GEOLOGY OF THE RIVIÈRE GRANDIN MAP AREA (HOTTAH TERRANE AND WESTERN GREAT BEAR MAGMATIC ZONE), DISTRICT OF MACKENZIE

Project 820009

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Abstract

Hottah Terrane comprises deformed metasedimentary and metavolcanic rocks cut by two distinct suites of plutons: a deformed suite of intermediate bodies (1.914-1.9 Ga) and a suite of undeformed leucogranites (1.9-1.875 Ga). Sedimentary and volcanic rocks of the Bell Island Group, a basal unit of the Great Bear Magmatic Zone, unconformably overlie rocks of Hottah Terrane and are intruded by swarms of granitoid plutons and porphyries. One of the plutons, the Yen, has large areas of associated intrusion breccias of problematic origin. Both Hottah Terrane and Great Bear Magmatic Zone are cut by swarms of transcurrent faults. At least two of the faults had a component of vertical extension, as indicated by the existence of associated thrust faults similar to positive flower structures found in other wrench zones. The recognition of a deformed arc-like plutonic suite generated between 1.914-1.9 Ga in the Hottah Terrane supports the interpretation that Coronation Margin developed in a back-arc setting.

Résumé

Le terrain de Hottah se compose de roches métasédimentaires et métavolcaniques déformées que traversent deux suites distinctes de plutons: une suite déformée de massifs intermédiaires (1,914 à 1,9 Ga) et une suite de leucogranites non déformés (1,9 à 1,875 Ga). Les roches sédimentaires et volcaniques du groupe de Bell Island, unité basale de la zone magmatique de Great Bear, reposent en discordance sur des roches du terrain de Hottah et sont traversées par des essaims de plutons granitoïdes et de porphyres. Un des plutons, le Yen, comporte de vastes étendues de brèches d'intrusion dont l'origine est énigmatique. Le terrain de Hottah et la zone magmatique de Great Bear sont tous deux traversés par des essaims de décrochements. Au moins deux de ces failles avaient une composante d'extension verticale, ainsi qu' en témoigne la présence de failles de chevauchement semblables aux structures << en fleurs>> positives observées dans d'autres zones de décrochements à rejet vertical. On a reconnu, dans le terrain de Hottah, la présence d'une suite plutonique déformée en arc qui aurait été produite entre 1,914 et 1,9 Ga; cette observation appuie l'interprétation selon laquelle la formation de la marge du Couronnement aurait eu lieu à l'arrière d'un arc.

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Introduction

Detailed geological mapping of the early Proterozoic rocks occurring in the Rivière Grandin map area (86 D) was completed during the summer of 1984. This mapping is part of a continuing project in western Wopmay Orogen to understand the geology and tectonic significance of Hottah Terrane as well as the western part of the Great Bear Magmatic Zone in map areas 86 D and 86 E (Hildebrand et al., 1983, 1984; see Fig. 48.1).

The first geological examination of the area was that of Kidd (1936) who mapped a strip from Great Bear Lake to Great Slave Lake. Later, a detailed study of Beaverlodge Ridge by Henderson (1949) focused on low tonnage uranium showings found there in the early 1930s. More recently, McGlynn (1979) mapped the areas in reconnaissance fashion and was the first to recognize a complex of tectonized metamorphic rocks (Hottah Terrane of Hildebrand, 1981) unconformably beneath rocks of the Great Bear Magmatic Zone. Hildebrand et al. (1983) suggested, on the basis of geochronological and geological data collected during 1982, that Hottah Terrane is exotic with respect to Coronation Margin (eastern Wopmay Orogen) and was accreted to it between about 1.9 and 1.89 Ga. This paper reports the results of 1:50 000 scale mapping of those parts of the Rivière Grandin map area not mapped during 1982 and presents a revised tectonic model for the evolution of Wopmay Orogen.

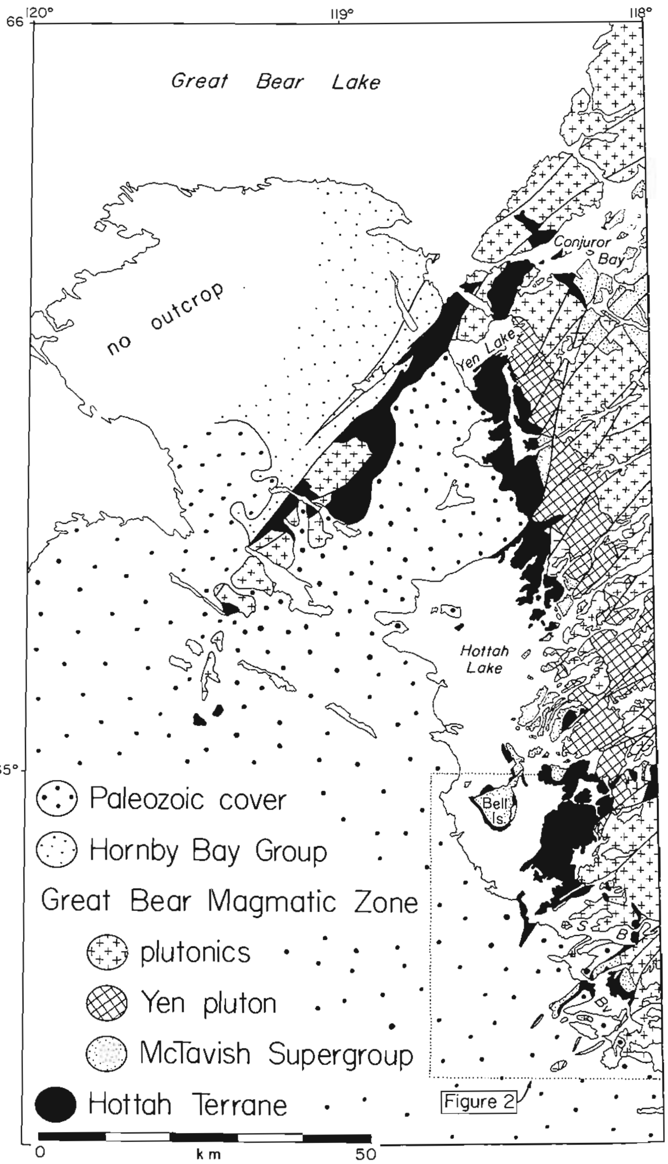


Figure 48.1. Generalized geological map of the Leith Peninsula (86E) and the north half of the Rivière Grandin (86D) map areas showing distribution of Hottah Terrane, McTavish Supergroup, and Great Bear plutonic rocks. SB = Stairs Bay; Bv = Beaverlodge Lake.

Acknowledgments

We would like to thank Dianne Paul and Andrew Muirhead for their cheerful, pleasant, and able assistance; Martin Irving (GSC) and Craig Robinson (DIAND) for their superb job of expediting; and Mike Hogan (Latham Island Airways) for careful air support. Peter Lipman and Roy Bailey, both of the USGS, spent a week with us in the field and provided stimulating discussions on the outcrop. As usual, R. Tirrul and S. Hanmer contributed greatly to our understanding of various aspects of structural geology. Many of the ideas related to the back-arc setting of Coronation Margin originated during discussion with P.F. Hoffman. I.G. Reichenbach and P.F. Hoffman critically read the manuscript and suggested many ways to improve it.

