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Résumé de l'article

The Quebec part of the Abitibi volcanic belt is the subject of an intensive research project oriented towards providing detailed petrological and geochemical data integrated with stratigraphy and tectonics. In establishing the changing composition of the volcanic pile in the region north and south of Rouyn (from monotonous tholeiite basalt in the lower sections to intermingled calc-alkaline and tholeiitic series in the higher sections) such diverse subjects as the role of immiscibility in the formation of variolites, and the nature of quench-texture in Archean tholeiites have been investigated. A conference series designed to provide a means of exchange of information between project personnel and researchers investigating related topics elsewhere in Canada was convened. The feedback obtained during the conference series resulted in new directions being initiated within the confines of the project, and a complete traverse of the Abitibi volcanic pile from south of Rouyn to Matagami is planned.

Grenvillian "marble belt" would have been spared the brunt of the deformation.

From the presentations as well as from the discussion, one gets the impression that most experts would agree on the following:

a) The Grenvillian orogeny may be explained in terms of plate tectonics
b) It reactivated a pre-existing complex of plutonic and metamorphic rocks
c) It is not the result of evolution of a miogeocline-eugeocline couplet
d) Archean rocks may well occur farther southeast than a 30 or 50 km fringe inside the Grenville Front
e) The Grenville Front is not a suture line
f) The evolution and history of anorthositic suites is one key to the Grenville problem
g) The Grenville Province may not be unique, but only better known than others of similar age or evolution
h) More field information is urgently needed.

Besides reviews of existing data that brought every one up to date on the state of the art, glimpses of new approaches were given by some speakers. Dallmeyer for instance has successfully worked out the late and post-orogenic uplift history of some Grenvillian terrain in the U.S. Similar work in large areas of continuous Precambrian rocks would be extremely useful to petrographers, tectonicians, and to geophysicists for their crustal studies.

Baragar implied that pre-Grenvillian rift zones in the Grenville Province may be traced by studying the distribution of (metamorphosed) rift-type igneous rocks. In terms of models, the Tibetan is possibly the most intriguing. It may be that the "Grenville problem" will not be one very much longer.

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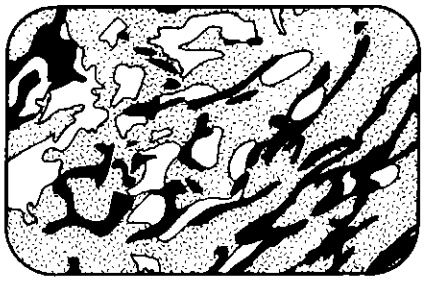

Canadian Shield Volcanic Belts with Emphasis on the Abitibi Volcanic Pile

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Summary

The Quebec part of the Abitibi volcanic belt is the subject of an intensive research project oriented towards providing detailed petrological and geochemical data integrated with stratigraphy and tectonics. In establishing the changing composition of the volcanic pile in the region north and south of Rouyn (from monotonous tholeiite basalt in the lower sections to intermingled calc-alkaline and tholeiitic series in the higher sections) such diverse subjects as the role of immiscibility in the formation of variolites, and the nature of quench-texture in Archean tholeiites have been investigated. A conference series designed to provide a means of exchange of information between project personnel and researchers investigating related topics elsewhere in Canada was convened. The feedback obtained during the conference series resulted in new directions being initiated within the confines of the project, and a complete traverse of the Abitibi volcanic pile from south of Rouyn to Matagami is planned.

Introduction

Commencing in mid 1972, the Minister of Education of the Government of Quebec started funding a research project entitled the "Geochemistry of Volcanic Piles of the Noranda Region". This project formed a part of the Ministry's programme encouraging concerted team research on topics within Quebec. This project, which has been funded for two years and has just been renewed for the period of 1974-1975, is led by L. Gélinas and C. Brooks and involves as other principal researchers and associates, colleagues from the École Polytechnique, the Université de Montréal, the Quebec Department of Natural Resources and the Geological Survey of Canada.

