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Preliminary report on

THE GEOLOGY OF THE FLAVRIAN AND POWELL PLUTONS, COUNTY OF ROUYN-NORANDA

by

Raymond Goldie

Dept. of Geological Sciences

Queen's University

Kingston, Ontario

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1. Introduction

The Flavrian and Powell plutons in Rouyn, Beauchastel and Duprat townships, Québec, were chosen for study because, although they appear to have played an integral part in the geological history of an important mining camp, they had never been mapped as a unit.

2. Acknowledgements

I thank Mr. Marc van de Walle of the Ministry of Natural Resources, Rouyn, for having suggested the topic. He and Mr. J. MacIntosh, the Resident Geologist at Rouyn, are also thanked for their great help during the field program. Mr. Brian Kotila, who was sponsored by Queen's University, Kingston, Ont., provided competent field assistance in 1973. Drs. C. J. Hodgson and T. H. Pearce reviewed this manuscript.

The support of the Québec Ministry of Natural Resources in 1972, and of Queen's University and the National Research Council of Canada in 1973 is gratefully acknowledged.

3. Access

Most of the mapped area within Rouyn and Beauchastel townships is within a mile of a road. Mining and logging roads extend into Duprat township, but terminate up to three miles from some of the more remote exposures. Although Flavrian Lake is suitable for canoe travel, the streams which link the other lakes of the area are clogged by beaver dams.

4. Previous work

Parts of the area have been previously mapped by Cooke et al (1931), Robinson (1940, 1943), Mackenzie (1941), Kindle (1941), Wilson (1941, 1962), L'Espérance (1950, 1951, 1952), Mathewson (1950) and Behr et al (1958).

Publications by Dugas (1960, 1965) and Hogg (1960) supplement some of the Québec government's 1 inch:1000 ft. compilation maps of the area (N.E. Duprat (1950), S.W. Duprat (1959), S.E. Duprat (1950), N.W. Beauchastel (1960), N.E. Beauchastel (1965) and N.W. Rouyn (1953)).

Maps in the files of the Resident Geologist, Rouyn, which were found useful are those of Lee-Poirier (1942: S.W. contact of the Flavrian pluton), Héré Fault Copper Co. (1957 and 1958: the eastern Powell pluton), Joliet-Quebec Mines Ltd. (1959: The eastern Powell pluton), Marcon Mines Ltd. (1962: The eastern Powell pluton) and Waite Dufault Mines Ltd. (1969: S.W. Duprat township).

Gussow (1937) was the first to describe and chemically analyze the Flavrian pluton: his work is the basis for calling the acid rocks of the Powell and Flavrian plutons "tonalites". Other names which have been applied to these rocks are "siliceous granite" (Cooke et al, 1931), "granodiorite" and "alaskite" (Kindle, 1941, Wilson, 1941 and L'Espérance, 1952), "albite granite" (Robinson, 1943 and Hogg, 1960), "quartz tonalite to alaskite" (L'Esperance, 1951) and "pink granodiorite" and "grey quartz diorite" (the central and marginal facies respectively: Goodwin and Ridler, 1970). Further chemical analyses were published by Wilson (1941) and Webber (1962).

Volcanic rocks of the Rouyn-Noranda area have been dated by Dey Sarkar (1971), who obtained a Rb/Sr isochron age of $(2.53 \pm 0.7) \times 10^9$ yr. (using $\lambda = 1.39 \times 10^{-4}$/yr., Dey Sarkar, pers. comm., 1973). Krogh and Davis (1971) dated samples from the Dufault granodiorite and from the Don Rouyn pit (in the Powell pluton) at 2.755×10^9 yr., and found volcanic rocks from near Montbrun to be "a few million years older" (U-Pb (zircon) method:

locations of the samples were personally communicated by Krogh, 1973).

Wilson (1941) considered the relative ages of rock units in the area to be as follows:

	↑	syenite and "later diabase"
		minor mafic and felsic dikes
		Powell pluton and Flavrian pluton
decreasing		minor mafic and felsic dikes
age		major quartz diorite intrusions
		minor mafic and felsic dikes
		volcanics

Bibliographies of descriptions of mines and showings in the area have been compiled by the Quebec Dept. of Natural Resources (1967) and Waddington (1969).