Hottah Terrane

In the map area, rocks of the Hottah Terrane can be divided into 3 main groups, based on lithology and degree of deformation. The oldest rocks are deformed metasedimentary and metavolcanic rocks. They are intruded by a suite of tectonized plutons, mainly intermediate in composition. Both the tectonized plutons and the supracrustal rocks are cut by a number of undeformed leucocratic granites.

Supracrustal rocks (Holly Lake metamorphic suite)

Rocks included under this heading are psammites, pelitic schists, probable volcaniclastic rocks, minor hematite beds, and mafic to intermediate lava flows. They are metamorphosed to assemblages typical of the amphibolite facies and sedimentary bedding is in many places completely transposed. Metasedimentary rocks are commonly cut by sheets of fine- to medium-grained leucocratic syenogranite.

The lava flows mapped this year occur east of Hottah Lake (Fig. 48.2) and are mostly fine grained dark rocks, probably andesite, containing 10-30% plagioclase phenocrysts up to 1.5 cm (Fig. 48.3) and quartz amygdules up to 5 mm. The groundmass is now recrystallized to mixtures of quartz, biotite, plagioclase, and amphibole(?). The flows are variably strained and in places there is no visible deformation. In other areas plagioclase phenocrysts are strongly lineated, measuring 2 x 10 mm in cross-section and several centimetres long, or only slightly stretched but strongly flattened.

Deformed plutonic rocks

Large expanses of exposed Hottah Terrane are composed of deformed granitoid plutons of mainly dioritic, quartz dioritic, granodioritic, and monzogranitic composition (McGlynn, 1979; Hildebrand et al., 1983; 1984). Hornblende or biotite + hornblende generally constitute the ferromagnesian assemblage. U-Pb ages from zircons in these bodies range from 1.914-1.90 Ga (Hildebrand et al., 1983; Bowring, in prep.).

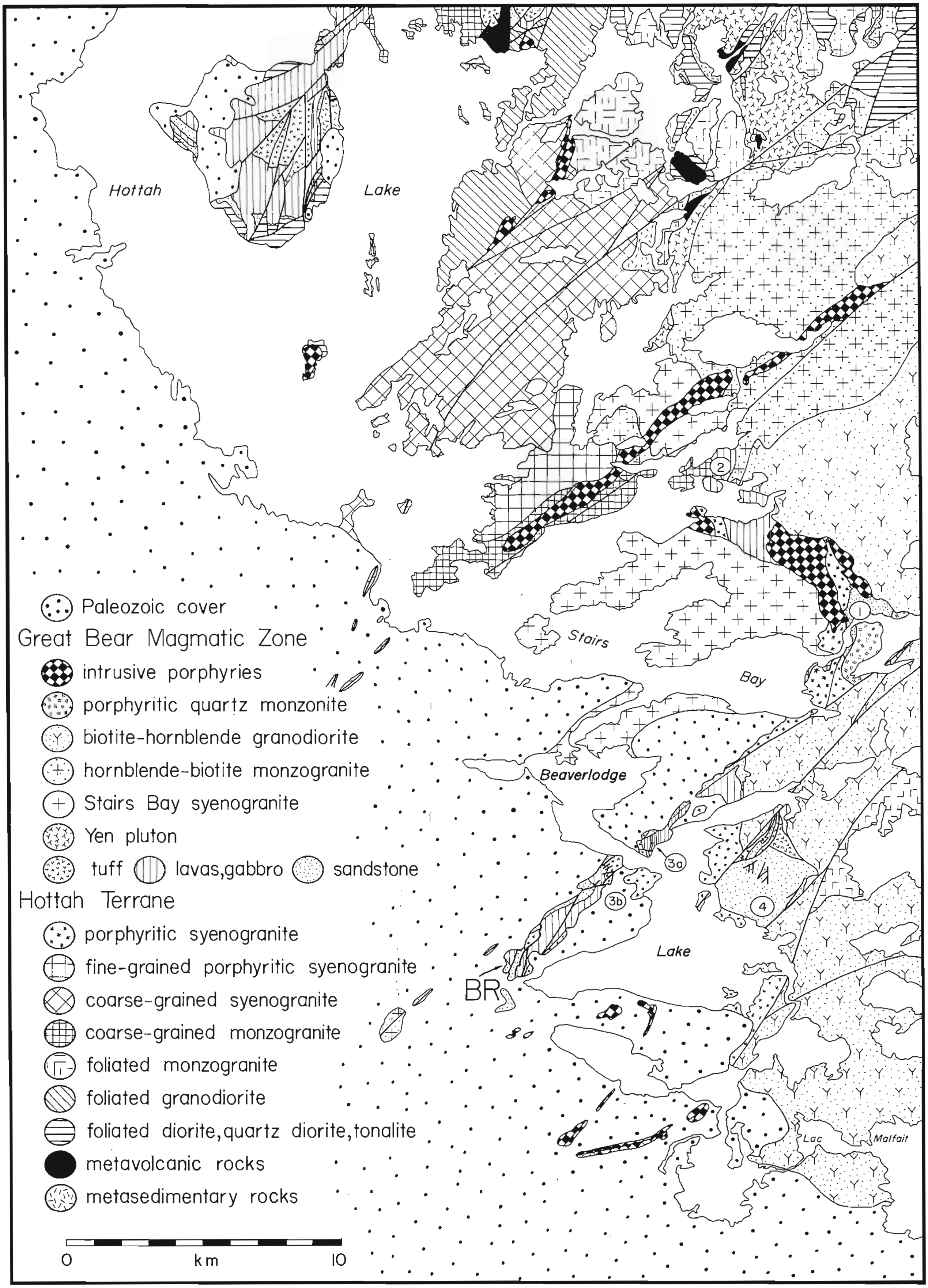


Figure 48.2. *Generalized geological map of the northeast corner of the Rivière Grandin map area. Numbers in ellipses refer to localities discussed in text. Beaverlodge Ridge is a prominent ridge that extends from BR in a northeasterly direction to the southeast corner of Stairs Bay.*

Figure 48.3. Plagioclase porphyritic amygdaloidal andesite of the Hottah Terrane. Penny in centre for scale. (GSC 204113-A)

During the past field season, several small plutons of deformed hornblende diorite, quartz diorite, and tonalite were mapped east of Hottah Lake (Fig. 48.2). Penetrative deformation ranges from slight to intense, but overall, quartz-bearing rocks are more deformed (Fig. 48.4). Intrusive relations between bodies are sufficiently complex that maps at 1:16 000 scale fail to portray them accurately.

