Adjacent rocks are commonly iron formation or quartz-rich pelitic schist. The largest gossan seen covers an area approximately 500 m by 10 m but widths can reach 60 m where several thin rusty beds lie closely spaced in parallel. More typical gossans have strike lengths of 100 m or less and widths of 10 m or less. The chief metallic mineral is pyrite; pyrrhotite, although common, is much less abundant. Chalcopyrite and, rarely, bornite and malachite are subordinate constituents.

No rusty sulphidic zones were seen in the granitic terrane outside the greenstone belts except in close association with mafic (generally amphibolitic) inclusions. None of these were of significant size and none appeared to be of economic interest.

In 1977, the Geological Survey of Canada conducted lake-sediment and lake-water geochemical and airborne radiometric reconnaissance surveys over most of southern Melville Peninsula, including the northern part of the map area. The geochemical data were released in 1978 and the radiometric data in 1979, in the form of maps showing simplified geology and the distribution of values for Zn, As, F, Ni, U, Mn, Hg, Cu, Pb, Co, Mo and Fe (Geological Survey of Canada, 1978) and U, Th, K and total counts (Geological Survey of Canada, 1979a, b).

The surficial environment of the southern half of Melville Peninsula appears, on average, to be considerably richer in uranium than most other areas of the Canadian Shield that have been similarly surveyed so far.

Maurice (1979) followed up some of this work in 1978 by investigating an area of anomalously high uranium north and south of Folster Lake, where the Folster Lake Formation - Archean basement unconformity is exposed. He found that the granitic rocks are significantly enriched in uranium and that concentrations increase towards the unconformity. The preliminary, somewhat limited results suggest enrichment of uranium along fractures in the basement, due perhaps to remobilization of uranium. The Folster Lake strata have low radioactivity except in the basal rocks; high readings recorded in the latter may be related, in part, to the presence of allanite. Maurice concluded that the unconformity with its underlying metamorphosed regolith presents an attractive target for uranium exploration.

Despite the failure to discover economic or significant ore bodies other than iron formation in the map area, there can be little doubt that the economic potential is good. This optimism is based on two lines of evidence: the numerous gossans in the Prince Albert belts and the marked similarities between these and other greenstone belts of proven economic value.

The Eastern Goldfields Province, which has figured prominently in comparisons with the Prince Albert belts throughout this report, is the major producer of gold, silver and nickel in Western Australia (Williams, 1975) and one of the most important mining districts in the world. Gold, with silver as an important byproduct, is found in a variety of rocks in the greenstone belts but tends to be concentrated in felsic and mafic volcanics and related sediments. Rich nickel deposits are associated with peridotitic zones of ultramafic flows (komatiites), which are accompanied by magnesian and tholeiitic metabasalts and volcanogenic sediments. Most workers are agreed that these are magmatic deposits of sulphides separated from the ultrabasic melts. Metamorphism of amphibolite-facies grade, characteristic of these deposits, has remobilized and perhaps even upgraded the sulphides (Groves et al., 1979). Nickel sulphide deposits related to ultramafic volcanism have recently been discovered in the Archean of Zimbabwe (Williams, 1979). Eckstrand (1975) considered the nickel potential of the Prince Albert Group to be significant.

Field relations in greenstone belts of many parts of the world suggest mafic and ultramafic rocks as source rocks for gold and a certain amount of analytical data supports this idea. Particular mention may be made of results from Archean ultramafic lavas, which indicate Au concentrations far in excess of those in modern mafic lavas (Anhaeusser, 1976). Talc-carbonate alteration of ultramafic rock, such as occurred in the Prince Albert Group, has been proposed as an important mechanism for leaching gold and releasing silica for transporting and hosting the gold (Pyke, 1975). Recent neutron activation analyses, however, show very low Au values in South African ultramafic lavas and cast doubt on the quality of data obtained with less accurate techniques (Anhaeusser, 1976). Nevertheless, Anhaeusser felt that without more data the concept that Archean volcanics are exceptionally rich in gold cannot yet be dismissed.

The spatial association of gold with oxide-facies iron formation has long been known (ibid.). The presence of abundant magnetite-quartz iron formation in the Prince Albert Group thus takes on added significance.

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APPENDIX

Key
Abbreviations used in Appendix

mesonormative mineral		modal mineral	
Q	Quartz	Pg	Plagioclase
C	Corundum	Kf	Potassium feldspar
MGBI	Phlogopite	Qu	Quartz
FEBI	Annite	Bi	Biotite
OR	Orthoclase	Mu	Muscovite
AB	Albite	Ch	Chlorite
AN	Anorthite	Hb	Hornblende
WO	Wollastonite	Ep	Epidote
EN	Enstatite	Sp	Sphene
FS	Ferrosilite	Ox	Fe-Ti oxide
MGACT	Tremolite	Ap	Apatite
FEACT	Ferro-actinolite	Cc	Calcite
MT	Magnetite		
HM	Hematite		
TN	Sphene		
AP	Apatite		
CC	Calcite		

Table 1. Chemical and modal analyses, unit Ato

Sample Number	FS-73-120	FS-73-121	FS-73-122	FS-73-125	FS-73-126	FS-73-127	FS-73-128	FS-73-19	FS-73-21	FS-73-23	FS-73-15	FS-73-24	FS-73-28	FS-73-32	FS-G-38-4
SiO_2	70.86	75.72	61.43	67.30	75.28	72.59	73.05	76.87	69.70	70.90	68.5	75.2	66.9	73.1	78.0
TiO_2	0.34	0.06	0.87	0.50	0.20	0.29	0.30	0.07	0.39	0.35	0.50	0.14	0.41	0.28	0.29
Al_2O_3	14.12	13.97	18.27	15.53	12.58	13.80	14.48	13.19	14.90	14.39	15.9	13.6	15.8	14.4	11.3
Fe_2O_3	0.00	0.00	0.37	0.68	0.46	0.00	0.29	0.00	0.22	0.00	1.4	0.8	1.0	0.5	0.4
FeO	3.00	1.30	4.60	3.50	1.70	3.00	2.20	1.20	2.40	3.10	1.8	0.9	3.2	1.8	1.6
MnO	0.07	0.03	0.07	0.06	0.04	0.05	0.03	0.04	0.04	0.05	0.05	0.04	0.07	0.04	0.04
MgO	0.83	0.39	1.84	1.27	0.39	0.86	1.13	0.40	1.23	0.78	1.19	0.60	1.13	0.96	0.79
CaO	3.04	1.31	2.69	2.68	2.42	2.93	0.45	1.23	3.30	3.01	3.64	2.21	3.97	3.38	1.00
Na_2O	4.13	3.88	3.19	3.18	4.70	4.00	3.21	4.06	5.00	4.90	4.1	4.2	4.1	3.8	2.3
K_2O	1.93	2.17	4.01	3.33	0.76	1.57	3.22	2.31	1.20	1.10	0.69	1.38	1.44	1.21	4.30
P_2O_5	0.14	0.06	0.41	0.18	0.04	0.12	0.14	0.06	0.17	0.14	0.16	0.07	0.16	0.11	0.08
CO_2	0.39	0.10	0.05	0.18	0.24	0.29	0.04	0.08	0.03	0.19	0.0	0.0	0.0	0.1	0.0
H_2O	0.90	0.80	1.30	1.20	0.30	0.60	1.20	0.70	0.60	0.40	0.8	0.6	0.8	0.7	0.5
Total	99.75	99.79	99.10	99.59	99.11	100.10	99.74	100.21	99.18	99.31	98.7	99.7	99.0	100.4	100.6
Rb	65	45	112	82	22	40	68	76	30	28	21	26	63	42	78
Sr	130	67	89	120	170	140	29	30	230	220	290	230	230	180	50
Ba	440	580	630	650	250	320	800	190	350	320	490	330	460	300	800
Zr	190	63	540	170	180	170	180	60	190	200	170	100	220	120	180
Cu	45	31	35	27	52	49	71	26	17	40	<10	<10	33	14	< 10
Zn	49	0	48	73	32	42	22	0	46	46	31	73	74	59	18
Pb	4	6	3	4	5	5	1	3	3	4	6	6	7	6	10
K/Rb	246	400	297	336	286	325	393	253	333	325	271	438	190	238	458
Rb/Sr	0.50	0.67	1.26	0.68	0.13	0.28	2.34	2.53	0.13	0.13	0.07	0.11	0.27	0.23	1.56
Sr/Ba	0.30	0.12	0.14	0.18	0.68	0.44	0.04	0.16	0.66	0.69	0.55	0.70	0.50	0.60	0.06
Na_2O/K_2O	2.1	1.8	0.8	1.0	6.2	2.5	1.0	1.8	4.2	4.4	5.9	3.0	2.8	3.1	0.5