5 Field work

The writer spent 2 1/2 months in 1972 and 4 months in 1973 in the field.

All of the areas previously mapped as part of the Flavrian and Powell plutons, and some adjacent areas were examined. Except for a small portion of the Powell pluton in the eastern part of the township, the mapping in Beauchastel township was done at a scale 1:5000. All other exposures of the Powell pluton and most other exposures of the Flavrian pluton were mapped at 1 inch:1 mile. Several small critical areas were mapped at a scale of 1:500.

The traces of most of the faults in Figs. 1 and 2 are from Sharpe (1967) and a 1962 map by Marcon Mines Ltd. of the eastern Powell pluton.

6. General Geology

6.1 General classification of the rocks

Cobalt Series conglomerate *

Keweenawan-type diabase dikes

Alkaline dikes *

F Felsitic dikes and plugs

D Dioritic dikes

JX St. Jude Breccia

TN Nora Leucotonalite

TH Hybrid tonalitic rocks

TX Tonalitic breccia

T Undifferentiated tonalitic rocks

MD Méritens Diorite

HD Héré Melatonalite

Chert *

B Mafic volcanic rocks

A Felsic volcanic rocks

* Exposures are too small to be shown on Figure 1.

6.201 Stratigraphy and structure of some mafic volcanic rocks, B.

The following stratigraphic succession occurs in mafic volcanics to the east of the small south-trending lobe of tonalite at the southern end of the Flavrian pluton:

Unit 2		- top not seen
	upper	heterogeneous flow breccia with feldspar phenocrysts
		- contact not seen: probably gradational
	middle	pillowed and massive aphyric volcanics
		- contact not seen
	lower	pillowed and massive feldspar porphyritic volcanics
		a few mm. of chert
Unit 1	upper	heterogeneous flow breccia with feldspar phenocrysts
		- gradational contact
	middle	pillowed and massive aphyric volcanics
		- contact not seen
	lower	pillowed and massive feldspar porphyritic volcanics
		- base not seen

Except in the area within a few hundred metres of the tonalite lobe, bedding in this sequence dips gently to the northwest. Beds close to the lobe, however, may dip steeply to the east and locally are even overturned: this disturbance is attributed to emplacement of the tonalite.

Breccia, overlain by pillowed lavas (probably corresponding to upper Unit 1 and lower and middle Unit 2 respectively) is found on the western side of the tonalite lobe. Beds in these rocks dip very gently to the southeast.

The structures mapped in this area therefore define a gently-folded, south-plunging syncline, the axial plane of which probably dips east at about 80°. The core of the syncline is occupied by the lobe of tonalite (Fig. 1). The syncline is so gently folded that is is not apparent whether or not satellite dikes of the tonalite lobe were folded with the volcanics, and hence whether or not emplacement of the tonalite preceded regional deformation. Careful measurements of the exact attitudes of approximately vertical columnar joints, which are ubiquitous in the tonalite lobe, may solve this problem.

6.202 Héré Melatonalite, HM

Highly altered melatonalitic rocks which occur as blocks up to 1 1/2 km in diameter within the Powell pluton are here named Héré Melatonalite, HM, after a lake which overlies part of the largest block of the unit. Although no lithologic variations are discernable on weathered surfaces, on fresh surfaces it can be seen that HM is heterogeneous, with quartz-rich and quartz-poor varieties occurring in close proximity.

HM fragments constitute the bulk of recognizable xenoliths in the tonalite breccia (TX) of the Powell Pluton. Although TX grades into hybrid tonalite (TH), there is no evidence of hybridization at the contacts of the main blocks of HM. In this respect, HM differs from Méritens Diorite, MD.

Age Relationships

Tonalitic (T) and dioritic (D) dikes and felsitic (F) dikes and plugs are common and locally very abundant in HM. HM appears to be in chilled contact with felsic volcanics of the Blake River Group, but alteration has made interpretation difficult. It is, in fact, possible that the volcanics were deposited nonconformably on a basement of Héré Melatonalite.

