

GEOCHEMISTRY AND AGE OF THE TOBAGO IGNEOUS ROCKS

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ABSTRACT

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The island of Tobago, situated at the SE corner of the Caribbean plate, is made up of groups of volcanic, plutonic and metamorphic rocks. The volcanics are mainly calc-alkaline island-arc rocks which range from basalts to rhyodacites. They have been affected by metamorphism of the lower zeolite zone facies. The plutonic rocks, which intrude the volcanics range from high-Al gabbros to biotite granodiorites, are much fresher. The metamorphics are of the greenschist facies and are overlain by the volcanics. All these rocks were hitherto believed to be of Cretaceous age, but new K-Ar dates from the freshest available samples, including a mineral determination, show a Lower Cretaceous age for the pluton. It therefore indicates that the overlying volcanics are at least of Lower Cretaceous age. Upper Cretaceous ages obtained for the volcanics appear to be artificially young due to the effects of metasomatic alterations on these rocks. It also appears that the Tobago metamorphic rocks may be of a Jurassic age, similar to that of equivalent rocks in neighbouring Trinidad.

GENERAL GEOLOGY OF TOBAGO

The sample locality/geology map shown in Fig. 1 is based on MAXWELL (1948). His main formations are still followed with little refinement of the original boundaries. Three metamorphic formations of the greenschist facies are identified in a broad anticlinal structure. The oldest is the Main Ridge Sericite Schist Formation which is a metashale. This is succeeded by greenschists, greenstones and amphibolites of the Parlatuvier Formation. The youngest metamorphic formation is the Mt. Dillon group of quartzites and micaschists of the north-west.

The metamorphic group is intruded by at least two elongate ultrabasic bodies which are strongly sheared and partly serpentinitized. These bodies were previously grouped with ultramafics of the intrusive complex (MAXWELL, 1948). We prefer to regard them as fault-emplaced slices of partly-altered igneous cumulate material similar to other serpentinites found

throughout the Greater Antilles and the Venezuelan Mountains (KEMP, 1972; MATTSON, 1977). In contrast, the fresh or only lightly metasomatized coarse-grained pyroxenites, found within the intrusive complex, are dykes or crystal cumulates formed within the younger intrusive body.

The volcanic group which has been divided into four formations by MAXWELL (1948) occupies the southern third of the island and is separated from the metamorphics by the intrusive complex. The oldest volcanic group, the Goldsborough Formation consists mainly of greygreen dacitic tuffs, tuff-breccias, dykes and lava flows. These rocks are overlain by andesitic and basaltic tuffs, breccias, agglomerates and intercalated lava flows of the Bacolet and Merchiston Formations. A sequence of dark, porphyritic dacite and keratophyre lava flows, the Hawks Bill Formation overlies the Bacolet volcanics.

GEOCHEMISTRY

Samples of the volcanic, metavolcanic and intrusive rocks were analyzed for major and for some trace elements, at the University of Montreal. The major-element chemistry shows a close similarity between the Goldsborough and Hawks Bill

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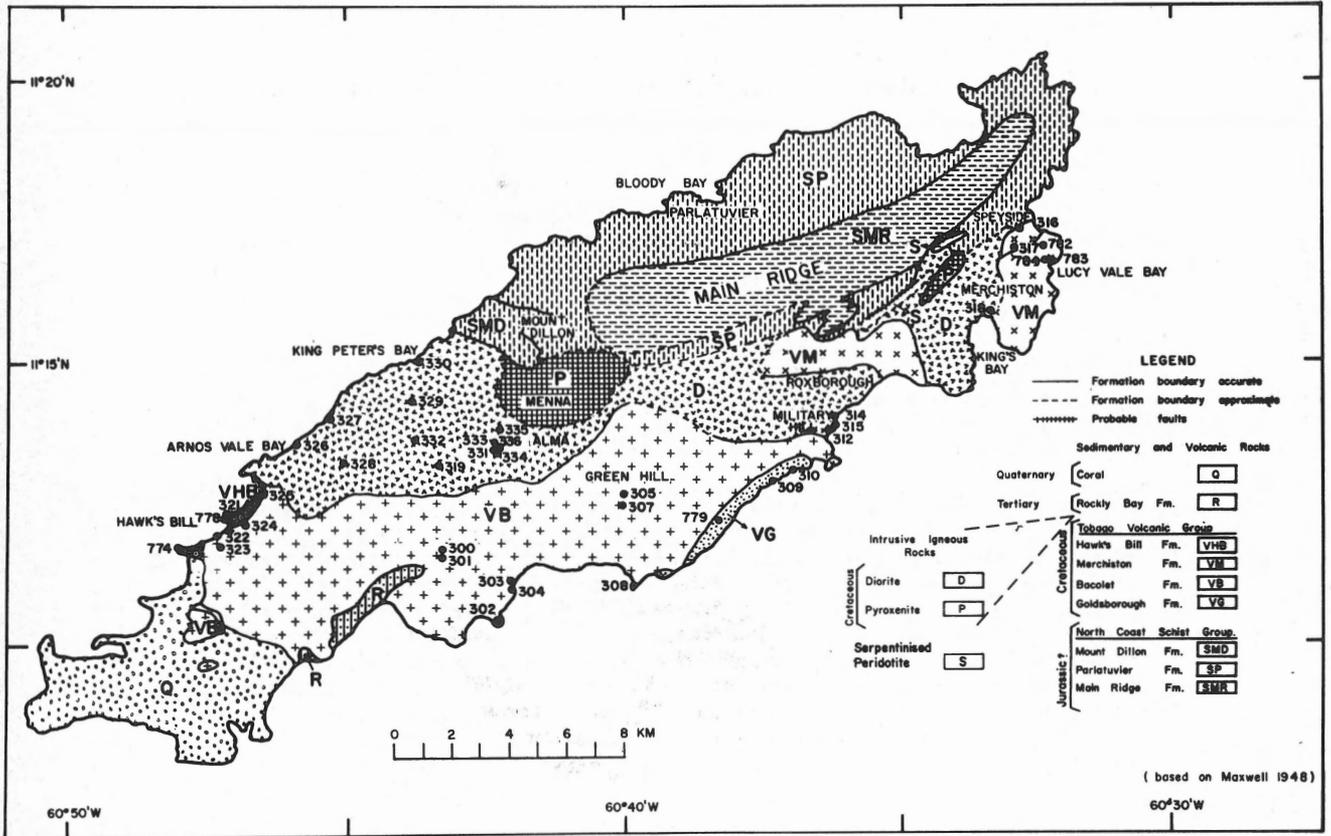