Mesonorm															
Q	32.74	40.21	22.62	30.22	38.60	36.14	39.83	39.26	27.96	30.83	33.33	38.78	28.37	37.56	44.10
C	1.54	3.68	6.74	3.71	0.59	1.69	6.40	2.37	0.43	0.96	3.16	1.70	1.33	1.71	1.80
MGBI	3.11	1.46	6.97	4.81	1.47	3.22	4.27	1.42	4.55	2.80	4.27	2.25	4.27	3.59	2.98
FEBI	6.47	2.80	9.58	6.92	3.24	6.40	4.46	2.61	4.88	6.60	2.46	1.22	5.99	3.39	3.09
OR	5.64	10.41	14.04	12.91	1.65	3.41	14.10	11.49	1.41	0.72		6.14	2.33	2.90	22.23
AB	37.81	35.55	29.48	29.38	43.13	36.50	29.63	37.38	45.41	44.99	37.96	38.44	37.83	34.65	21.16
AN	10.72	5.37	7.53	9.51	9.74	11.08	0.02	5.00	13.94	11.66	15.74	10.21	17.69	14.66	3.51
EN											0.19				
FS											0.11				
MT			0.40	0.73	0.49		0.31		0.25		1.51	0.85	1.07	0.53	0.43
TN	0.62	0.11	1.61	0.93	0.37	0.53	0.56	0.13	0.71	0.64	0.93	0.26	0.76	0.51	0.54
AP	0.31	0.13	0.90	0.40	0.09	0.26	0.31	0.13	0.37	0.30	0.35	0.15	0.35	0.24	0.18
CC	1.05	0.27	0.14	0.49	0.65	0.78	0.11	0.21	0.08	0.51				0.27	
Mode															
Pg	61	44	62	51	67	59	61	37	58	62	69	61	66	70	45
Kf															6
Qu	35	47	28	44	30	38	36	34	24	32	25	30	22	20	28
Pg+Kf+Qu[a]		5						13	8						
Bi	3	tr	9	4	tr	2	1		6	3	3	6	8	6	8
Mu	tr	3			tr		tr	15	1			tr		1	9
Ch		tr	tr	tr	2	tr	1		1	2	1	tr		tr	
Hb											tr				
Ep				tr					2		1	1	3	2	3
Sp								tr			tr	tr	tr	tr	tr
Ox	tr	tr	tr					tr	tr	tr		tr	tr		tr
Cc	tr	tr		tr											

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[a] Fine-grained crush

Table 2. Chemical and modal analyses, units Agn and Aagn

	Agn											
	Low K, Rb											
Sample Number	FS-G-29-2	FS-G-28-2	FS-G-24-4	FS-G-23-2	FS-G-28-8	FS-G-17-9A	FS-G-15-3A	FS-73-115	FS-74-46	FS-G-30-5	FS-G-31-5	FS-G-31-3
SiO_2	69.6	77.0	65.3	72.6	71.1	71.5	74.5	72.4	71.8	65.50	70.9	70.2
TiO_2	0.32	0.10	0.58	0.42	0.38	0.37	0.20	0.20	0.16	0.35	0.41	0.50
Al_2O_3	15.4	13.5	15.6	12.9	15.5	14.1	14.9	15.3	15.6	17.50	15.2	13.8
Fe_2O_3	0.9	0.4	1.0	0.8	1.0	0.3	0.3	0.4	0.5	0.6	0.0	0.6
FeO	1.6	1.0	4.5	3.0	1.6	2.7	1.1	0.9	0.7	1.8	2.3	2.5
MnO	0.04	0.04	0.12	0.06	0.06	0.06	0.03	0.03	0.03	0.04	0.04	0.05
MgO	1.05	0.34	2.49	1.41	0.96	1.30	0.59	0.62	0.68	1.56	1.00	1.00
CaO	3.35	1.49	5.30	3.51	3.18	3.45	2.68	2.75	0.91	1.66	1.58	1.71
Na_2O	4.3	4.7	3.6	2.9	4.4	3.6	4.3	5.3	6.1	7.7	3.3	3.0
K_2O	1.60	1.61	1.25	1.16	1.80	1.39	1.82	1.33	1.77	1.74	4.39	4.79
P_2O_5	0.12	0.07	0.17	0.11	0.10	0.12	0.07	0.09	0.06	0.12	0.12	0.17
CO_2	0.0	0.10	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1
H_2O	0.8	0.4	0.7	0.7	0.7	0.7	0.4	0.3	0.6	0.5	0.5	0.7
Total	99.1	100.8	100.6	99.6	100.9	99.6	100.9	99.6	99.0	99.2	99.8	99.1
Rb	63	39	47	40	64	47	48	44	26	81	150	130
Sr	460	110	260	240	390	250	310	550	190	340	270	220
Ba	260	310	450	450	320	320	850	350	360	790	1000	1400
Zr	110	10	110	110	30	100	50	100	20	140	220	260
Cu	14	<10	24	19	<10	< 10	23	< 10	<10	<10	< 10	11
Zn	42	57	55	49	37	54	12	31	<10	35	46	47
Pb	7	54	4	6	10	6	17	10	12	11	26	26
K/Rb	211	344	221	240	233	245	314	250	565	178	243	306
Rb/Sr	0.14	0.35	0.18	0.17	0.16	0.19	0.15	0.08	0.14	0.24	0.56	0.59
Sr/Ba	1.77	0.35	0.58	0.53	1.22	0.78	0.36	1.57	0.53	0.43	0.27	0.16
Na_2O/K_2O	2.68	2.92	2.88	2.50	2.44	2.59	2.36	3.98	3.45	4.42	0.75	0.63
Mesonorm												
Q	30.19	37.98	25.10	42.62	30.36	36.54	34.46	28.84	26.20	10.37	30.50	30.43
C	1.34	2.02		1.46	1.63	1.30	1.54	0.67	2.82	0.96	3.53	2.08
MGBI	3.95	1.26	6.16	5.37	3.54	4.90	2.17	2.29	2.51	5.65	3.73	3.79
FEBI	2.61	1.78	5.79	5.78	2.51	5.56	2.06	1.56	1.05	3.19	4.91	4.85
OR	5.56	7.64		0.13	6.89	1.88	8.12	5.48	8.27	4.59	20.92	23.74
AB	39.48	42.34	32.72	26.98	39.65	33.14	38.67	47.78	55.00	68.00	30.07	27.74
AN	15.05	5.97	22.98	15.77	13.21	15.42	12.16	12.40	2.94	5.51	5.07	5.15
WO												
EN			2.10									
FS			1.98									
MGACT			0.35									
FEACT			0.33									
MT	0.96	0.42	1.06	0.87	1.05	0.32	0.31	0.42	0.52	0.62		0.65
TN	0.59	0.18	1.06	0.78	0.69	0.68	0.36	0.36	0.29	0.62	0.75	0.93
AP	0.26	0.15	0.37	0.24	0.21	0.26	0.15	0.19	0.13	0.25	0.26	0.37
CC		0.26			0.26				0.26	0.26	0.27	0.27
Mode												
Pg	83	72	52	49	81	47	51	68	48	64	60	51
Kf	tr	2		tr	tr	2	19	tr	18	tr	14	23
Qu	9	23	34	37	11	37	24	26	21	31	21	18
Bi	4	2	4	7	4	6	4	3	8	4	4	7
Mu	1	tr		tr	1	1		1				
Hb			8									
Ch	tr	tr		2	tr	3			3		tr	tr
Ep	1	tr	1	3	tr	2	1	tr	1			
Sp	tr		tr	tr		tr						
Ox	1	tr		tr	1	tr			tr			
Ap										tr	tr	
Cc												