6.203 Méritens Diorite

A rock type found only within the Flavrian pluton is here named Méritens Diorite, MD, after a lake near the most extensive exposures of the unit. MD is a fine to medium grained dioritic to tonalitic rock which contains about 40% mafic minerals (amphibole and chlorite), up to 20% quartz, and 45% or more plagioclase. Contacts with the enclosing tonalitic rocks (T, TH, TX) are steep; and either sharp, with MD clearly the older rock, or gradational. At gradational contacts, MD, by the appearance of quartz phenocrysts and glomerophenocrysts, and a tendency of amphiboles towards an acicular habit, increasingly resembles hybrid tonalite (TH) over distances of up to tens of metres. The majority of xenoliths of recognizable provenance in the tonalitic breccia (TX) of the Flavrian pluton are MD. At the northeast end of the northeast **trending** block of MD (Fig. 1), xenoliths of mafic volcanics occur within MD, and MD dikes cut mafic volcanics.

MD is cut by tonalitic (T), dioritic (D) and felsitic (F) dikes.

6.204 Tonalite of the Flavrian and Powell plutons, T

Description

In Fig. 1, tonalitic rocks are subdivided into undifferentiated tonalitic rocks (T), hybrid rocks (TH), breccia (TX) and Nora Leucotonalite (TN).

T consists mainly of quartz and feldspar with up to 25% mafic minerals (especially chlorite, amphibole and epidote). Pyrite is abundant and magnetite or chalcopyrite pods up to several cm. in diameter occur rarely. Apart from a quartz-magnetite-biotite vein, biotite appears to be absent from the unit.

The average grain size of the rock and the relative proportions of each mineral may vary greatly in a single exposure. Spherulitic tonalite is common: the spherulites are comprised of granophyric intergrowths of quartz and albite.

Age relationships within tonalitic rocks

Evidence that the Flavrian and Powell plutons are multiple intrusions is provided by xenoliths, dikes and internal contacts.

Tonalitic xenoliths, lithologically similar to the surrounding rock, occur rarely in both plutons.

Leucotonalite ("aplitic") dikes are common in both plutons, are cm. to dm. wide, have highly variable orientations, and sometimes grade along strike into the rocks they cut. Such dikes probably represent a late differentiate of the host tonalite. Other, more mafic tonalite dikes within T occur rarely and may have a similar origin, or may be apophyses of younger tonalitic intrusions.

Only one major internal contact was found within T. In the southwest portion of the Flavrian pluton, a sharp contact which separates two similar tonalitic rocks could be traced for 160 m. The southern, slightly more felsic unit is the younger. Further evidence for multiple intrusion of tonalitic rocks is presented in section 6.206, where it is shown that TH is probably contaminated T, and that TH is sometimes in sharp contact with T.

Age relationships between tonalitic and other rocks

All the contacts observed between tonalite (T) and volcanics, between T and Méritens Diorite (MD) and T and Héré Melatonalite (HM) are unambiguous: T is the younger rock.

With the following exceptions, felsitic intrusions (F) cut tonalitic rocks. South of the largest block of HM in the eastern Powell pluton, and in lot 39, Range IV, Duprat township, hybrid tonalite, TH, is cut by F dikes which are in turn cut by T dikes. In lot 42, Range IV, Duprat township, an F dike in T is itself cut by a dike of T. Xenoliths of Méritens Diorite, MD, in tonalitic breccia (TX) in lot 33, Range III, Duprat township contain F dikes.

With the following exceptions, dioritic dikes (D) cut T. In the southwest portion of the Flavrian pluton, the easterly-trending D dike depicted in Fig. 1 cuts the pluton, but has been intruded by T near the contact with the volcanics. In the Powell pluton (e.g., in the exposures immediately north of the turn-off to the Don Rouyn pit) T transects feldspar porphyritic mafic dikes. Other ostensible instances of T cutting D may in fact be pegmatitic segregations within large intrusions of D.

To summarize, emplacement of T was intermittent, and overlapped in time with intrusion of dikes of F and probably of D.

6.205 Tonalitic breccia, TX

TX is a breccia comprised of xenoliths in sharp contact with a tonalitic matrix. (Rocks characterized by fragments with gradational contacts were classified as hybrid tonalite, TH. However, many exposures classified as TX, especially in the Powell pluton, are locally TH.) Ten percent xenoliths were chosen as the dividing line between tonalite (T) and breccia.