The first two years of the project resulted in the accumulation of a considerable amount of data within the realms of field relationships, petrology and geochemistry. In order to maximize the usefulness of this data and expose our students to relevant research in other parts of Canada, a conference series on Canadian Shield Volcanic Belts was organized. This conference series which convened on the campus of the Université de Montréal and the École Polytechnique, during the interval November 1973 to April 1974, involved 18 presentations of ongoing research in diverse topics related to ancient volcanic rocks. The following section gives a progress report on the research project, and this is followed by a brief outline of the topics presented and discussed during the conference series.

Project Report

The research project has involved the establishment of a sampling traverse oriented roughly north-south in the vicinity of Rouyn and running from the southern limit of volcanics south of Rouyn, north towards Lake Abitibi (Fig. 1). This traverse provides a reference zone which intersects all of the main lithological entities of the area. It is essentially a petrological and geochemical traverse but its establishment has been closely integrated with regional mapping (in collaboration with E. Dimroth, Q.D.N.R.). We have used as a base for geochemistry, the detailed

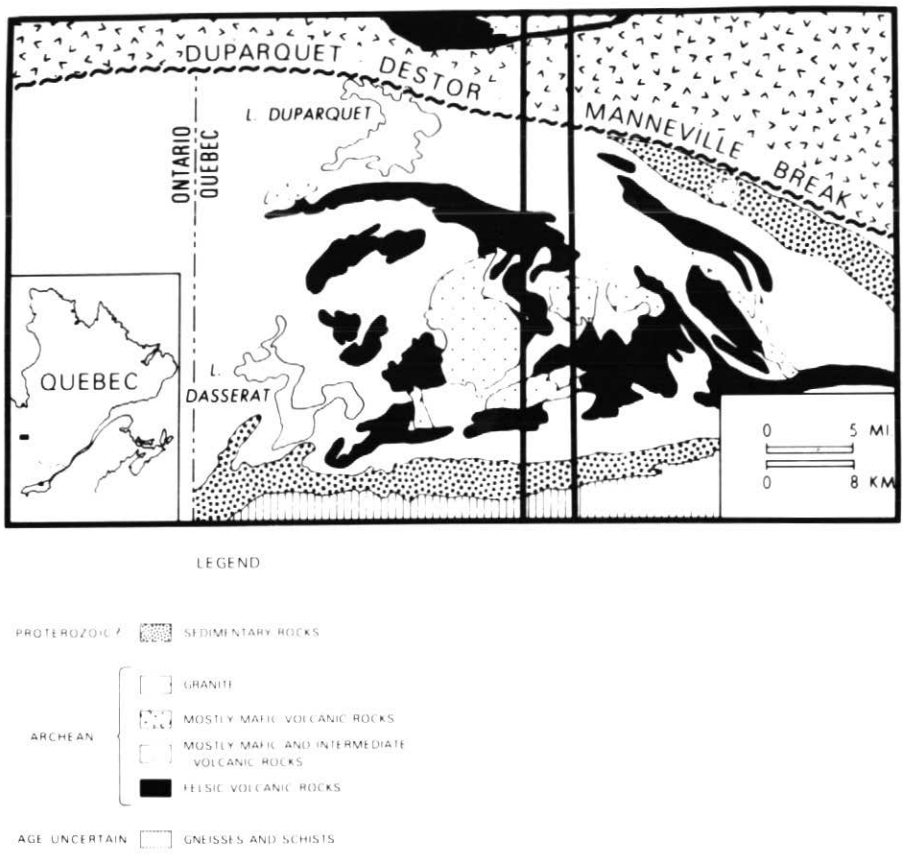

Figure 1
Location of sampling traverse, Rouyn-Noranda region.

petrographic examination of over 1000 samples from which over 500 have been analyzed for major-element composition. From these 500, it is planned to select samples for trace-element analysis. Regions adjacent to the traverse are not ignored and thesis topics such as "the geochemistry of sterile and mineralized rhyolites" are currently the subjects of study.