											Aagn	
High K, Rb												
FS-G-32-1	FS-G-32-2	FS-74-65	FS-G-33-1	FS-G-21-3	FS-G-29-1B	FS-G-9-5	FS-72-33	FS-G-16-2	FS-73-113	FS-73-144	FS-72-22	FS-72-27
71.1	62.6	65.6	72.8	66.0	67.7	73.7	73.4	75.4	73.6	73.9	62.68	70.4
0.45	1.13	0.55	0.19	0.39	0.51	0.16	0.31	0.16	0.15	0.32	0.72	0.46
12.8	14.5	16.8	13.1	15.8	14.8	14.1	12.7	14.0	13.7	12.5	15.58	14.7
1.5	2.0	0.9	0.4	1.4	1.2	0.6	0.7	0.1	0.6	1.7	0.92	1.3
1.9	4.9	2.3	1.5	2.2	2.3	1.2	1.8	1.3	0.8	1.2	4.10	1.3
0.05	0.09	0.05	0.05	0.07	0.06	0.06	0.06	0.04	0.03	0.03	0.10	0.04
1.03	1.96	1.51	0.83	1.54	1.27	0.71	1.01	0.38	1.04	0.55	2.44	1.96
1.66	3.20	0.95	0.82	2.17	2.65	1.09	1.55	1.64	0.73	0.73	3.71	0.84
3.2	2.7	2.7	4.0	3.4	2.5	2.7	2.9	3.7	3.4	3.0	3.95	3.0
4.72	4.49	7.45	3.97	4.89	4.37	5.55	3.86	3.46	3.95	4.36	4.24	5.17
0.21	0.53	0.25	0.09	0.21	0.18	0.07	0.13	0.08	0.08	0.05	0.44	0.23
0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.4	0.0	0.0	0.1		
0.7	0.8	1.0	0.8	1.0	0.8	0.5	1.2	0.6	0.9	0.7	0.7	1.2
99.3	98.9	100.1	98.8	99.2	98.3	100.4	100.0	100.9	99.0	99.1	99.6	100.6
190	180	300	160	200	97	180	170	160	200	120	174	160
220	340	200	140	390	460	300	290	210	140	72	600	340
870	1100	1100	620	1400	1800	1100	1200	640	820	1700	2860	1100
310	420	430	110	140	180	20	110	30	130	160	200	190
15	38	18	< 10	32	< 10	40	14	<10	14	< 10	27	14
59	69	38	33	44	41	38	55	37	29	15	84	45
35	18	36	11	9	11	55	12	16	19	9	26	31
206	207	206	206	203	374	256	188	179	164	302	202	268
0.86	0.53	1.50	1.14	0.51	0.21	0.60	0.58	0.76	1.43	1.67	0.29	0.47
0.25	0.31	0.18	0.22	0.28	0.26	0.27	0.33	0.17	1.57	0.04	0.21	0.31
0.68	0.60	0.36	1.01	0.69	0.57	0.49	0.75	1.07	0.86	0.69	0.93	0.58
30.33	24.32	19.22	32.08	22.77	30.57	32.63	38.23	34.98	35.71	37.28	16.40	30.40
0.55	2.38	4.28	2.11	2.46	2.53	2.26	2.88	1.74	3.24	2.57		4.18
3.90	7.51	5.63	3.13	5.80	4.87	2.65	3.82	1.41	3.93	2.10	9.09	7.31
2.71	8.80	4.07	2.90	3.47	3.92	2.07	3.28	2.70	1.19	1.00	7.92	1.58
24.57	17.43	38.54	20.26	23.76	21.42	30.28	19.00	18.03	20.79	24.74	14.73	25.41
29.58	25.25	24.57	36.79	31.23	23.40	24.58	26.77	33.47	31.39	27.89	35.91	27.32
5.45	8.83	1.18	0.94	7.57	10.62	4.45	3.32	7.11	2.65	1.60	12.41	1.08
											0.31	
1.61	2.18	0.95	0.43	1.50	1.31	0.64	0.75	0.11	0.64	1.84	0.97	1.38
0.83	2.12	1.00	0.35	0.72	0.96	0.29	0.57	0.29	0.28	0.60	1.31	0.84
0.46	1.18	0.54	0.20	0.46	0.40	0.15	0.29	0.17	0.18	0.11	0.95	0.50
			0.81	0.27			1.08			0.27		
6	26	53	29	45	52	37	31	50	43	47	27	38
70	21	32	40	24	23	26	26	14	17	17	20	35
19	25	10	24	23	19	29	25	29	32	34	25	16
3	12	2		5	4	2		4	tr	tr	15	
			2	1		3		2	3	tr		
	9										11	
tr	4	2	3			tr	12		5		tr	10
tr	2		tr	1	tr	2	4	tr				
tr			tr		tr		2				1	
1	1	1	tr	tr	tr					tr		tr
			tr	tr								
										tr		

Table 3. Chemical and modal analyses, unit Ag

Sample Number	FS-G-29-4	FS-G-5-4	FS-G-17-8	FS-G-18-4A	FS-G-18-4B	FS-G-11-3	FS-72-35	FS-72-34	FS-72-31	FS-72-32	FS-72-23
SiO_2	74.3	75.6	70.0	76.4	76.7	74.5	79.7	75.9	75.56	70.17	72.30
TiO_2	0.24	0.13	0.46	0.09	0.00	0.20	0.01	0.22	0.07	0.24	0.18
Al_2O_3	13.4	12.8	14.2	12.8	13.9	14.0	11.5	12.8	13.32	15.58	14.24
Fe_2O_3	0.8	0.8	1.3	0.7	0.0	1.0	0.0	1.2	0.40	0.86	0.62
FeO	1.1	0.4	1.9	0.4	0.5	0.7	0.6	0.6	0.40	1.30	1.00
MnO	0.04	0.03	0.06	0.05	0.01	0.04	0.02	0.06	0.05	0.05	0.04
MgO	0.67	0.45	1.22	0.56	0.14	0.63	0.17	0.75	0.14	0.74	0.61
CaO	1.58	0.85	2.58	0.65	0.53	1.76	0.35	1.42	0.48	2.68	1.08
Na_2O	3.0	2.6	2.7	2.7	3.5	3.3	3.0	2.7	4.14	3.79	3.02
K_2O	4.29	5.10	4.31	5.69	5.43	4.14	5.07	4.69	4.80	3.84	5.97
P_2O_5	0.08	0.07	0.16	0.05	0.05	0.08	0.04	0.09	0.03	0.10	0.08
CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12
H_2O	0.4	0.5	0.9	0.7	0.3	0.5	0.3	0.4	0.20	0.40	0.60
Total	99.9	99.3	99.8	100.8	101.1	100.8	100.8	100.8	99.6	99.8	99.9
Rb	180	340	150	340	130	110	340	160	277	71	242
Sr	310	120	420	96	46	490	27	340	29	430	150
Ba	910	680	1200	420	95	1100	41	1200	87	1200	860
Zr	70	80	80	40	0	20	50	90	100	170	210
Cu	<10	<10	15	<10	<10	< 10	14	14	< 5	0	<10
Zn	45	29	40	18	<10	40	<10	40	0	36	81
Pb	21	32	14	22	23	18	14	28	33	9	38
K/Rb	198	124	239	139	347	313	124	243	143	449	205
Rb/Sr	0.58	2.83	0.36	3.54	2.83	0.22	12.59	0.47	9.55	0.16	1.61
Sr/Ba	0.34	0.18	0.35	0.23	0.48	0.44	0.66	0.28	0.33	0.36	0.17
Na_2O/K_2O	0.70	0.51	0.63	0.47	0.64	0.80	0.59	0.58	0.86	0.99	0.50
Mesonorm											
Q	35.41	37.60	31.50	35.44	32.00	33.71	39.57	37.22	30.16	26.39	28.48
C	1.61	2.01	1.54	1.39	1.55	1.47	0.61	1.32	0.66	0.95	1.71
MGBI	2.52	1.70	4.61	2.09	0.51	2.34	0.63	2.80	0.52	2.75	2.28
FEBI	1.64	0.15	2.92	0.28	1.05	0.61	1.30	0.25	0.56	2.01	1.60
OR	23.26	29.85	21.46	32.59	31.07	22.83	29.09	26.18	27.97	19.97	33.40
AB	27.49	24.03	24.92	24.58	31.40	29.89	27.25	24.58	37.55	34.43	27.54
AN	6.61	3.40	10.43	2.62	2.30	7.57	1.46	5.77	1.96	11.94	3.50
MT	0.85	0.86	1.40	0.74		1.05		1.27	0.42	0.91	0.66
TN	0.44	0.24	0.85	0.16		0.36	0.02	0.40	0.13	0.44	0.33
AP	0.17	0.15	0.35	0.11	0.11	0.17	0.09	0.20	0.06	0.22	0.17
CC											0.32
Mode											
Pg	51	38	31	36	31	47	32	30	31	33	31
Kf	16	26	37	24	41	24	36	35	39	36	39
Qu	29	30	24	37	26	24	30	30	27	24	19
Bi	2	2	5	1	tr	2	1	3	tr	4	3
Mu	tr	1		tr	1	1			2		2
Ch	1	1		tr		tr					5
Ep	tr	1	2	tr		1	tr	1		2	
Sp	tr		1				tr	tr	tr	1	tr
Ox		tr		tr		tr		tr			