Six types of xenolith occur:

1. fine-grained chloritic rocks

2. rare fine-grained felsic fragments

3. dioritic to tonalitic rocks, more mafic and generally more fine-grained than the enclosing rock

4. Méritens Diorite, MD (in the Flavrian pluton)

5. Héré Melatonalite, HM (in the Powell pluton)

6. Hybrid tonalite, TH (in the Flavrian pluton).

The xenoliths range from cm. to m. in diameter and are usually rounded to subrounded, whether or not the xenolith displays evidence of reaction with the host rock.

Two styles of reaction between xenoliths and T were recognized. Recrystallization of xenoliths to a coarser-grained rock with stubby amphiboles and irregular felsic veins characterizes the first style. Vague, rounded "ghost xenoliths" are interpreted as an extreme product of this style of assimilation.

Five features characterize the second style of assimilation which is by far the most common:

1) Occurrence of quartz phenocrysts and glomerophenocrysts (up to 1 cm. in diameter) within the xenoliths and, less abundantly, in the host tonalite up to metres away from xenoliths. These phenocrysts may be rimmed by an amphibole layer (up to 1 mm. thick) which is often, in turn, rimmed by up to several mm. of intergrown feldspar and quartz.

2) Xenoliths are often surrounded by a halo, up to several mm. wide, of unusually felsic tonalite which may in turn be rimmed by a zone of tonalite more mafic than usual.

3) Amphiboles, which are commonly coarser-grained and more acicular than those in apparently unassimilated xenoliths, tend to occur in clumps with "felsic haloes".

4) The felsic haloes which surround clumps of amphiboles, quartz phenocrysts and the exteriors of the xenoliths are often interconnected,

giving the xenoliths a blotchy appearance.

5) Variable grain size of the xenoliths with the average grain size greater than that of unassimilated xenoliths.

Although TX grades into hybrid tonalite, TH, over tens of metres, contacts with T are sharper: xenolith concentrations rise from near zero to tens of percent over a metre or less.

6.206 Hybrid tonalitic rocks, TH

The features characteristic of the most common style of reaction between tonalite and xenoliths (section 6.205), namely quartz phenocrysts and glomerophenocrysts, felsic haloes, coarse acicular amphiboles and variable grain sizes; are also typical of TH.

Two main types of TH occur:

Type 1: tonalite without a fragmental texture.

Type 2: breccia in which the majority of fragments are Type 1 TH. At least some of the xenoliths are in gradational contact with the tonalitic matrix, and the characteristic hybrid features may be present in the xenoliths and matrix, or in the xenoliths alone.

Relationships between TH and older rocks

TH sharply transects Héré Melatonalite, HM, and sometimes Méritens Diorite, MD. However, contacts between TH and MD are usually gradational. Xenoliths and outliers of mafic volcanics are invariably in sharp contact with TH, but show no signs of assimilation.

Relationships between TH and younger rocks

Contacts between TH and T are usually gradational, but in two localities they are sharp. In lot 34, Range IV, Duprat township, TH sharply abuts against T, and in lots 38 and 39, Range V, Duprat township, the same TH is in sharp contact with Nora Leucotonalite, TN. However, the TH is also cut by several TN dikes, some of which grade along strike into the TH.

Interpretation

TH is interpreted as Héré Melanotonalite (HM), Méritens (MD) and possibly other rocks, in varying degrees of assimilation by tonalitic rocks (T). To account for the ubiquity of gradational contacts between MD and TH, and the almost complete lack of macroscopic evidence for alteration of volcanic rocks in contact with TH, it is further suggested that much of the MD was still hot, perhaps locally liquid, when hybridized. Gradational terminations of TN dikes in TH are ascribed to emplacement of TN while the TH was still hot.

6.207 Nora Leucotonalite, TN

A felsic (<5% mafic minerals) tonalite occurring in the vicinity of Lake Nora is here named Nora Leucotonalite. The nature of the contact with more mafic tonalite (T) to the west is unknown. Other relationships of TN are discussed in section 6.206.

6.208 St. Jude Breccia, JX

This rock is composed of angular fragments (of the order of cm. to m. in diameter) of diorite, tonalite and mafic and felsic volcanics. In the sample taken, the matrix is a green mafic rock with abundant sulphides and white feldspar phenocrysts. However, according to Robinson (1943), the matrix is "granitic".