It soon became apparent after the first field season that the thin-section examination was going to provide new data on the volcanic rocks, and so far, quench-texture phenomena (Figs. 2 and 3) identical with those found on the Atlantic sea-floor have been observed (Gélinas and Brooks, 1974) and the phenomenon of immiscibility in variolitic lavas has been studied in detail (Gélinas, Brooks and Trzcienski, 1974). Quench textures in devitrified acidic glass (varioles) set in a devitrified iron-rich mafic-glass furnish convincing if not irrefutable evidence of the processes of immiscibility during formation of the volcanic pile. It has long been known that the structure of volcanic piles can be deciphered using zones of variolitic lava as marker horizons (e.g., Henderson and Brown, 1952) but mostly varioles have been regarded as merely a phenomenon of devitrification. If our contention that variolites are primary and produced by immiscible processes is correct, then they can indeed form a useful stratigraphic marker. This possibility is currently a thesis topic within the project.

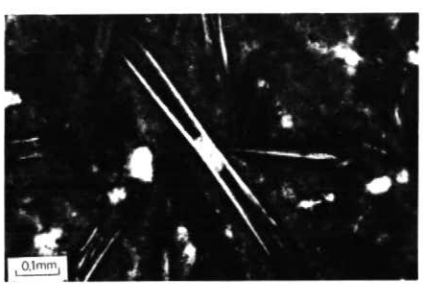

Figure 2
Quench calcic plagioclase in tholeiitic metabasalt.

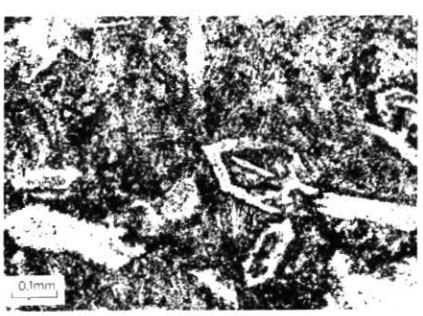

Figure 3
Quench olivine replaced by quartz in high-Mg metabasalt.

In dealing with the petrography of these rocks it was found that remarkably low degrees of metamorphism were encountered. Prehnite-pumpellyite facies rocks were common containing numerous occurrences of primary clinopyroxene and calcic plagioclase. Automatic X-ray diffraction techniques have been devised (in collaboration with G. Pouliot, École Polytechnique) which provide routine modal-analyses of ultramafic, mafic and acidic rocks. Data from this type of analysis is intended to be integrated with the field-mapping aspects led by E. Dimroth such that establishment of metamorphic isograds can be made within the belt.

The geochemical data obtained to date reveal a chemical stratigraphy in which the "basal" lower sections of the volcanic pile north of the Destor-Duparquet Manneville Break consist of monotonous tholeiites. These pass to tholeiites showing marked iron-enrichment, and then to an intermingled series of tholeiitic and calc-alkaline affinity rocks. The analogy with modern island-arcs based on this data is enticing and has already been made (Gélinas and Brooks, 1974). As more data becomes available, finer detail is expected to be added to this picture. For instance the main basin-like structure that enfolds the Rouyn area appears to contain a thick section of low-K andesite symmetrically placed on either limb of the basin.

The research project has two major directions in which the funding has been applied. Firstly a considerable amount has and is being used for support of graduate students (14

undergraduate students and currently 7 postgraduate students with thesis topics embraced within the project have participated in the research effort, and the 1974-1975 extension of the project involves support of a further 12 postgraduate students – 4 at the Ph.D. level; all of the field work associated with the project has been financed by the Quebec Department of Natural Resources). Secondly, a large part of the funding has been used to extend the geochemistry facilities accessible to project personnel. The equipment purchased includes: (i) a Phillips computer package installed on a Phillips X-ray fluorescence machine at the Ecole Polytechnique (in collaboration with G. Perrault, E.P.), thereby permitting routine, automated analysis of major elements in Archean volcanics. (ii) Acquisition of a data-file from which both literature data together with the analyses completed at E.P. can be retrieved using either chemical, structural or textural search-parameters. The data retrieved is immediately available via a cathode-screen display. (iii) A gas chromatograph (on order) which permits rapid analysis (4 minutes total) of powdered samples for CO_2 and H_2O (partly funded by the N.R.C.). In future all samples collected will be analysed for volatile contents using this equipment thereby enabling a selection of the "better" samples for further analysis.