Table 4. Chemical and modal analyses, unit Agr

Sample Number	FS-73-2	FS-G-28-5	FS-G-28-1	FS-73-57	FS-74-6	FS-74-38	FS-74-39	FS-G-34-1	FS-G-30-7
SiO_2	75.3	74.4	76.0	75.8	73.3	71.3	68.4	73.5	76.3
TiO_2	0.56	0.21	0.06	0.00	0.19	0.34	0.51	0.20	0.15
Al_2O_3	11.9	13.2	13.7	13.7	13.4	13.5	15.6	13.9	12.1
Fe_2O_3	0.7	0.4	0.5	0.2	0.7	1.5	0.7	0.6	0.7
FeO	1.9	1.4	0.2	0.0	1.0	1.0	1.6	0.9	1.0
MnO	0.06	0.03	0.03	0.01	0.03	0.04	0.04	0.03	0.02
MgO	0.90	0.92	0.21	0.19	0.52	0.95	0.82	0.60	0.66
CaO	1.36	0.76	0.28	0.24	0.64	1.51	2.30	1.26	0.46
Na_2O	2.6	2.8	2.0	3.0	3.0	2.3	4.3	4.2	1.8
K_2O	4.70	5.36	7.56	6.59	5.45	5.58	3.94	4.43	6.22
P_2O_5	0.16	0.09	0.04	0.05	0.08	0.14	0.12	0.08	0.08
CO_2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1
H_2O	0.6	0.9	0.4	0.2	0.4	0.5	0.4	0.4	0.6
Total	100.7	100.5	101.0	100.0	98.7	98.8	98.8	100.3	100.2
Rb	160	190	270	190	290	160	140	180	160
Sr	160	240	150	45	130	520	310	210	220
Ba	680	970	860	420	700	1500	1200	510	1100
Zr	190	20	<10	70	130	80	170	110	150
Cu	14	18	<10	<10	<10	< 10	12	10	< 10
Zn	36	25	<10	<10	17	25	42	26	22
Pb	10	12	14	26	15	12	25	26	19
K/Rb	244	234	232	288	156	289	234	204	322
Rb/Sr	1.00	0.79	1.80	4.22	2.23	0.31	0.45	0.86	0.73
Sr/Ba	0.24	0.25	0.17	0.11	0.18	0.35	0.26	0.41	0.20
Na_2O/K_2O	0.55	0.52	0.26	0.45	0.55	0.41	1.09	0.95	0.29
Mesonorm									
Q	37.99	34.31	32.74	30.65	32.42	32.87	22.96	28.20	39.63
C	1.29	2.10	2.08	1.45	2.06	2.18	1.39	0.89	2.45
MGBI	3.38	3.45	0.78	0.71	1.97	3.62	3.07	2.21	2.49
FEBI	3.47	2.63	0.01		1.52	0.78	2.78	1.37	1.50
OR	24.07	28.43	44.60	38.87	30.96	31.39	20.00	24.01	35.24
AB	23.84	25.59	18.13	27.20	27.73	21.39	39.25	37.84	16.60
AN	3.83	2.49	0.93	0.87	2.05	4.93	8.35	3.78	0.62
MT	0.75	0.43	0.53	0.02	0.75	1.62	0.74	0.63	0.75
HM				0.12					
TN	1.03	0.39	0.11		0.35	0.63	0.93	0.36	0.28
AP	0.35	0.20	0.09	0.11	0.18	0.31	0.26	0.17	0.18
CC						0.27	0.27	0.53	0.27
Mode									
Pg	26	43	24	12	28	39	62	58	46
Kf	33	20	35	70	30	25	12	15	27
Qu	31	32	32	17	37	30	20	23	22
Bi	6		2		tr	2	2	2	tr
Mu		tr		tr	1	tr		tr	
Hb							2		
Ch		3	4		1	1		1	3
Ep	2	tr	2			1	1		
Sp	1	tr	tr		} 2		tr	tr	
Ox	tr	tr	tr			1	tr	tr	tr

Table 5. Chemical analyses, unit md

Sample Number (FS-)	73-11	73-22	73-123	73-67	74-93	72-21	1	2
SiO_2	52.3	49.2	48.3	47.6	48.5	49.14	49.61	50.3
TiO_2	0.62	0.87	0.97	0.71	1.16	0.76	1.43	2.2
Al_2O_3	16.2	15.1	15.3	13.9	13.8	14.16	16.01	14.3
Fe_2O_3	1.5	1.1	2.1	2.0	2.1	2.30		3.5
FeO	7.5	11.1	11.5	10.4	12.4	7.40	11.49[a]	9.3
MnO	0.16	0.21	0.25	0.22	0.24	0.19	0.18	
MgO	6.98	7.19	7.15	9.65	6.74	9.48	7.84	5.9
CaO	8.96	10.9	10.1	11.3	10.6	10.58	11.32	9.7
Na_2O	3.4	2.0	2.5	1.5	1.9	2.19	2.76	2.5
K_2O	0.90	0.44	0.39	0.67	0.41	1.33	0.22	0.8
P_2O_5	0.22	0.12	0.14	0.08	0.19	0.12	0.14	
CO_2	0.3	0.9	0.1	0.0	0.2	0.00		
H_2O	1.2	1.5	1.3	2.0	1.3	1.90		
Total	100.2	100.6	100.1	100.0	99.5	99.55		
Rb	29	8	7	18	6	61		
Sr	88	66	65	51	79	210		
Ba	160	52	24	72	54	200		
Zr	180	75	69	66	110	88		
Cu	120	190	210	110	240	0		
Pb	9	10	12	10	10	3		
Zn	60	64	84	79	79	80		
Ni	110	93	110	150	97	170		
Cr	93	180	230	260	78	400		
V	150	290	370	310	360	230		
K/Rb	259	450	457	311	567	180		
Rb/Sr	0.33	0.12	0.11	0.35	0.08	0.29		
Sr/Ba	0.55	1.27	2.71	0.71	1.46	1.05		
K/Ba	47	69	133	78	63	55		
Theta	34	38	35	38	37	34		

[a] All Fe as FeO

1. Average ocean floor basalt (Cann, 1971).
2. Average modern continental tholeiite basalt (Condie, 1976b, Table III).

Table 6. Reconnaissance microprobe analyses of amphibole and chlorite of metamorphosed ultramafic lava of the Prince Albert Group

Sample Number	FS-74-73		FS-74-76			FS-74-79	
Mineral[a]	Hb	Ch	Hb	Ch	Ch	Hb	Ch
SiO_2	55.0	27.3	47.0	30.1	28.2	53.5	27.4
TiO_2	< 0.1	nd	< 0.1	< 0.1	< 0.1	0.1	< 0.1
Al_2O_3	1.3 (0.1-1.5)	11.8	2.4	9.7	9.7	2.3	16.7
FeO[b]	3.3	6.6	8.6	17.4	16.9	8.6	11.6
MnO	0.1	nd	0.1	nd	nd	0.2	0.1
MgO	22.4	29.5	24.1	33.0	34.5	17.1	24.0
CaO	13.1		10.6			12.9	
Na_2O	< 0.1		< 0.1			< 0.1	
K_2O	nd		nd			0.1	
Niggli *mg*	0.92		0.83			0.78	
Fe/Fe+Mg		0.11		0.23	0.22		0.21

[a] Hb amphibole, Ch chlorite, [b] All Fe as FeO. nd – Not detected.