The overall intermediate nature of the entire suite of deformed plutons mapped in Hottah Terrane during the current project is very similar to plutonic suites characteristic of continental margin arcs in younger terranes, as well as in the Great Bear Magmatic Zone. This suggests that Hottah Terrane may represent a 1.914-1.9 Ga magmatic arc.

Undeformed plutonic rocks

Several plutons of relatively undeformed granitic rock considered to belong to Hottah Terrane were mapped in the Stairs Bay-Beaverlodge Lake area. We have used several criteria in order to differentiate undeformed plutons of the Hottah Terrane from those of Great Bear Magmatic zone: (1) several bodies lie unconformably beneath rocks of the Bell Island Group; (2) they are cut by numerous glomeroporphyritic diabase and gabbro dykes identical to sills related to volcanism in the Bell Island Group (see Hildebrand et al., 1983); (3) the original ferromagnesian minerals are often recrystallized to clots of tiny biotite and/or chlorite flakes; (4) in places they have suffered severe cataclastic deformation; (5) they are often extremely leucocratic (<5% ferromagnesian minerals); and (6) they may contain blue quartz, a feature which we have not noticed in Great Bear granites. In general, most bodies show two or more of the above features.

A large body of medium grained chlorite syenogranite to alkali-feldspar granite lies unconformably beneath sandstone northeast of Stairs Bay and on Beaverlodge Ridge (Fig. 48.2). The body is variably porphyritic (20-40%) with spherical phenocrysts or snowflake clots of potassium feldspar to 3 cm in a groundmass of anhedral blue quartz (2-3 mm), anhedral-subhedral plagioclase (3 mm), potassium feldspar and 10-20% chlorite. In many places, most notably at the northeast end of Stairs Bay, the rock has suffered severe cataclasis. The granite is riddled with brittle fractures and potassium feldspar phenocrysts were crushed into tiny angular chips, which are in a dark chloritic matrix.

Another body, one of the largest plutons mapped in Hottah Terrane, occurs northwest of Stairs Bay. It is a medium- to coarse-grained leucocratic syenogranite that generally contains less than 5% mafic minerals, mostly chlorite. Anhedral grey quartz ranges from 1-4 mm and plagioclase is subhedral (<2 mm). The pluton weathers various shades of white, pink and red.

A smaller pluton of fine grained porphyritic syenogranite cuts the above pluton along its southern margin at the west end of Stairs Bay. It contains subhedral-euhedral potassium feldspar phenocrysts (1-5 cm long) and anhedral-subhedral blue quartz (3-5 mm) sitting in a much finer grained groundmass of anhedral plagioclase, quartz, potassium feldspar, and tiny biotite flakes. The pluton is cut by numerous diabase dykes.

Coarse grained monzogranite outcrops along the east side of the above body. The age relationship with its western neighbour is unknown as the contact was not seen due to poor outcrop. The pluton is characterized by its coarse grained, non-porphyritic, leucocratic nature. It is similar to leucocratic monzogranite mapped directly beneath the Hottah Great Bear unconformity on eastern Bell Island (Hildebrand et al., 1983).

The leucocratic plutons clearly postdate ductile deformation in Hottah Terrane and are, in several instances, unconformably overlain by rocks of the Great Bear Magmatic Zone. Thus, their age of emplacement is constrained by the youngest deformed pluton in Hottah Terrane (1.90 Ga) and the oldest dated rock in Great Bear Magmatic Zone (1.875 Ga). We suggest that the granites of the leucocratic suite were generated during collision of Hottah Terrane with Coronation Margin. If true, their U-Pb ages should fall close to 1.88 Ga, the approximate age of post-tectonic plutons in Hepburn batholith (Hoffman and Bowring, 1984; Bowring, in prep.).

Great Bear magmatic zone

McTavish Supergroup

At locale 1 (Fig. 48.2) the unconformity between rocks of the Great Bear Magmatic Zone and Hottah Terrane is well exposed. There, crossbedded cobbly to granular arkose fills paleovalleys cut into granitoid rocks. The best exposed paleovalley has a steep scarp, interpreted as an east side down normal fault and preserved as a buttress unconformity about 15 m high along its western margin. In the lowest part of the paleovalley a thin (<1 m) conglomerate containing subrounded to subangular clasts of granite and quartz porphyry overlies a relatively low relief surface of bleached

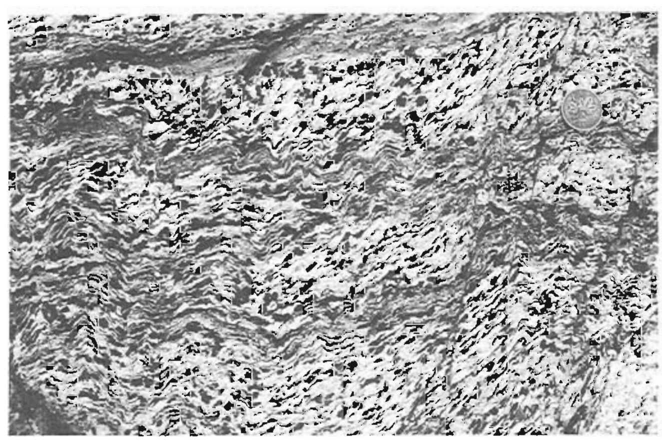


Figure 48.4. Deformed hornblende quartz diorite of the Hottah Terrane. (GSC 204112-E)

and altered granite. The rest of the paleovalley is filled with crossbedded granular to pebbly arkose, except adjacent to the scarp where angular blocks of granite up to 4 m across were found in the arkose. Apparently, the blocks spalled from the steep escarpment during sedimentation. The arkose occurs only within the paleovalleys and out of them the granite is overlain, as is the arkose within them, by 30-40 m of crossbedded and rippled quartz arenite in beds varying in thickness up to 1 m. The quartz arenite is, in turn, overlain by thinly bedded to laminated tuff, siltstone, and mudstone. The total thickness of these units is unknown due to cover and younger plutons, but 50 m are exposed. The tuffs are white to pink fine grained beds up to 0.3 m thick. They are interpreted as waterlain airfall tuff because they are intercalated with siltstone and mudstone. In general, the siltstones are well-layered rocks with interbedded 1-3 mm greenish, fine sandy layers and 2 cm limy beds. In some places there are abundant slump folds and synsedimentary breccias.

Amygdaloidal basalt directly overlies intensely weathered granite at locale 2 (Fig. 48.2). The buried erosional surface has up to 1 m of relief and the granite is hematized and more strongly weathered in hollows. The lowermost basalt flow has a 0.5 m thick basal flow breccia containing sparse elongate granite clasts. Locally, basaltic magma flowed down into v-shaped open fractures within the uppermost 0.3 m of basement. The basalt flows are cut by abundant gabbro intrusions, probably sills. Overlying the basalt flows is a complex of siliceous ash-flow tuff and lava. The lava flows have abundant associated flow and talus breccias and the ash-flow tuff is strongly eutaxitic with lineated pumice fragments and minor flow folds.