Many questions concerning the Archean volcanics have been raised as a result of the exchange of information during the conference series, and because of it we plan to diversify the basic project orientation into: (i) an extension of our field of study to a complete traverse of the Abitibi belt from south of Rouyn to Matagami, (ii) an intensification of our efforts concerning the nature and geochemistry of the Archean ultramafic rocks of Quebec (in collaboration with L. Imreh, Q.D.N.R.), and (iii) an extension of the studies to include the sedimentary rocks associated with the volcanics (J. Lajoie, U. de M., has joined the team for this purpose).

We have found that even simple petrographic examination of well studied areas can produce new and meaningful data which can be applied to stratigraphic, tectonic and geochemical interpretations. Such data in sufficient quantity is essential before any model for the formation of the Abitibi belt, or more generally, any model of Archean crustal evolution can be proposed and tested.

Conference Presentations

The series got under way with a general picture of volcanism and tectonism in the Canadian Shield by R. Baragar. Baragar's presentation set the stage for the series in which a division into Archean and Proterozoic phenomena was made evident.

With regard to the Archean volcanism the accent was equally divided between field relationships and geochemistry with other integrated topics covering such fields as petrography and petrology. In view of the orientation of the project leading to the conference series, talks concerning the Abitibi volcanic belt were prominent. For example, Dimroth (Q.D.N.R.) presented a preliminary interpretation of the field relationship of the volcanic and associated sediments in the Rouyn-Noranda area of this belt. The use of pyroclastic rocks to define proximal and distal volcanogenic facies was demonstrated by him and the Porcupine Destor fault (following Dimroth "Destor-Duparquet-Manneville Break") was shown to be a fundamental structural entity along which komatiites occur associated (at least spatially) with sodic porphyrys. (Note: *komatiites* are ultramafic and mafic rocks distinctively high in MgO and Ca/Al and low in alkalis, particularly K_2O – see Viljoen and Viljoen, 1969 – ed.). The importance of this break which markedly affects the rock types encountered at the surface appears to be less well developed in the Ontario Section of the Abitibi volcanic belt as compared to the Quebec section. This was mentioned by Nick Arndt of the University of Toronto in his discussion of ultramafic rocks of the Abitibi belt, with emphasis on those in the Munro and Warden Townships of Ontario. Arndt presented a series of views of the ultramafic flows and intrusives which seem to be more and more a focus of interest as a possible Archean-only phenomenon.

The general geochemistry of the Abitibi belt was given by A. M. Goodwin of the University of Toronto. Goodwin emphasized the changing geochemical composition of the volcanic pile (especially in the Ontario section) from the basal primitive ultramafic members through tholeiitic lava of moderate non-enrichment trend, to upper high-alumina calc-alkaline lavas. Ridler (G.S.C.) presented data on the alkali-basalts of the Kirkland Lake region of the Abitibi belt which are unique in comparison to volcanics of most Archean belts of the Canadian Shield. Like other volcanics of this antiquity, high water contents were shown to be a feature of the meta-volcanic composition. In the general picture these alkaline rocks appear to be younger than those discussed by Goodwin.

Different slants on the geochemistry of the volcanics of the Abitibi belt were given by J. Descarreaux of Val d'Or, who showed that the "normal" composition of metavolcanics was modified in regions of metallogenesis (higher MgO, K_2O, lower Na_2O) thereby allowing the possibility that hydrothermal modification of rock compositions could be a potential exploration tool, and F. Agterberg (G.S.C.) who showed that geomathematical treatment of trace elements patterns could be used to define possible deposits in volcanic rocks.