Table 7. Chemical analyses of ultramafic lavas, Prince Albert Group

Sample Number (FS-)	74-72	74-73	74-74	74-75	74-76	1	2	3	4
Analyst	GSC	GSC	FJ	FJ	GSC				
SiO_2	39.8	43.9	41.46	43.77	42.1	40.0	41.4	43.5	43.2
TiO_2	0.22	0.26	0.16	0.31	0.24	0.14	0.33	0.26	0.37
Al_2O_3	4.61	7.08	4.02	7.40	6.43	3.70	6.90	5.3	7.4
Fe_2O_3	4.1	4.2	9.55^a	8.85^a	4.4				
FeO	5.7	5.0			4.8				
FeOt	(9.4)	(8.8)	(8.59)	(7.96)	(8.8)	8.2	12.4	9.2	11.1
MnO	0.16	0.15	0.20	0.18	0.14	0.15	0.24	0.16	0.20
MgO	32.4	26.2	32.34	26.68	28.0	35.1	25.6	27.7	22.9
CaO	2.71	7.15	3.55	6.87	5.69	3.28	5.90	4.09	6.99
Na_2O	0.1	0.1	0.04	0.13	0.3	0.07	0.06	0.46	0.49
K_2O	0.14	0.14	0.01	0.02	0.15	0.10	0.07	0.2	0.1
P_2O_5	0.04	0.04	0.00	0.00	0.03			0.01	0.02
CO_2	0.5	0.0			0.0			0.11	0.26
H_2O	9.3	6.1	10.00^b	5.90^b	6.8			9.26	6.93
Total	99.8	100.3	101.33	100.11	99.1				
S	0.11	0.10			0.11		0.04	0.05	0.007
Rb	5	6	0.1	0.7	5	3	3		
Sr	< 10	< 10	2	13	< 10	6	3	20	50
Ba	8	< 5	19	19	< 5			5	5
Zr	45	32	9	14	50			30	20
Cu	150	50	17	4	90			20	20
Zn	60	40			60	54	101	70	60
Ni	1900	1200	1820	1200	1500	2290	1470	1390	870
Cr	2400	2700	2220	2700	2600	1762	3080	2680	3050
V	63	84			100				
Y			2	4					
CaO/Al_2O_3	0.59	1.01	0.88	0.93	0.88	0.89	0.86	0.77	0.94
CaO/TiO_2	12	28	22	22	24	23	18	16	19
Al_2O_3/TiO_2	21	27	25	24	27	26	21	20	20

[a] Total Fe as Fe_2O_3. [b] Loss on ignition. Analyst FJ: Fryer and Jenner (1978).

Samples 74-72 and 74-73, and 74-74 and 74-75 are cumulate zone and spinifex zone pairs from two lava flows. Sample 74-76 is a spinifex rock.

1, 2. From a cumulate zone and a spinifex zone, respectively, Munro Township, Ontario (Arndt et al., 1977, Table 7, cols. 1 and 3).

3, 4. From the cumulate and spinifex zones, respectively, of a lava flow, Mount Clifford, Western Australia (Barnes et al., 1974, Table 11, cols. 9 and 5).

Table 8. Chemical analyses of metabasalts, Prince Albert Group

Sample Number (FS-)	74-24	74-101	72-41	74-105	74-104	74-106	74-102	74-87	74-107	72-43	74-109	74-108	Average (excl. 74-108)
											Pillow		
											core	rim	
Analyst	GSC	FJ	GSC	FJ	FJ	FJ	FJ	GSC	FJ	FJ	FJ	FJ	
SiO_2	45.0	48.00	48.3	48.87	49.12	49.71	50.05	50.3	50.72	52.30	52.79	49.84	49.6
TiO_2	1.05	0.91	0.34	1.16	0.90	1.04	0.64	0.79	1.90	0.95	0.67	0.61	0.94
Al_2O_3	16.3	14.93	10.8	14.74	15.06	15.28	15.77	15.1	12.80	11.84	15.26	16.18	14.4
Fe_2O_3	1.7	13.46[a]	0.0	13.92[a]	12.31[a]	11.57	10.89[a]	1.4	18.21[a]	12.37[a]	9.19[a]	10.43[a]	
FeO	11.9		13.4					9.4					
FeO_t	(13.4)	(12.11)	(13.4)	(12.52)	(11.08)	(10.41)	(9.80)	(10.6)	(16.38)	(11.13)	(8.27)	(9.38)	11.7
MnO	0.23	0.21	0.32	0.20	0.21	0.20	0.19	0.18	0.21	0.21	0.18	0.18	0.21
MgO	9.16	9.18	13.2	7.28	8.11	6.64	8.15	8.40	4.27	7.65	8.16	8.68	8.2
CaO	9.64	10.18	10.0	9.60	11.24	11.73	11.26	8.55	9.62	11.30	10.63	9.97	10.3
Na_2O	1.4	2.08	1.1	2.97	2.38	2.50	2.36	3.4	3.13	2.77	2.22	2.12	2.4
K_2O	0.93	0.25	0.33	0.38	0.11	0.24	0.12	0.38	0.11	0.08	0.42	1.32	0.30
P_2O_5	0.13	0.07	0.10	0.12	0.06	0.08	0.06	0.09	0.08	0.07	0.07	0.07	0.08
CO_2	0.0		0.1					0.0					
H_2O	2.9	0.81[b]	1.6	0.59[b]	0.73[b]	0.61[b]	0.66[b]	1.4	0.51[b]	0.57[b]	0.64[b]	0.57[b]	1.0[c]
Total	100.3	100.08	99.6	99.83	100.23	99.60	100.15	99.4	101.56	100.11	100.23	99.97	
S	0.11		0.16					0.08					
Rb	39	14.9	16	16.7	5.8	5.6	3.2	10	4.8	7.6	25	82	14
Sr	43	80	14	68	125	118	148	71	117	145	104	110	94
Ba	64	110	17	110	80	120	60	96	180	60	140	350	94
Zr	74	50	58	62	41	50	43	76	86	48	57	59	59
Cu	180	52	220	57	88	39	72	66	6	64	3	4	77
Zn	110		150					60					
Pb	7.1		10					4.4					
Ni	180	225	510	128	138	79	178	120	<10	67	151	148	162
Cr	160	149	1100	146	320	285	270	440	<20	141	249	262	297
V	33		150					290					
Y		19		24	15	19	20		41	16	18	17	21
K/Rb	198	139	171	189	157	356	311	315	190	87	139	134	205
Rb/Sr	0.91	0.19	1.14	0.24	0.05	0.05	0.02	0.14	0.04	0.05	0.24	0.74	0.28
Sr/Ba	0.67	0.73	0.82	0.62	1.56	0.98	2.47	0.74	0.65	2.42	0.74	0.31	1.13
K/Ba	121	19	161	29	11	17	17	33	5	11	25	31	41

[a] Total Fe as Fe_2O_3. [b] Loss on ignition. [c] Total volatiles. FJ: Fryer and Jenner (1978).