At location 3a (Fig. 48.2) at least 50 m of well bedded sandstone unconformably overlies granite of the Hottah Terrane, but a complete section is not present due to complex faulting. The granite is generally altered and bleached such that few ferromagnesian minerals remain unaltered. The unconformity itself is generally planar with only minor local relief. The overlying sandstone is mostly fine to coarse quartz arenite with sparse granules and pebbles of vein quartz. Bedding ranges in thickness from 1 or 2 cm to about 2 m. Some bedding surfaces are rippled and many beds are internally crossbedded. Interbedded with the sandstone are discontinuous lenses of laminated, greenish-weathering tuff and minor beds of siltstone and mudstone. The sedimentary section is overlain by stubby quartz-phyric dacite lava flows with well developed basal breccias and locally by thin basalt flows. In some areas there is a thin volcanic cobbly conglomerate between the sandstones and lavas. This section is cut by gabbro sills and intermediate porphyry bodies that, in some cases, are similar in modal mineralogy to the dacite lavas.

Examination of the unconformity at 3b (Fig. 48.2) reveals only minor pebbly sandstone and conglomerate, such that intermediate lavas lie, for the most part, directly on granitic basement. The pebbly sandstone fills local depressions up to 1 m deep and is a massive unsorted rock that weathers maroon to dark purple. The lava flows are probably dacitic and weather various shades of purple, steel grey, and brown. They are generally amygdaloidal and in places have well developed devitrification features and flow banding. Intercalated with the dacites are thin aphyric basalt(?) flows. These flows are generally amygdaloidal and weather shades of blue-grey. At the south end of Beaverlodge Ridge minor lenses of sandstone and conglomerate are intercalated with the lava flows. The conglomerates are polymictic aggregates of volcanic and sedimentary clasts, mostly subrounded, in a sandy hematitic matrix. The sandstones vary from quartz arenites to feldspathic wackes. Overlying the sequence of lava flows are thin tuff beds of unknown composition and provenance. Locally, polymictic bouldery conglomerate and gritstone fills channels cut into the tuff and underlying lava flows. Capping the entire section is at least 60 m of white to pink weathering arkose and quartz arenite. The top of the sandstone is not exposed. The sandstones are well bedded rocks in beds up to 1 m thick. In the few places where there are bands of heavy minerals crossbedding is seen, but in most outcrops there was no visible internal stratification, perhaps because the sands are very clean and there is little size variation among grains.

The unconformity at location 4 (Fig. 48.2) is only locally well exposed; where quartz arenite and arkosic conglomerate overlie an irregular surface eroded into quartz-potassium feldspar porphyry. Angular to subangular clasts of the porphyry, ranging up to 70 cm across, occur in the sandstone within a metre or so of the unconformity. In addition, a few pebbles of jasper, vein quartz, and fine grained plagioclase porphyritic lava were found. The overlying sandstones are mostly fine-to medium-grained, light-coloured rocks with minor quartz pebbly lenses. Near the top of the sandstone section, beds of fine grained, crossbedded, red to brown weathering lithic arkose occur. The sandstones are overlain by a succession of welded tuffs with locally well developed eutaxitic foliation. They are mostly intermediate in composition and contain broken phenocrysts of plagioclase, alkali feldspar and quartz, as well as tiny lithic fragments, in a dark green to grey groundmass. The top of the section is not exposed as it is intruded by a younger granodiorite-monzogranite pluton. Both the sandstone and the tuffs are intruded by myriads of hornblende-plagioclase porphyry dykes and sills.

Additional exposures of the unconformity and overlying basal sandstone were found east of Hottah Lake. Most of those exposures are large pendants or enclaves in younger granitoid plutons of the Great Bear Zone. In general, only a few metres of sandstone are exposed and they are arkosic, similar to outcrops of the basal sandstone found elsewhere. The overlying lava flows are not present due to the intrusion of Great Bear plutons.

All of the above sections are similar to those described by Hildebrand et al. (1983) on Bell Island and to the north. They are all characterized by a basal sandstone or conglomerate above the Hottah unconformity and are in turn overlain by a wide variety of mafic to intermediate lava flows and ash-flow tuff. Therefore, the supracrustal rocks described above are included in the Bell Island Group of Hildebrand et al. (1984).

Great Bear plutons

Several large plutons compositionally and texturally typical of those found elsewhere in the Great Bear Magmatic Zone were mapped during the field season (Fig. 48.2). We provide descriptions for only two of the more interesting bodies, the Yen pluton and the Stairs Bay syenogranite.

Yen pluton. This pluton is the largest magmatic body mapped during the current project. It extends from Yen Lake southward to just north of Stairs Bay (Fig. 48.1), a distance of about 60 km. Because it is intruded by younger granite plutons its original extent is unknown, but presumably it was even larger. The pluton was informally called the Zebulon pluton by Hildebrand et al. (1983) but subsequent mapping has demonstrated that it is continuous with a pluton that Hildebrand (1983) named the Yen pluton after its occurrence east of Yen Lake. Because the name Yen pluton has precedence, the term Zebulon is abandoned and the entire mass is now referred to as the Yen pluton.

Throughout most of its area of outcrop, the Yen pluton is a homogeneous body of medium grained biotite-hornblende granodiorite to monzogranite with ferromagnesium content varying between 10 and 25%. Characteristic of the pluton is the presence of euhedral prisms of hornblende up to 1 cm long. Biotite is mostly fresh, forms plates up to 5 mm across, and often occurs as clots or aggregates up to 1 cm in diameter. Plagioclase is slightly greenish on the fresh surface, subhedral to euhedral, and ranges up to 8 mm long. Quartz and potassium feldspar are mostly interstitial. However, in some areas potassium feldspar phenocrysts up to 2 cm long occur, but they never constitute a large enough percentage to shift the modal composition into the syenogranite field.

The contact of the pluton with its wall rocks is very irregular and there is a narrow metamorphic aureole of hornblende hornfels developed in the country rocks. In places adjacent to the outer contacts the hornblende crystals define a lineation, but it is not consistent, even over a single outcrop. It probably originated during convective flow within the magma body and the variability of the lineation may reflect turbulent eddies adjacent to the chilled marginal zone. Occurring locally at the contact are discontinuous layers, 1-10 cm thick, of variable composition (Fig. 48.5). They are more or less parallel to the margin and truncations by successive layers are common. Another characteristic feature of the margin of the Yen pluton is the occurrence of zones of intrusion breccia that range up to 1 km wide. Figure 48.6 depicts somewhat typical relationships found along much of the western margin of the pluton, where there are large areas of intrusion breccia. Continuous north-south strips, or zones, of breccia are made up of blocks of similar rock type, such as schist or diorite, with little or no rotation of individual enclaves. That is, the foliation varies little in direction from block to block, yet in the two-dimensional view seen on the outcrops each block is surrounded by granodiorite. In general, diorite and quartz diorite enclaves are angular (Fig. 48.7), while schist enclaves are elongate and irregular in shape (Fig. 48.8). Where the pluton intrudes older gabbro, veins of granodiorite fill fractures, and enclaves occur only immediately next to the contact (Fig. 48.9). Large tongues of granodiorite with sparse, partly digested xenoliths, intrude the zones of intrusion breccia (Fig. 48.6). They probably represent pulses of magma that migrated upwards after the intrusion breccias had formed. Similar features, but on a smaller scale, are seen where younger granites intrude the Yen. Figure 48.10 shows a large enclave of Yen granodiorite veined by aplite and included in a younger granite. Close inspection (Fig. 48.11) shows that the younger granite cuts the aplites. This suggests that either