The attitude of the body of JX is unknown.

6.209 Dioritic and felsitic intrusions

Dioritic Intrusions, D

These rocks contain about 50% feldspar, up to 15% mafic minerals (chlorite and stubby hornblende), up to 15% quartz and minor though ubiquitous sulphides (pyrite, chalcopyrite and pyrrhotite). Although D is usually massive and equigranular, quartz and feldspar porphyritic, pegmatitic, and banded variants occur.

D dikes range from cm. to hundreds of metres wide. The orientations of those mapped in the southern Flavrian pluton were rarely consistent for more than a few hundred metres.

Felsitic intrusions, F

Rocks of this unit are aphanitic to fine-grained, and may contain phenocrysts of quartz and feldspar (up to 5 mm. in diameter) and spherulites (up to 1 cm. in diameter). Quartz and feldspar constitute most of the groundmass. Some dikes possess banding (defined by colour variations or alignment of spherulites) which either runs parallel to the dike walls, or is contorted and isoclinally flow-folded about axes parallel to the dike walls.

No dikes with compositions intermediate between F and D were found.

F occurs as isolated dikes, as swarms of dikes which have so intensely intruded the country rock and one another that virtually no country rock is left, and as plug-dike complexes. The latter consist of plugs with ovoid cross sections, which are interconnected by the dikes which project irregularly from them. The orientations of the dikes are controlled by pre-existing fractures in the host rock, and are crudely radial.

Weeks (1963) described two felsite bodies in the Quemont mine which resemble those described above: both are vertical and pipe-like or conical, have observed vertical extensions of up to 1 km. and cross-sectional areas of up to 150,000 m^2.

Age relationships between F and D

In the Flavrian pluton, one F dike is cut by D, two D dikes are cut by F and two D dikes are cut by other D dikes.

Intrusion of F and D was much more intense in the Powell pluton. Fault zones are commonly discontinuously occupied by dikes sheared parallel to themselves, indicating emplacement into an active fault.

Analysis of cross-cutting relationships in an area mapped at 1:500 in the southeastern Powell pluton indicates the following history:

	↑
	Faulting
	F dike
	D dike and parallel faulting
	Faulting
	F dike and parallel faulting
decreasing	F dike and faulting
age	F dike
	Faulting
	D dike
	F dike
	Quartz veining
	F dike
	D dike and faulting
	Emplacement of Powell tonalite (T)

Displacements due to faulting were of the order of cm. to metres. There certainly were yet other episodes of diking, faulting and quartz-veining in the Powell pluton.

In neither the Flavrian nor the Powell pluton could irregularities in the shapes of dikes be ascribed to folding.

It is clear that at least some phases of faulting, D diking and F diking were essentially synchronous in the Powell pluton and probably the Flavrian pluton. The spatial association of F and D intrusions (with the exception of the large dioritic body in southern Duprat township) with each other, with the Beauchastel and Horne Creek faults, and with pluton margins (Fig. 2) suggests that faulting and intrusion were fundamentally related.

Age relationships between F intrusions, D intrusions and other geological events

Some F dikes in the Abitibi region were synvolcanic (Fig. 5, Goodwin et al, 1972), whereas others post-date the Timiskaming conglomerate (Graham, 1948). In section 6.204 of this paper it was shown that intrusion of F and perhaps D overlapped in time with emplacement of the Flavrian pluton.

South of the Horne Creek fault, felsite plug-dike complexes are commonly boudined, and isoclinally folded about axes parallel to one of the fracture cleavage directions (the most prominent of which is subparallel to the Horne Creek fault, which has a subvertical dip). The three-dimensional attitude of the folds could not be determined, and faulting prevented tracing any fold for more than a few metres.

6.210 Cobalt series conglomerate, Alkaline dikes, and "Keweenawan-type diabase"

A small outlier of conglomerate overlying volcanic rocks near the southern part of the Flavrian tonalite was correlated by Mackenzie (1941) with the Cobalt Series. It therefore post-dates all lithologies discussed above.

Alkaline dikes are of the order of tens of cm. across, and are composed of fresh, fine-grained to medium-grained green or purple rocks, usually rich in biotite and often containing feldspar phenocrysts up to 6 cm. long. Xenoliths are common, and may constitute the bulk of the rock ("pebble dikes"). Mackenzie (1941) considered that these xenoliths were derived from Cobalt Series conglomerate.