Table 9. Comparison of Prince Albert Group metabasalt with other basalts

	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	49.6	51.3	49.2	50.1			49.58	49.61	49.8	51.1	50.2	48.8
TiO_2	0.94	0.96	1.10	1.05			1.98	1.43	1.5	0.83	1.0	1.2
Al_2O_3	14.4	14.8	14.7	15.0			14.79	16.01	16.0	16.1	17.7	16.3
FeO_t	11.7	10.5	11.15	11.71			11.07	11.49	9.0	10.6	9.8	8.9
MnO	0.21		0.21	0.18			0.18	0.18				
MgO	8.2	6.7	6.21	6.62			7.30	7.84	7.5	5.1	5.4	0.2
CaO	10.3	10.8	8.90	9.71			10.36	11.32	11.2	10.8	9.8	8.5
Na_2O	2.4	2.7	2.48	2.10			2.37	2.76	2.75	1.96	2.7	12.5
K_2O	0.30	0.18	0.47	0.35	0.26	0.28	0.43	0.22	0.14	0.40	0.9	2.2
P_2O_5	0.08	0.12	0.18				0.24	0.14				0.19
CO_2			1.52	0.26			0.03					0.1
H_2O	1.0[a]	1.2	3.00				1.41					
Total		99.3					99.74	101.00				
Rb	14	9			5.9	6.38			1	5	10	∽ 1
Sr	94	105	177	117	175	152			135	225	300	124
Ba	94		143	129	70	96			11	60	100	
Zr	59	61	106	43					85	60	100	
Cu	77	107	102	127						80	80	105
Ni	162	170	161	110		120			100	25	50	181
Cr	297	367	249	161		320			300	50	50	407
V		320	363	248								247
Y	21											
K/Rb	205	430			360	365			1160	660	350	∽ 1600
Rb/Sr	0.28	0.08				0.042			0.007	0.022	0.03	0.008
Sr/Ba	1.13		1.24	0.91		1.58			12	4	3	
K/Ba	41		27	22	30	24.3			105	66	30	

[a] Total volatiles.

1. Average Prince Albert Group metabasalt (Table 8).
2. Average tholeiitic basalt, Eastern Goldfields region, Western Australia (Hallberg and Williams, 1972).
3. Average basalt, Superior Province (Goodwin, 1977, Table IV).
4. Average basalt, Yellowknife belt (Baragar and Goodwin, 1969).
5. Canadian Archean basalt composite (sample B of Hart et al., 1970, Table 1).
6. Average of 525 Archean basalts (Jahn, 1977).
7. Average tholeiite (Le Maitre, 1976, no. 28).
8. Average ocean floor basalt (Cann, 1971).
9. Average low-K tholeiite of mid-ocean ridges (Condie, 1976a, Table 7-3).
10. Average island arc low-K tholeiite (Condie, 1976a, Table 7-3 and 1976b, Table III).
11. Average calc-alkaline tholeiite (Condie, 1976b, Table III).
12. Average Lau Basin basalt (Hawkins, 1977, Table 1).

Table 10. Chemical analyses of meta-andesites, Prince Albert Group

Sample Number (FS-)	73-6	74-71	74-84	74-35	Average	
						Recalculated Anhydrous
SiO_2	55.5	55.8	59.9	61.1	58.1	58.8
TiO_2	0.66	0.86	1.12	1.13	0.94	0.95
Al_2O_3	15.3	14.9	15.3	15.5	15.2	15.4
Fe_2O_3	2.7	1.2	1.0	2.4	1.8	1.8
FeO	6.1	7.1	8.3	5.4	6.7	6.8
FeO_t	(8.5)	(8.2)	(9.2)	(7.6)	8.3	8.4
MnO	0.15	0.18	0.19	0.14	0.16	0.16
MgO	6.94	5.93	2.85	3.50	4.8	4.8
CaO	6.86	6.78	6.12	4.65	6.10	6.2
Na_2O	2.3	5.2	2.3	2.8	3.2	3.2
K_2O	2.49	0.60	1.44	1.94	1.62	1.64
P_2O_5	0.11	0.17	0.22	0.26	0.19	0.19
CO_2	0.0	0.0	0.0	0.0		
H_2O	1.5	1.4	1.0	1.8	1.4	
Total	100.6	100.1	99.7	100.6		
S	0.08	0.09	0.05	0.12	0.10	
Rb	77	17	37	51	46	
Sr	110	140	170	110	132	
Ba	340	320	390	350	350	
Zr	90	130	160	140	130	
Cu	67	1260	16	81	81	
Zn	65	53	91	110	80	
Pb	8.5	11	4.5	9	8	
Ni	70	75	14	13	40	
Cr	100	27	6	< 5	34	
V	190	180	180	190	185	
K/Rb	268	293	323	316	300	
Rb/Sr	0.70	0.12	0.22	0.46	0.38	
Sr/Ba	0.32	0.44	0.44	0.31	0.38	
K/Ba	61	16	31	46	38	

[a] Total volatiles.

1. Average 'andesite', Eastern Goldfields Province, Western Australia (Williams, 1975, Table 2); analysis recalculated volatile-free to 100%.
2. Average andesite, Marda complex, Western Australia (average of analyses 1 – 7 in Table II of Hallberg et al., 1976).
3. Average andesite, Superior Province (Goodwin, 1977, Table IV).

4, 5. Average Archean low-alkali and high-alkali 'andesites', respectively (Condie, 1976b, Table IV).

6. Average modern island arc andesite (Condie, 1976a, Table 7-3).

7, 8. Average modern calc-alkaline low-K and high-K andesites, respectively (Condie, 1976a, Table 7-3).

1	2	3	4	5	6	7	8
58.6	58.7	55.9	56.7	58.9	57.3	59.5	60.8
1.1	0.81	0.91	0.92	0.65	0.58	0.70	0.77
16.8	14.9	15.6	14.0	15.5	17.4	17.2	16.8
	1.9	2.01	2.3	1.5			
	5.7	5.90	7.0	4.5			
7.9	7.4	7.71	9.1	5.8	7.3	6.1	5.1
0.1	0.11	0.16					
4.9	4.0	4.07	5.4	4.5	3.5	3.4	2.2
6.0	6.6	5.88	6.6	5.1	8.7	7.0	5.6
3.6	3.5	3.67	3.4	4.0	2.63	3.68	4.10
0.6	1.2	1.11	0.67	1.9	0.70	1.6	3.25
	0.24	0.21					
	0.2	1.60					
5.9[a]	1.9	2.54					
	36		22	75	10	30	90
	378	242	278	580	215	385	620
	744	358	230	547	100	270	400
	196	145	150	190	90	110	170
	32	64	60	36			
	57	80	97	81			
		8					
	76	61	70	60	15	18	3
	116	111	125	88	44	56	3
	133	232					
	294		253	210	580	440	300
	0.10		0.08	0.13	0.05	0.08	0.14
	0.51	0.68	1.2	1.1	2.2	1.4	1.6
	13	26	24	29	58	49	68

Table 11. Chemical analyses of metadacites, Prince Albert Group

Sample Number (FS-)	72-39	73-132	74-96	74-27	73-110	74-26	74-25	73-71	73-94
Analyst	GSC	GSC	GSC	GSC	FJ	GSC	GSC	FJ	GSC
SiO_2	65.3	66.0	66.3	66.9	66.98	67.7	68.1	68.19	68.6
TiO_2	0.62	0.63	0.52	0.50	0.54	0.65	0.69	0.48	0.61
Al_2O_3	15.5	15.1	16.4	13.2	16.92	14.1	13.4	12.01	17.7
Fe_2O_3	1.1	0.9	0.8	1.3	4.59[a]	0.6	0.1	8.55[a]	0.4
FeO	4.4	4.1	2.7	5.0		5.1	6.1		1.1
FeOt	(5.4)	(4.9)	(3.4)	(6.2)	(4.13)	(5.6)	(6.2)	(7.69)	(1.4)
MnO	0.16	0.07	0.04	0.14	0.08	0.08	0.14	0.07	0.03
MgO	2.49	2.30	1.48	4.18	2.09	4.01	3.17	2.15	0.88
CaO	3.29	5.03	2.78	3.49	2.11	2.74	3.50	1.95	4.14
Na_2O	1.1	4.5	3.3	0.6	1.03	2.4	1.1	3.07	5.6
K_2O	4.28	0.70	4.08	2.21	4.24	2.03	1.69	2.18	0.64
P_2O_5	0.29	0.24	0.22	0.12	0.13	0.16	0.16	0.06	0.23
CO_2	0.0	0.0	0.6	0.0		0.0	0.0		0.0
H_2O	1.7	1.0	1.0	2.6	1.50[b]	0.8	2.0	1.89[b]	0.2
Total	100.2	100.6	100.2	100.2	100.21	100.4	100.2	100.60	100.1
S	0.14	0.07	0.08	0.40		0.11	0.12		0.09
Rb	248	13	83	74	118	97	77	69	15
Sr	290	140	87	30	63	77	57	106	170
Ba	3100	180	600	170	670	220	170	1310	170
Zr	190	210	180	150	205	110	200	85	160
Cu	85	130	130	110	27	48	72		54
Zn	46	38	69	72		74			24
Pb	33	9.6	7.7	4.8		12			7.3
Ni	24	25	< 10	100	38	43	61		< 10
Cr	8	27	6	120	40	140	150		11
V	56	58	49	68		110	88		58
Y					17			15	
K/Rb	143	447	408	248	298	173	182	262	354
Rb/Sr	0.86	0.09	0.95	2.47	1.87	1.26	1.35	0.65	0.09
Sr/Ba	0.09	0.78	0.14	0.18	0.09	0.35	0.34	0.08	1.00
K/Ba	11	32	56	108	52	76	82	14	31

[a] Total Fe as Fe_2O_3. [b] Loss on ignition. [c] Total volatiles. FJ: Fryer and Jenner (1978).