Figure 48.5. *Discontinuous compositional banding in marginal facies of Yen pluton. Pen in upper right for scale. (GSC 204112-P)*

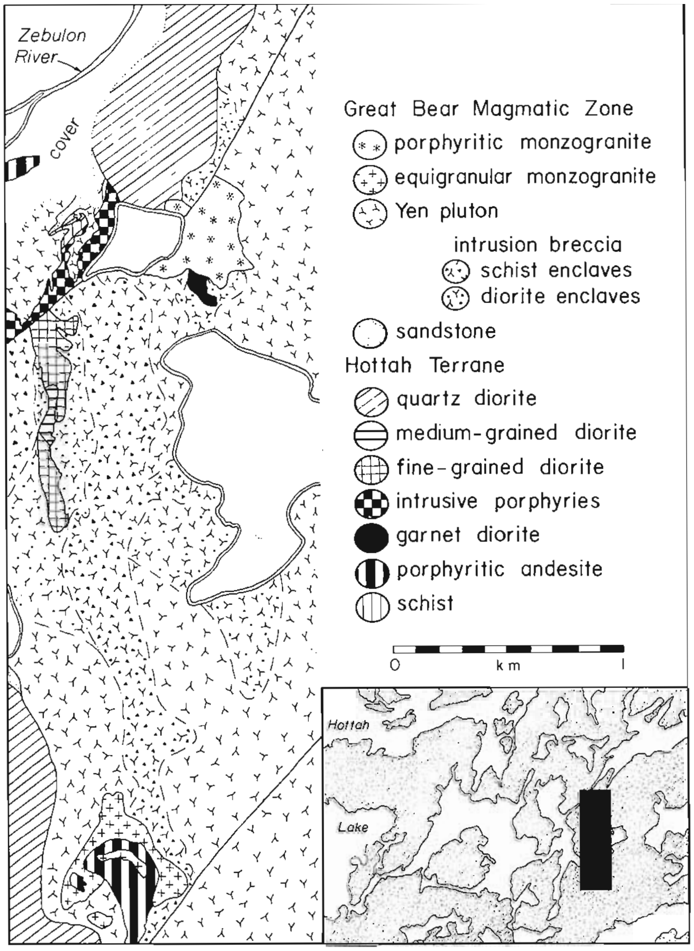


Figure 48.6. *Geological sketch map of part of the west margin of the Yen pluton showing distribution of intrusion breccias and "ghost stratigraphy".*

Figure 48.7. *Intrusion breccia of diorite blocks in granodiorite near margin of Yen pluton. (GSC 204112-H)*

the aplites and the younger granite are unrelated or that the aplites represent an earlier pulse of magma from the same body as the younger granite. Because aplites are not known to cut the Yen, except where it is in contact with younger granitoid bodies, the second possibility is favoured.

Where the Yen pluton intrudes quartz arenite, the sandstone is disaggregated and individual grains of quartz are included in the granodiorite. The net effect is to make the granodiorite in the immediate vicinity richer in quartz.

Where the pluton cuts other rock types, xenoliths become smaller, more irregular and more diffuse away from the contact. Ultimately, the xenoliths either sink or are completely digested and the only evidence of their former existence are small clots of biotite.

The above evidence suggests that the Yen pluton intruded, at least in its final stages, by block stoping. Inclusion of different rock types may affect the chemical, and hence modal, composition of the pluton, but without knowing the composition of the original magma we are unable to evaluate the changes quantitatively.

Figure 48.8. *Intrusion breccia of schist blocks in granodiorite near margin of Yen pluton. Compare the shape of these blocks with those in Figure 48.7. (GSC 204112-L)*

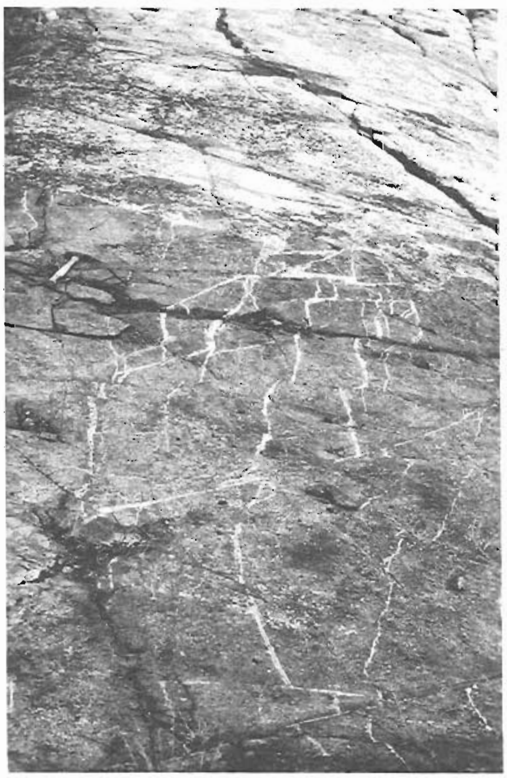


Figure 48.9. *Yen granodiorite intruding Great Bear gabbro. (GSC 204112-D)*

Figure 48.10. *Large block of Yen granodiorite in younger monzogranite. Pen in centre for scale. (GSC 204112-F)*

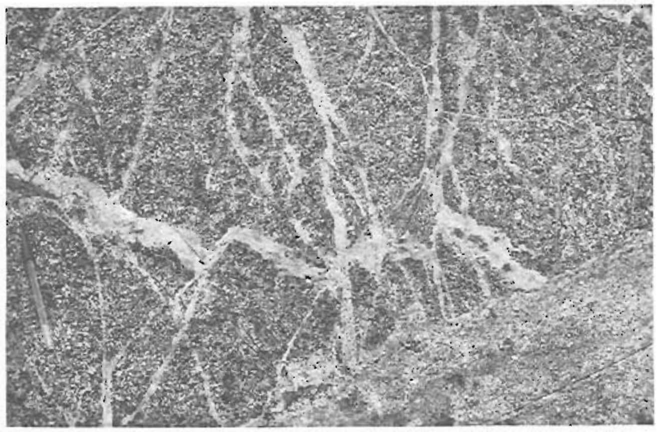


Figure 48.11. *Detailed view of contact between Yen granodiorite (top) and younger monzogranite (bottom right). Note that the monzogranite intrudes the aplite veins in the granodiorite. (GSC 204113-D)*