"Keweenawan-type diabase" dikes are fresh, and typical of diabase dikes found throughout the Canadian Shield. The dikes are of the order of tens of metres across.

Both alkaline and "Keweenawan-type" dikes transect all lithologies discussed in earlier sections. Mackenzie (1941) found float boulders of Cobalt conglomerate cut by an alkaline dike.

6.3 Alteration of rocks other than Cobalt conglomerate and alkaline and "Keweenawan-type" dikes

Quartz veins, up to metres wide, are common in the plutons. Some were emplaced during a period of faulting, felsitic diking and dioritic diking (section 6.209); others transect all lithologies.

Feldspar veins, up to several mm. in diameter, are rare, and at one locality are cut by quartz veins.

Tonalite in the vicinity of fractures has often been partially leached of its mafic constituents. In some cases this alteration preceded dioritic (D) diking.

The following types of alteration transect all lithologies. Epidote and epidote-quartz occur as veins, blotches up to a few mm. across regularly distributed throughout rocks, and as selective replacement of xenoliths. Chlorite is ubiquitous, and occurs as veins up to a few mm. across, and as an alteration product of feldspars and mafic minerals. Amphibole veins are rare, are up to several cm. across, and are rimmed by a few mm. of quartz and feldspar. Disseminated hematite, and hematite veins (which usually occupy joints) occur throughout both plutons. Pods (up to 1 cm. in diameter) and veins of magnetite and chalcopyrite are rare.

The relationship of alteration to hematite, pyrite, chalcopyrite and bornite mineralization in the Don Rouyn pit is currently being studied by Brian Kotila of Queen's University.

A 20 mm. x 5 m. body elongated N35°E which occurs in lot 55, Range II, Duprat township contains tubular varioles (up to 1 cm. across) and felsic net veining which, in places, follows flow structures of the host felsic volcanics. The contacts of the body can be defined to within a few dm. In lot 40, Range II, Duprat township, there is a roughly circular, sharply bounded area, 30 m. in diameter, of tonalite more felsic than the surrounding tonalite.

These structures may represent alteration pipes which possibly terminated in massive sulphide bodies.

7 Geometric relationships

This study did not directly solve the problem of whether or not the Powell and Flavrian plutons interconnect.

Only one contact was observed between the Powell pluton and the volcanics: it is vertical. In the Horne Mine, the Powell pluton is not found south of the Horne Creek fault but is encountered immediately north of the fault 1200 m. below the surface, about 1250 m. east of the easternmost surface exposure of the pluton (Dresser and Denis, 1949). According to Wilson (1941), the south side of the Horne Creek fault has been displaced downwards and the few surface exposures of tonalite south of the fault are harbingers of a greater mass at depth.

Méritens Diorite (MD) has steep contacts with the Flavrian tonalite, which is younger. The northeastern contact between MD and volcanic rocks (which is collinear with the contact between the Flavrian tonalite, T, and the volcanics) dips moderately to steeply outwards. The MD body in the northern Flavrian pluton appears, therefore, to be a subvertical prism, an interpretation in accord with the aeromagnetic data.

The eastern contact of the Flavrian pluton dips outward at a shallow angle (drill-hole data: A. Spence, pers. comm., 1973). A nearly horizontal dip is inferred in the eastern part of Range II, Duprat township: here a tongue of tonalitic rocks occupies a valley which is surrounded by hills of volcanics. The alteration pipe examined in this area (section 6.3) and the alteration pipe of the "Bedford works" cut the volcanics and are presumed to have emanated from the tonalite magma below.

Tonalite also occupies the low ground, and volcanics the higher exposures around the lobe of Flavrian tonalite in Range VIII, Beauchastel township. Deformation of volcanics by emplacement of the tonalite is very local (section 6.201), and tonalite was not encountered in the Halliwell Mine to the west of the lobe (Mackenzie, 1941). These facts suggest that the lobe is flat-topped, with steep eastern and western contacts.