1. Average 'dacite', Eastern Goldfields Province, Western Australia (Williams, 1975, Table 2); analysis recalculated volatile-free to 100%.
2. Average dacite, Marda complex, Western Australia (average of analyses 8 – 16 in Table II of Hallberg et al., 1976).
3. Average andesite, Superior Province (Goodwin, 1977, Table IV).

4, 5. Average Archean USV and DSV 'dacites', respectively (Condie, 1976b, Table V).

6, 7. Average modern island arc and calc-alkaline dacites, respectively (Condie, 1976b, Table V).

73-92	Average								
GSC		Recalculated Anhydrous	1	2	3	4	5	6	7
69.1	67.3	68.2	65.2	63.2	66.7	64.0	66.2	66.8	64.9
0.59	0.58	0.59	0.6	0.7	0.52	0.50	0.28	0.2	0.60
15.1	14.9	15.1	15.9	14.4	14.9	15.8	16.5	18.2	16.0
0.3				1.6					
3.6			3	4.7					
(3.9)	4.9	5.0	3.4	6.1	4.3	5.2			
0.06	0.09	0.09	0.1	0.1	0.10				
1.21	2.40	2.43	3.4	2.8	1.85	3.0	1.6	1.5	1.7
2.50	3.15	3.19	4.2	4.3	3.02	3.2	3.9	3.2	4.7
6.2	2.9	2.9	5.3	3.7	4.16	4.0	5.2	5.0	4.2
0.33	2.24	2.27	1.8	2.2	1.52	2.7	2.0	1.0	1.8
0.19	0.18	0.18		0.2	0.17				
0.3				0.2	1.32				
0.8	1.4[c]			1.8	1.57				
100.3									
0.12									
8	80			68		68	33	15	40
53	107			256	198	390	600	250	500
77	667			792	315	1090	590	250	450
420	191			217	217	260	50	80	100
99	84			61	37				
45	52			65	72				
10	12				8				
< 10	34			53	23	25	25	1	8
7	56			59	44	45	30	5	10
23	64			91	102				
				24		8	2	25	30
342	286			269		330	503	800	400
0.15	0.97			0.27		0.17	0.06	0.08	0.08
0.69	0.37			0.40	0.63	0.36	1.0	0.8	1.3
36	50			21	40	21	28	35	35

Table 12. Microprobe analyses of garnet in metarhyolite sample FS-73-93 of the Prince Albert Group

	Grain 1		Grain 2		Average	
	Centre	Edge	Centre	Edge	Centre	Edge
SiO_2	36.74	37.14	36.87	36.89	36.80	37.02
TiO_2	0.06	0.05	0.06	0.03	0.06	0.04
Al_2O_3	19.85	20.13	20.08	20.16	19.96	20.15
Cr_2O_3	0.06	0.05	0.07	0.05	0.06	0.05
FeO[a]	30.46	31.14	30.61	31.13	30.54	31.14
MnO	8.49	8.01	8.43	7.76	8.46	7.88
MgO	1.34	1.29	1.34	1.19	1.34	1.24
CaO	2.05	2.15	2.22	2.45	2.14	2.30
Na_2O	0.04	0.08	0.01	0.12	0.02	0.10
K_2O	nd	nd	nd	nd	-	-
Total	99.09	100.04	99.69	99.78	99.38	99.92

[a] All Fe as FeO. [b] nd – Not detected. Analyses by M. Bonardi, GSC.

Table 13. Chemical analyses of metarhyolites, Prince Albert Group

Sample Number (FS-)	74-90	73-93	74-91	73-117	73-109	74-83	74-85	74-92	73-97	73-89	72-38	74-33	73-65	74-95	73-64	Average
Analyst	FJ	FJ	GSC	GSC	GSC	GSC	GSC	GSC	GSC	FJ	GSC	GSC	FJ	GSC	GSC	
SiO_2	69.74	69.92	70.3	70.9	71.0	72.5	73.1	73.5	74.1	74.19	75.0	75.2	76.05	77.0	78.6	73.4
TiO_2	0.40	0.45	0.46	0.28	0.37	0.39	0.31	0.38	0.34	0.13	0.13	0.23	0.16	0.19	0.17	0.29
Al_2O_3	13.74	14.07	14.1	15.2	15.7	13.7	15.5	14.2	13.1	12.55	13.6	11.9	11.65	12.8	11.8	13.6
Fe_2O_3	4.43[a]	5.17[a]	0.8	0.5	0.6	0.0	0.6	0.4	0.4	2.72[a]	0.7	0.5	3.00[a]	0.5	0.5	
FeO			3.1	1.7	1.8	4.0	1.5	1.1	3.3		1.2	2.3		0.1	0.8	
FeO_t	(3.99)	(4.65)	(3.8)	(2.1)	(2.3)	(4.0)	(2.0)	(1.4)	(3.6)	(2.45)	(1.8)	(2.7)	(2.70)	(0.5)	(1.2)	2.6
MnO	0.06	0.06	0.04	0.06	0.03	0.06	0.03	0.03	0.02	0.03	0.05	0.07	0.08	0.02	0.03	0.04
MgO	0.69	1.33	1.24	0.98	1.85	1.73	0.69	0.58	2.30	1.97	1.04	2.43	1.12	0.71	1.25	1.33
CaO	2.69	2.46	3.00	2.30	2.76	2.71	2.30	2.70	0.56	1.60	1.73	1.72	0.95	0.74	1.15	1.96
Na_2O	3.87	3.79	5.0	4.2	2.3	3.4	3.4	3.7	4.0	3.18	2.5	0.7	1.00	3.3	1.8	3.1
K_2O	1.89	1.23	0.60	1.51	2.71	0.77	2.05	1.90	1.14	1.76	3.73	3.67	3.71	2.85	2.98	2.38
P_2O_5	0.11	0.10	0.17	0.13	0.17	0.12	0.11	0.13	0.09	0.00	0.07	0.05	0.00	0.05	0.05	0.09
CO_2			0.0	0.0	0.0	0.0	0.0	0.4	0.0		0.0	0.0		0.2	0.1	
H_2O	1.16[b]	0.75[b]	0.6	1.0	1.2	1.0	0.6	0.5	1.3	1.05[b]	0.6	1.6	1.28[b]	0.8	1.0	1.0[c]
Total	98.78	99.33	99.4	98.8	100.5	100.4	100.2	99.5	100.6	99.18	100.4	100.4	99.00	99.3	100.2	
S			0.06	0.08	0.08	0.06	0.07	0.08	0.07		0.09	0.10		0.09	0.08	
Rb	61	34	22	79	75	23	55	48	21	57	162	120	83	54	71	64
Sr	85	122	110	200	68	110	110	110	19	50	73	41	50	20	16	79
Ba	540	300	180	470	500	150	570	430	150	480	910	180	990	510	660	468
Zr	258	358	220	60	180	590	170	310	240	179	250	280	442	220	200	264
Cu	10	4	40	10	280	50	15	37	55	18	35	200	3	52	31	56
Zn			25	41	31	53	29	14	20		43	69		16	33	34
Pb			9.6	16	6.6	6.5	4.3	10	7.4		60	11		9.6	12	14
Ni	<10	<10	<10	<30	28	< 10	<10	< 10	<10	<10	<10	33	<10	<10	<10	9
Cr	<20	<20	< 5	<10	22	10	8	9	< 5	<20	< 5	< 5	<20	< 5	< 5	7
V			22	42	63	< 20	30	31	<20		<20	<20		<20	<20	22
Y	33	38								29			105			45[d]
K/Rb	257	300	226	159	300	278	309	328	450	256	191	254	371	438	348	298
Rb/Sr	0.72	0.28	0.20	0.40	1.10	0.21	0.50	0.44	1.10	1.14	2.22	2.93	1.66	2.70	4.44	1.34
Sr/Ba	0.16	0.41	0.61	0.42	0.14	0.73	0.19	0.26	0.13	0.10	0.08	0.23	0.05	0.04	0.02	0.24
K/Ba	29	34	28	27	45	43	30	37	63	30	34	169	31	46	38	46

[a] Total Fe as Fe_2O_3. [b] Loss on ignition. [c] Total volatiles. [d] Average of 11 analyses (Fryer and Jenner, 1978). FJ: Fryer and Jenner (1978).