Stairs Bay syenogranite. This pluton (Fig. 48.2) is a massive porphyritic biotite syenogranite. Phenocrysts of potassium feldspar are 1-3 cm long and are subhedral to euhedral. Subhedral crystals of plagioclase range up to 1.5 cm. Both feldspars occur in a fine- to medium-grained matrix of anhedral quartz, feldspar and tiny flakes of biotite. The pluton is cut by swarms of even finer grained porphyritic and nonporphyritic granite bodies. They are probably derived from the same magma body as the Stairs Bay since they only occur within the pluton and are cut by and cut the main body of granite. The outer contact of the pluton is well exposed northeast of Stairs Bay where it dips shallowly beneath Hottah Terrane granite (Fig. 48.12). The contact is razor sharp, very irregular in detail, and has a 1-3 cm thick border phase of very fine grained granite. Inward from this zone there are several metres of quartz-plagioclase-potassium feldspar porphyry with potassium feldspar phenocrysts to 2 cm. This zone contains abundant miarolitic cavities, 10-15 cm across, filled with pegmatitic quartz and potassium feldspar. Most are mineralogically zoned with quartz cores, as are numerous pegmatitic stringers which occur in the more interior parts of the pluton.

Intrusive porphyries

Two northeast-trending porphyries were mapped east of Hottah Lake. They are generally pink-weathering bodies, except at their margins where they weather red. The border

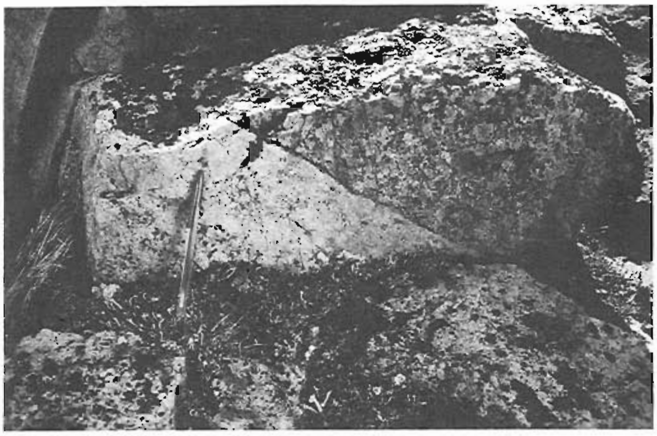
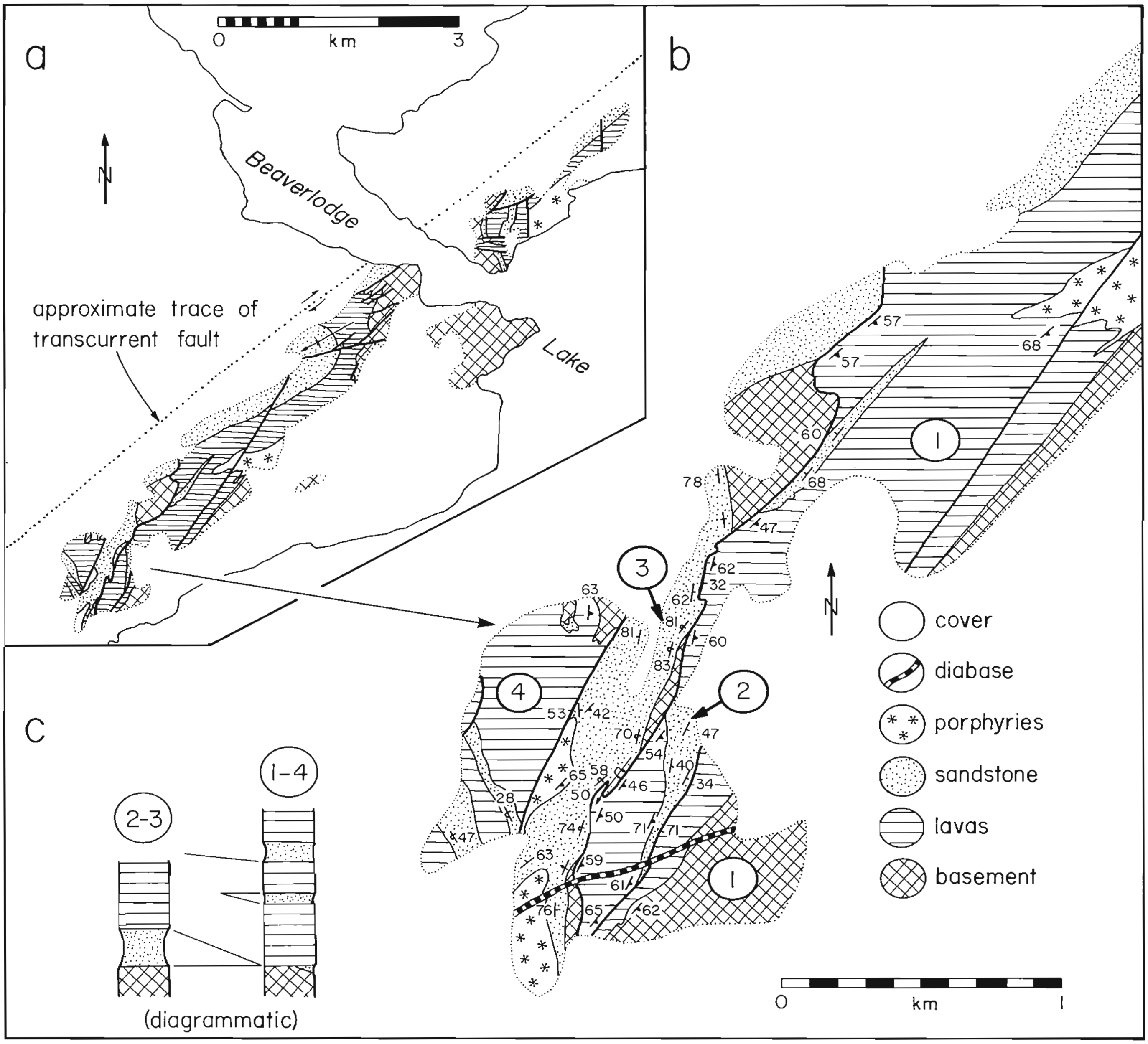


Figure 48.12 (opposite). Shallowly dipping contact between Stairs Bay syenogranite (bottom) and porphyritic granite of the Hottah Terrane. (GSC 204112-O)

Figure 48.13 (below). (a) Geological sketch map showing the geology of the southwestern corner of Beaverlodge Ridge; (b) Geological sketch map illustrating the geology of the thrust faults at the southwestern end of (a), numbers in ellipses refer to individual tectonic slices discussed in the text; (c) schematic stratigraphic sections in the various slices.



phase comprises about 10% anhedral-subhedral phenocrysts of quartz (1 mm) in a dark red aphanitic matrix that is locally flow-banded. The cores of the bodies contain up to 20% clear, greyish quartz phenocrysts ranging from 2-4 cm across, 5-30% subhedral to euhedral potassium feldspar crystals (2-5 mm), and less than 5% greenish subhedral plagioclase phenocrysts up to 3 mm long.