Two contacts at the southwestern margin of the Flavrian pluton dip outwards at 45° and at 61°. A few hundred meters to the northwest, the contact must be vertical ±45° (from an analysis of borehole data on file with the Resident Geologist, Rouyn). However, aeromagnetic trends cross the southwestern Flavrian pluton without deflection or attenuation: the mafic intrusions which are probably responsible for these trends must lie at no great depth and the Flavrian tonalite must here occupy a thin horizontal wedge. Whether these mafic intrusions predate or postdate the Flavrian tonalite is unknown. A horizontal contact between volcanics and T is also deduced in the area southwest of Lake Nora: in a region of low topography, exposures of volcanics alternate with exposures of T and TH; and in Ranges II and III, Duprat township, an outlier of mafic volcanics is in nearly horizontal contact with T.

These results support the conclusion of Behr et al (1958) that the Flavrian pluton never extended very far above the present erosion surface. The overall geometry of the pluton may be analogous to that of the slightly discordant, sill-like granitic body at the southern end of Sturgeon Lake (Ontario Dept. of Mines, 1970).

Dr. W. Jolly (pers. comm., 1974) found a northward decrease in metamorphic grade, from actinolite-epidote-biotite grade to prehnite-pumpellyite grade, across the Hunter Ck. fault. Thus, if the Flavrian pluton continues north of this fault with its upper surface at the same stratigraphic level, it has not yet been exposed.

As was pointed out in section 6.209, felsitic bodies have nearly vertical dips and may have extended at least 1 km. vertically.

8 Economic geology

Although several gold mines have operated in the mapped area, the only current mining activity is the Don Rouyn pit, operated by Noranda Mines Ltd. as a source of cupriferous siliceous flux for the Horne smelter. This ore-body has been described by Kirkham (1972) as having affinities with porphyry deposits.

9 Summary and Conclusions

The name "Noranda Igneous Complex" is proposed for the suite of rocks considered to have formed during a single Archaean magmatic episode in the Noranda area. The Complex includes the Blake River volcanics, the Powell and Flavrian plutons and associated minor intrusions. It does not include the alkalic and "Keweenawan-type" diabasic intrusives. Further work is needed to determine whether or not intrusions such as the Héré Melatonalite, the fresh dioritic rocks south of the Horne Creek fault in Beauchastel township, the Dufault Granodiorite and the Rouyn and Lake Pelletier "albite granites" (Wilson, 1949,1962) belong to the Complex.

Correlation of igneous rocks in the Noranda area is not a new idea: Dresser and Denis (1949), L'Espérance (1951) and Weeks(1963) considered intrusive felsitic porphyry bodies to be phases of the Powell and Flavrian plutons; Ryznar et al (1967) tentatively correlated such porphyries with volcanic rocks, and van de Walle (1972) considered the Flavrian and Powell plutons to be subvolcanic feeders.

A suggested scheme for the evolution of the Noranda Igneous Complex is outlined below.

Two or three distinct sources of magma; one acid, one basic and possibly one of intermediate composition, were continually tapped during formation of the Complex. Mafic volcanics, dikes and sills were derived from the basic magma. Four facies were derived from the acid magma: felsic volcanics, sub-volcanic feeders (F intrusions), a shallow intrusion (the Powell-Flavrian tonalite pluton) and the St. Jude breccia which is an explosion pipe resulting from a build-up of volatiles. Intermediate rocks are represented by volcanics and by early phases of the Powell-Flavrian pluton.

Volcanic and intrusive activity overlapped in time; for example, emplacement of tonalite began before the last eruptive event. The Complex is considered to be pre-orogenic to syn-orogenic.

Evidence for various aspects of this model is discussed below.

(1) Compositions of igneous rocks of the Noranda area are polymodal

The silica versus frequency histogram of volcanic rocks of the Abitibi belt is trimodal (Descarreaux, 1973) with peaks at about 48%, 63% and 76% silica. Felsitic (F) intrusions and tonalite probably correspond to the most siliceous volcanics; dioritic (D) dikes to the least siliceous volcanics and Méritens Diorite (MD) and Héré Melatonalite (HM) to the intermediate peak.