Table 14. Comparison of Prince Albert Group metarhyolites with other rhyolites

	1	2	3	4	5	6	7	8	9
SiO_2	73.4	74.3	72.0	77.3	74.4	73.7	73.5	71.7	74.0
TiO_2	0.29	0.29	0.3	< 0.1	0.3	0.30	0.14	0.19	0.25
Al_2O_3	13.6	13.8	15.8	12.7	12.8	13.6	12.7	16.4	13.3
Fe_2O_3					0.9	0.9	0.9	0.7	1.3
FeO					1.4	2.01	1.2	0.9	0.5
FeO_t	2.6	2.6	1.8	0.8	2.2	2.8	2.0	1.5	1.7
MnO	0.04	0.04		< 0.1	0.1	0.06			
MgO	1.33	1.35	0.9	0.3	0.3	0.78	0.8	0.5	0.3
CaO	1.96	1.98	1.4	0.2	0.5	0.94	1.1	1.7	1.5
Na_2O	3.1	3.1	5.7	2.8	4.0	3.92	3.3	5.0	4.0
K_2O	2.38	2.41	2.0	5.9	3.9	2.31	3.0	2.0	3.5
P_2O_5	0.09	0.09			0.04	0.13			
CO_2					0.2	1.03			
H_2O	1.0[a]		0.8[a]	0.2[a]	0.8	1.07			
Rb	64				116		43	41	100
Sr	79				131	107	100	110	150
Ba	468				1216	478	750	480	900
Zr	264				291	210	350	30	160
Cu	56				10	30			
Pb	34				34	48			
Zn	14					7.7			
Ni	9				7	18	10	10	1
Cr	7				< 10	9	12	12	2
V	22				8	65			
Y	45				30		30	2	10
K/Rb	298				266		580	405	250
Rb/Sr	1.34				1.41		0.43	0.37	0.67
Sr/Ba	0.24				0.12	0.22	0.13	0.23	0.2
K/Ba	46				31	40	33	35	32

[a] Total volatiles.

1. Average Prince Albert Group metarhyolite (Table 14).
2. Average Prince Albert metarhyolite, recalculated volatile-free to 100%.

3, 4. Average sodic and potassic 'rhyolites', respectively, Eastern Goldfields Province, Western Australia (Williams, 1975, Table 2); analyses recalculated volatile-free to 100%.

5. Average rhyolite, Marda complex, Western Australia (average of analyses 17-33 in Table II of Hallberg et al., 1976).
6. Average rhyolite, Superior Province (Goodwin, 1977, Table IV).

7, 8. Average Archean USV and DSV 'rhyolites', respectively (Condie, 1976b, Table V).

9. Average modern 'rhyolite' (Condie, 1976b, Table V).

Table 15. Chemical analysis of a diabase dyke (sample FS-74-94)

		Irvine-Baragar norm	
SiO_2	48.0	Q	
TiO_2	1.31	Or	5.5
Al_2O_3	15.6	Ab	21.6
Fe_2O_3	1.1	An	29.3
FeO	9.7	Di	2.8
MnO	0.16	Hd	2.0
MgO	7.42	En	14.3
CaO	9.31	Fs	11.7
Na_2O	2.5	Fo	2.3
K_2O	0.91	Fa	2.0
P_2O_5	0.17	Mt	1.6
CO_2	1.7	Il	2.5
H_2O	2.6	Ap	0.4
		Cc	4.0
Total	100.5		
S	0.16		
Rb	29		
Sr	350		
Ba	280		
Zr	91		
Cu	61		
Zn	81		
Pb	5		
Ni	82		
Cr	56		
V	170		
Theta	34		

GSC
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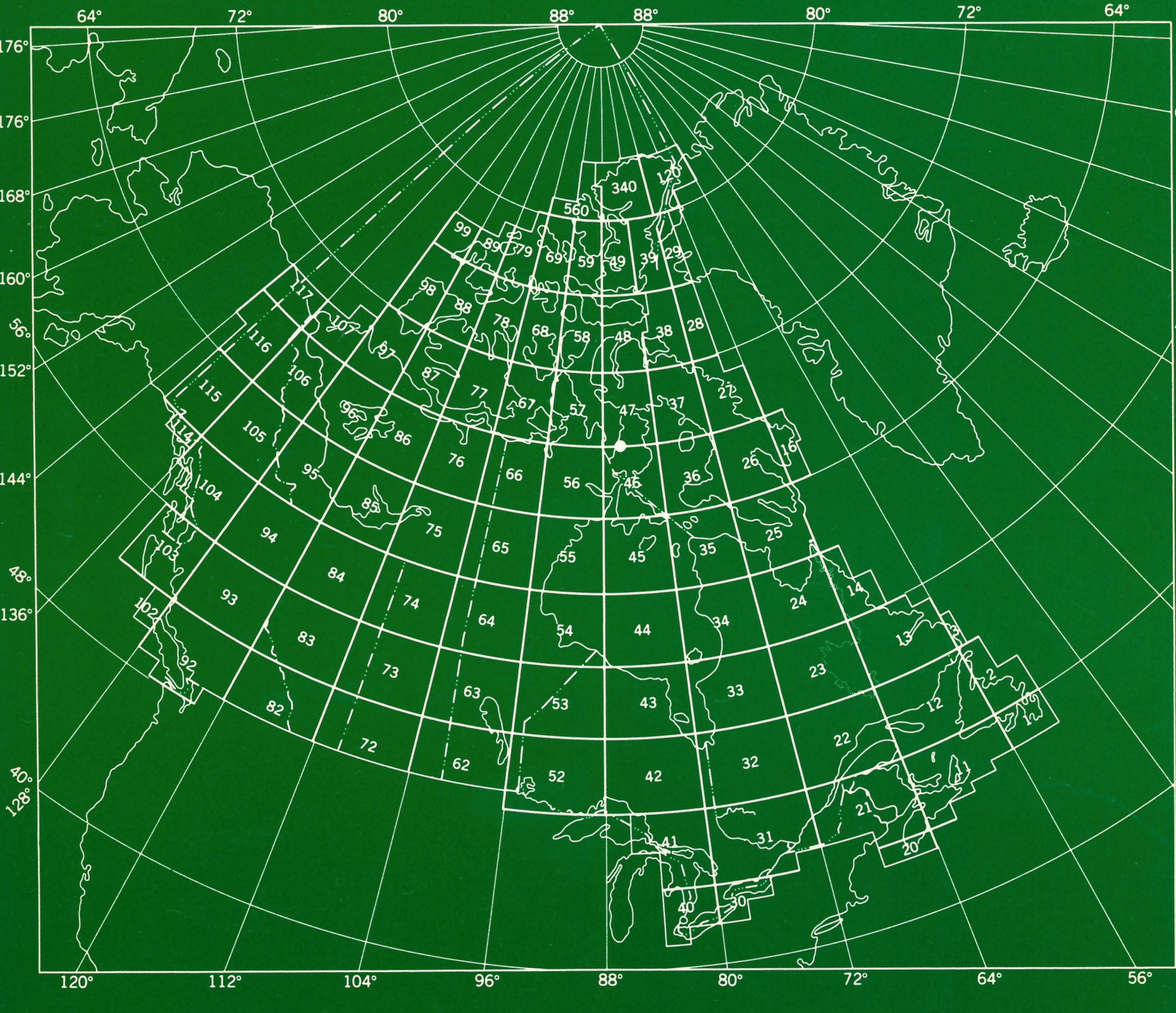

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