A comparison of the Abitibi belt with other Archean volcanic belts was made possible as a result of conferences given on the Kaminak belt (Ridler) and the Yellowknife volcanics (McGlynn, G.S.C.). The basement-supercrustal relationships of the rocks discussed by McGlynn were in direct contrast to those of Abitibi, where basement relationships are either not in evidence, or at best inconclusive. Similar comparisons were made possible in talks concerning Proterozoic volcanics of the Canadian Shield. Especially pertinent were the tectonic styles of the Cape Smith Belt and the Labrador Trough discussed by F. Taylor

(G.S.C.) and E. Dimroth (Q.D.N.R.) respectively.

Differences between Archean and younger volcanism were again made apparent in a discussion of the volcanism and plutonism associated with the Great Bear Batholith (Hoffman, G.S.C.), where pre-alkaline ignimbrites occur interlayered with basalt. Discussion of younger volcanics was terminated by a talk on the Keewenawan Plateau Basalts of the Coppermine District by R. Baragar (G.S.C.). Of interest was Baragar's observation that these plateau basalts could be of either tholeiitic or alkaline affinity and again the contrast with most Archean volcanic piles was evident.

The role of alteration in the geochemistry of volcanic rocks was discussed by B. Gunn (U. de M.) with especial reference to the modifications observed in the geochemistry of rocks from the Atlantic sea-floor and Bermuda. This possibility was also dramatically displayed in a film made by R. Baragar of the eruption of Heimaey Volcano, Iceland, where spectacular sea-water lava-interactions were filmed. The data from these two different sources threw a sense of caution into the geochemical interpretation of Archean rocks, especially with regard to post-extrusion modification of alkali compositions.

Data of a more petrological orientation was given by L. Gélinas (E.P.) who discussed new evidences for immiscibility in certain rocks (variolitic lavas) from the Rouyn area and in an additional conference he discussed quench textures observed in rocks from the same area. The latter were shown to be essentially identical with quench textures observed in sea-floor and lunar rocks. Brooks (U. de M.) reviewed the nature of komatiites stressing the need for chemical and textural criteria to identify these rocks, as well as proposing a model for formation of spinifex-texture due to dehydration-quenching.

Conference Summary

By the very nature of the conference series, we were not able to maintain specific directions throughout the series. Neither were we able to synchronize the participation of the numerous researchers who presented talks, such that vigorous discussion aimed at unravelling some of the problems of Archean volcanic piles was a feature of the series. Nonetheless the general orientation of the series permitted the audience and especially the participants of our research project to gain an up-to-date appreciation of Canadian Shield geology, to seek off-campus ideas on problems that have been manifest as the result of our project, and to view in a continually evolving manner a comparison of the Quebec section of the Abitibi belt, with the Ontario section, other Archean volcanic piles, and younger volcanics.

If a summary was to be made of the main overview resulting from the conferences series, it would be that the Archean volcanic piles are sufficiently different in their tectonic and chemical make-up that the models of crustal evolution applied to them do not as yet satisfy all the geological data on hand. This is especially pertinent to applications of plate-tectonic models, in which the Archean volcanics have been viewed as ancient sea-floor, or ancient island arcs. The increasing realization that there are Archean phenomena which may be unique (such as the ultramafic flows) may ultimately lead to a mélange of currently used models, with the result being a plate-tectonic type model of distinctly Archean flavor.

In conclusion we would like to mention that the exchange of information permitted by this conference series has been invaluable to both conferencees and members of the research project that led to the conference series. The success has encouraged us to consider a three day workshop to be held in February, 1975 in which the continuing results of our project will be presented. This workshop will be advertised later; however, persons desiring to attend are encouraged to notify us since participation will probably be somewhat limited.

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