(2) At least two different compositions of magma were available over long periods

In sections 6.204 and 6.209 it was shown that emplacement of tonalite (T) was intermittent and that intrusions of both felsitic (F) and dioritic (D) composition were emplaced before, during and after emplacement of T. Furthermore, felsic and mafic volcanic rocks were extruded simultaneously in the Noranda area (B.E. Gorman, pers. comm., 1974). Therefore, processes which made available at least two distinct magma types operated contemporaneously during much of the evolution of the Noranda Igneous Complex.

(3) Acid and basic igneous activity were spatially related

F and T intrusions are spatially associated with each other, with the Beauchastel and Horne Creek faults, and with pluton margins (section 6.209). Presumably the same fracture systems controlled upward migration of both acid and basic magmas.

(4) D intrusions are volcanic feeders

Speculation.

(5) F intrusions are volcanic feeders

F intrusions are very fine-grained compared with T intrusions, even though F and T are petrographically similar rocks which presumably were intruded into similar environments, and even though F intrusions may be over 1 km. in diameter. A possible explanation, in accord with the resemblance of F plug-dike complexes to volcanic feeders (section 6.209) is that F intrusions represent tonalitic magma which was quenched during a sudden loss of volatiles to the surface.

(6) The Powell and Flavrian bodies are part of a single pluton

This hypothesis is made on the basis of lithologic similarities.

(7) The Powell-Flavrian pluton is a high level intrusion

The scarcity of pegmatites, absence of gneissic structures, close spatial and temporal association with very fine-grained felsitic bodies and the variable and relatively fine grain size of T all indicate this. In addition, the surrounding volcanics are of low metamorphic grade (Dimroth et al, 1974) and hence have never been deeply buried.

(8) The St. Jude Breccia is an explosion pipe

Speculation.

(9) The Complex is pre-orogenic to synorogenic

(i) Volcanic rocks of the Abitibi belt are pre-orogenic to synorogenic (Goodwin and Ridler, 1970).

(ii) The work of L'Espérance (1951), who concluded that the Flavrian pluton had been arched as part of the "Duprat dome", suggests that emplacement of the pluton preceded, or was synchronous with orogeny.

(iii) The minor intrusions which were emplaced during folding (Espérance, 1951) and faulting (section 6.209) of the Powell-Flavrian pluton are considered to be synorogenic.

(10) <u>The Powell-Flavrian pluton was emplaced during the formation of the Blake River volcanics</u>

The intimate association of Powell-Flavrian tonalite with rocks presumed to be volcanic feeders, the petrological similarities between intrusive and extrusive rocks, and the pre-orogenic to syn-orogenic nature of both pluton and volcanics have been discussed previously. Two other lines of evidence also support the above proposition.

(i) alteration pipes of the synvolcanic (Sangster, 1972) base metal deposits of the Noranda camp are oriented away from the Flavrian pluton (Dugas and Hogg, 1962), suggesting that there was a source of heat (and possibly fluids) in this area during deposition of the Blake River Group.

(ii) Krogh and Davis' (1971) radiometric dating (section 4).

Some aspects of the history of one component of the Noranda Igneous Complex, the Powell-Flavrian pluton, have been deduced in this study. Méritens Diorite, MD, intruded volcanics of the Blake River Group and was, while still hot, invaded by the first of a series of tonalitic intrusions which eventually almost completely enveloped the MD, forming breccias and hybrid rocks. Héré Melatonalite also was formed before intrusion of the tonalite, but may be older than the Blake River Group. Intrusion of dioritic (D) and felsitic (F) rocks commenced before the emplacement of MD and continued during the intrusion, cooling, faulting and alteration of the tonalite.

Some of the major problems remaining are:

(1) Unravelling the hydrothermal and metamorphic history of the Powell-Flavrian pluton.

(2) How can the textures of the hybrid rocks of the pluton be accounted for?

(3) How was the pluton emplaced? L'Espérance (1951) and Behr et al (1958) considered the breccias of the pluton to result from stoping. However, flow structures perpendicular to the trend of the sub-vertical prism of Méritens Diorite (MD) in the north end of the pluton, and the provenance of the xenoliths (largely MD) do not support this interpretation.

(4) What were the relationships between the Powell-Flavrian pluton and deposits of gold and base metals?

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CORRECTION

In Figure 1, an intrusive contact west of Lake Duprat should strike E10°N, not E10°S, and should dip 75° to the north, not to the south. The symbol is shown correctly in Figure 2.