Two more porphyry bodies occur northeast of Stairs Bay where they intrude Hottah Terrane syenogranite, Great Bear volcanic and sedimentary rocks, and the Stairs Bay syenogranite. Age relations between the two bodies are unknown. In general, the porphyries weather grey or brown and contain mostly anhedral quartz (1-3 mm) and subhedral plagioclase (3 mm) phenocrysts in a dark aphanitic matrix. In places the eastern body also contains phenocrysts of hornblende and potassium feldspar.

Various small porphyry bodies cut volcanic and sedimentary rocks on Beaverlodge Ridge. They generally weather orange-red or green unless they are altered when they weather white. Total phenocryst abundance reaches 30-35%. The phenocrysts are mostly subhedral to euhedral laths of plagioclase (3 mm), in places flow-aligned, 1 mm prisms of amphibole, tiny clots of biotite, resorped subhedral potassium feldspar, and blue-grey to purple anhedral quartz phenocrysts.

Many other porphyries, mainly dykes and sills too small to show on the map, occur throughout the area. They are most common east of the southern half of Beaverlodge Lake, where they range from hornblende-plagioclase to quartz-potassium feldspar-plagioclase porphyritic.

Structure

Normal faults. Numerous normal faults that cut the oldest rocks of the Great Bear Magmatic Zone were mapped during the field season. The faults do not, for the most part, cut all of the supracrustal rocks but either die out upsection or are overstepped by younger rocks. Therefore, the faults are considered to be synvolcanic. The best examples occur on Beaverlodge Ridge just south of the narrows in Beaverlodge Lake, east of Beaverlodge Lake, and bounding paleovalleys northeast of Stairs Bay. They are similar to the swarm of normal faults mapped on Bell Island (Hildebrand et al., 1983) and may be related to those postulated to exist in the Conjuror Bay area (Hildebrand, 1983). Since in each area the faults cut correlative rocks that sit unconformably on the Hottah Terrane, a period of widespread extension was likely during the initial stages of Great Bear magmatism.

Transcurrent faults, folds, and flower structures. All of the early Proterozoic rocks of the area except younger diabase and gabbro are cut by northeast-trending transcurrent faults, most of which have right lateral separation (Fig. 48.2). They are part of a much larger swarm that occurs not only throughout the Great Bear Magmatic Zone but throughout Wopmay Orogen. They are thought to have been generated by east-west compression during plate collision west of Hottah Terrane (Hoffman et al., 1982).

Rocks of the Great Bear Magmatic Zone and Hottah Terrane (Fig. 48.13a) are folded into a large southwesterly trending and plunging syncline located on southwest Beaverlodge Ridge. The southwest trend of this fold is markedly different than the northwest trend typical for folds in the Great Bear Zone. North-northeast-trending thrust or reverse faults truncate the southeast limb of the fold in the southwest (Fig. 48.13b). The fault separating slice 1 from slice 2 (lower part, Fig. 48.13b) dips steeply (50-70°) to the southeast. Rocks in slice 1 dip approximately 50-60° to the northwest and those in slice 2 define a reclined isoclinal fold in the sandstone too tight to show on Figure 48.13b. Both limbs of the fold are roughly coplanar with the fault. The fault between slices 1 and 3 also dips to the southeast, but more gently (30-60°) than the fault between 1 and 2. The fault itself is tightly folded into southwest-trending reclined folds that plunge about 50° to the southwest. The rocks in slice 3 are, for the most part, overturned such that Hottah basement structurally overlies basal Great Bear sandstone. Rocks within a few metres of both of the above faults have a strong cleavage (Figs. 48.14, 48.15) that is approximately coplanar with the fault zones. However, the actual fault zones are marked by a few centimetres of vein quartz containing angular fragments of country rocks. The fault between slices 3 and 4 is not exposed, but rocks in slice 4 are overturned to the northeast.

The southwest-trending syncline and the reverse or thrust faults occur just south of a major transcurrent fault, as shown in Figure 48.13a. East of Beaverlodge Lake there are more reverse faults that occur along the south side of another transcurrent fault (Fig. 48.16). The strata in those slices dip steeply to the northwest and are overturned. The faults in that area appear to join, or climb out of, the transcurrent fault zone. The origin of the reverse faults is problematic but because they seem to be spatially related to the transcurrent faults they may be another manifestation of east-west shortening like the transcurrent faults and have been active synchronously with them. The geometry and relationships of the reverse faults to the transcurrent faults are remarkably similar to thrust and reverse faults thought to occur in wrench zones elsewhere (Harding et al., 1983). They call such faults "positive flower structures", presumably

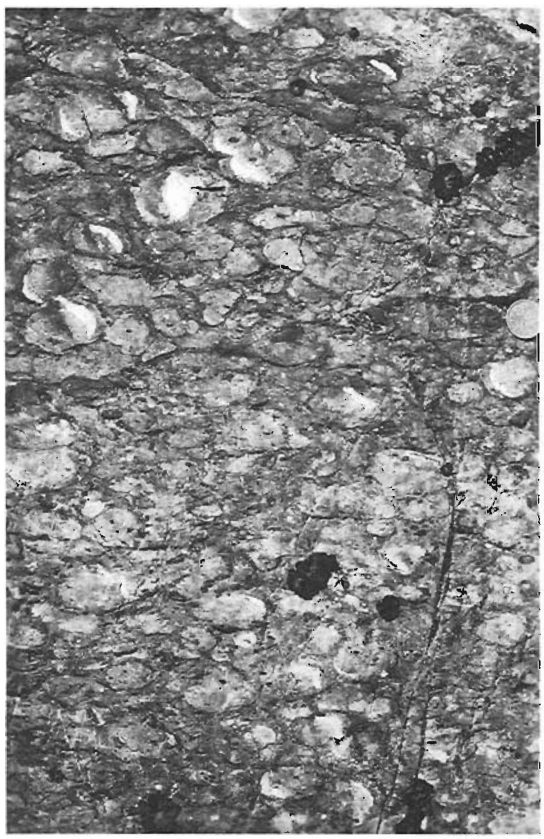


Figure 48.14. *Spherulites and crescent-shaped amygdules in Great Bear lava flow. The spherulites are slightly flattened in this photo. Photo taken 20 m from fault between slices 2 and 3. (GSC 204112-X)*

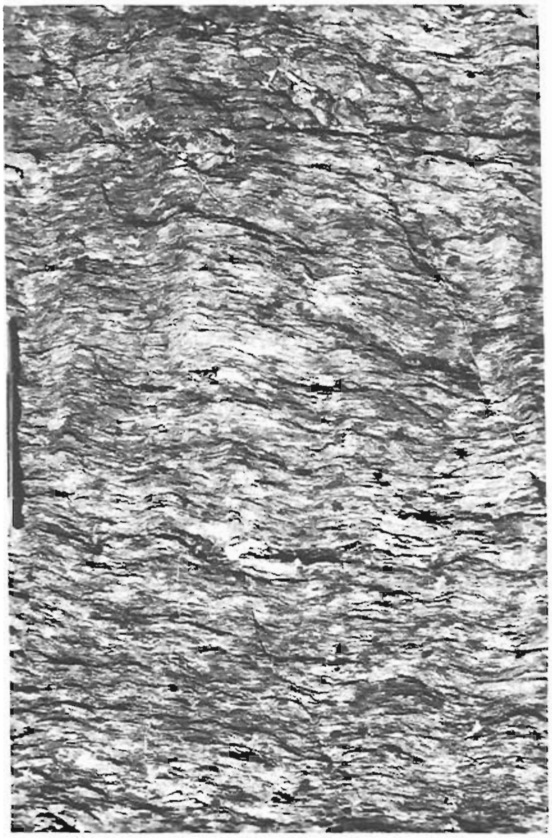


Figure 48.15. *Strongly flattened spherulites in Great Bear lava flow. Photo taken 2 m from fault separating slice 2 from slice 3. This is the same lava flow as that shown in Figure 48.14. (GSC 204112-W)*

because they grow up and blossom out of transcurrent faults. Faults of this type develop in order to accommodate a component of vertical extension. Thus, there can be considerable thickening, at least locally, during deformation. This is somewhat different than transcurrent faulting in the externides of Wopmay Orogen where Tirrul (1984) has shown that transcurrent deformation closely approximates plane strain, except in areas of extreme fault rotation where there is minor thickening by reverse faulting.

When the deformation deviates from plane strain then the fault patterns and separations may be very complex, for as shortening progresses new faults are born, some lock and die, and others continue to have slip along them. Ultimately this leads to a pattern of braided strike, reverse, and oblique slip faults whose kinematic history may be exceedingly difficult, if not impossible, to unravel.

Tectonic implications. The recognition of a suite of deformed intermediate plutons in Hottah Terrane has important implications for the tectonic evolution of Wopmay Orogen. The suite is compositionally similar to plutonic suites of continental magmatic arcs and was emplaced between 1.914-1.90 Ga (Hildebrand et al., 1983; Bowring, in prep.). Since the age of initial rifting in Coronation Margin is 1.90 Ga (Hoffman and Bowring, 1984), Hottah Terrane could not represent an active arc beneath which Coronation Margin was subducted, but the constraints on the ages of deformation in Hottah Terrane and Coronation Margin suggest that deformation in both areas was synchronous (Hildebrand et al., 1983). This, coupled with the overall eastward vergence of Calderian structures throughout

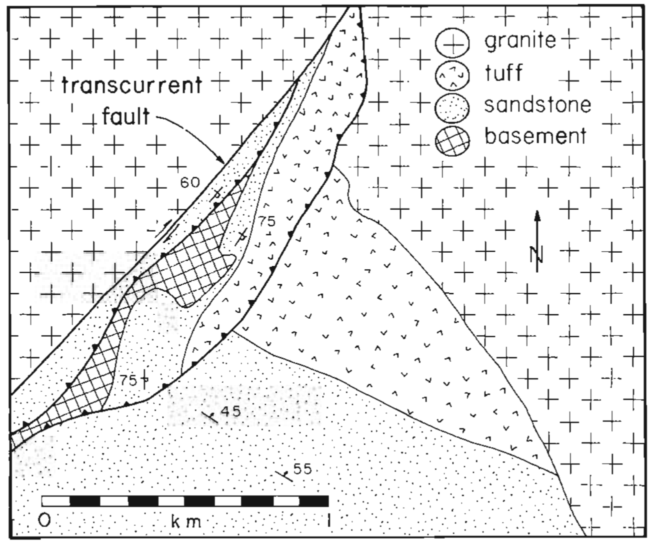


Figure 48.16. *Geological sketch map, east side of Beaverlodge Lake, showing reverse, or thrust, faults merging into transcurrent fault.*

the foreland (Tirrul, 1983) and hinterland (King, 1984) of Wopmay Orogen, suggest that the Hottah Terrane collided with and partly overrode the Coronation Margin. We had originally favoured a model in which Hottah Terrane was exotic with respect to Coronation Margin because of the absence, in Hottah Terrane, of Archean basement (Hildebrand et al., 1983). To date, however, we have not found basement of any age in Hottah Terrane and therefore the possibility exists that Hottah Terrane was rifted from Slave Craton at about 1.90 Ga.

If one accepts the possibility that Hottah Terrane was an arc between 1.914-1.9 Ga, and that it was contiguous with Slave Craton before 1.90 Ga, then subduction must have been easterly because rifting in Coronation Margin did not begin until 1.90 Ga. This implies that Coronation Margin developed in a back arc setting. The principal objection to a back arc model is that there is no arc-derived airfall tuff in the Coronation passive margin (Hoffman and Bowring, 1984) as expected for an active arc located to the west, for paleowind directions were from the southwest toward Coronation Margin (Hoffman et al., 1983). The key word here is active, for if, as the geochronology suggests, arc volcanism in Hottah Terrane shut down coincident with rifting in Coronation Margin then there would be no tuff deposited on the margin and the major objection to a back arc setting would be removed. Arc magmatism may have stopped due to a change in interplate slip vector (e.g. oblique convergence to oblique divergence), which could possibly lead to back arc extension. When convergence resumed, the back arc basin closed and the Hottah Terrane was thrust back against the Coronation Margin.

There need not have been an active arc related to closure of the back-arc basin for there may have been no oceanic crust between the older rifted Hottah Terrane arc and Coronation Margin. Alternatively, if there was oceanic crust between them, the ocean may not have been wide enough for the descending slab to reach the 100 km depth necessary for the generation of arc magmatism (Marsh, 1979). Quite simply, for a slab dipping at 30° the ocean would have to be at least 200 km wide for the leading edge to even reach 100 km depth, and for a 15° dipping slab it would have to be nearly 400 km. In the case of Coronation Margin the ocean would have been floored by young, buoyant oceanic lithosphere or thinned continental lithosphere and the dip of the slab would probably have been very shallow (Molnar and Atwater, 1978).

Furthermore, if the resumption of east-dipping subduction is linked to the closure of the back-arc basin, then one would expect arc magmatism to resume 5-15 Ma later. This is because it would take 20 Ma for a 30° dipping slab converging at 1 cm/year to reach 100 km depth and nearly 8 Ma for a 15° dipping slab converging at 5 cm/year to reach the same depth. This prediction is consistent with the observed onset of Great Bear arc magmatism at about 1.875 Ga (Hoffman and Bowring, 1984), 10-15 Ma after the onset of Calderian Orogeny. Thus, the geology and geochronology are compatible with the Coronation Margin evolving due to opening and closing of a back-arc basin synchronous with a magmatic lull in the arc.

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