Fig. 1
Geologic map of Tobago.

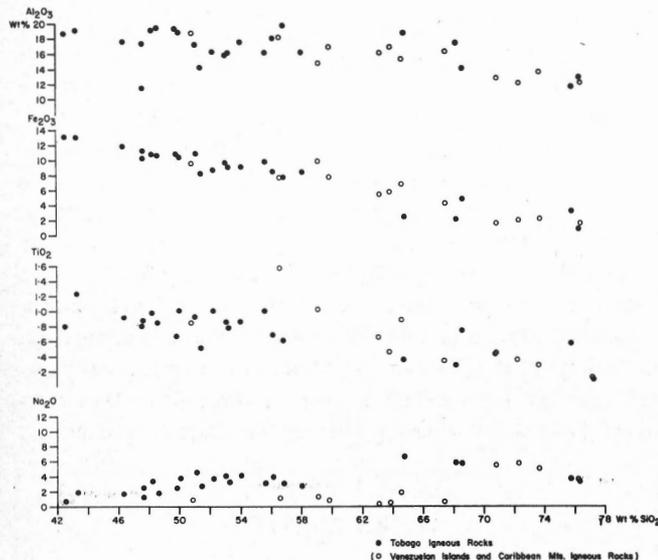


Fig. 2
Harker diagram for rocks from Tobago and Southern Caribbean Plate Boundary.

acid rocks and an almost identical nature between the Bacolet and Merchiston Formations. Andesites with over 57% SiO_2 are rare (Fig. 2). The rocks from the central intrusive complex (Fig. 3) form a series ranging from high-Al gabbros and meladiorite (17-22% Al_2O_3) through aluminous diorites and granodiorites (18% Al_2O_3) to low-Al adamellite (13% Al_2O_3). A chemically distinct group of diorites and microdiorites have 14-17% Al_2O_3 , corresponding with a modal increase in clinopyroxene.

Throughout the Volcanic Group there is abundant evidence of patchy alteration. Vesicles, joint planes and some primary

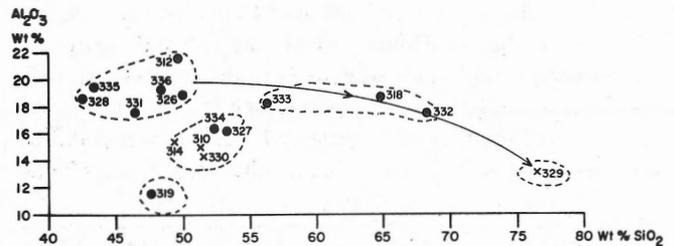


Fig. 3
 Al_2O_3/SiO_2 plots for samples from the central intrusive complex.

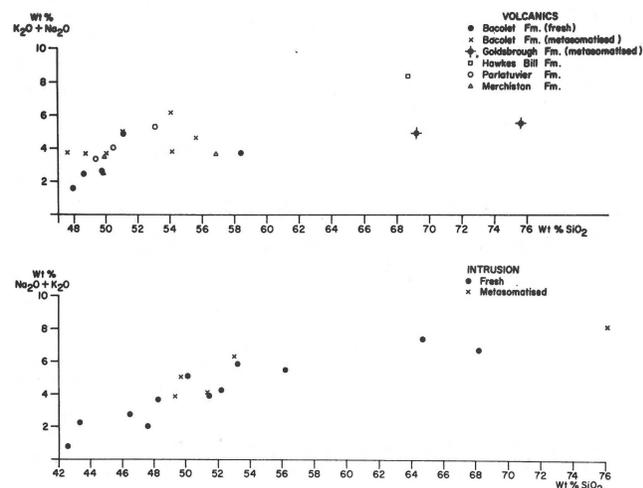


Fig. 4
K₂O+Na₂O/SiO₂ plots.

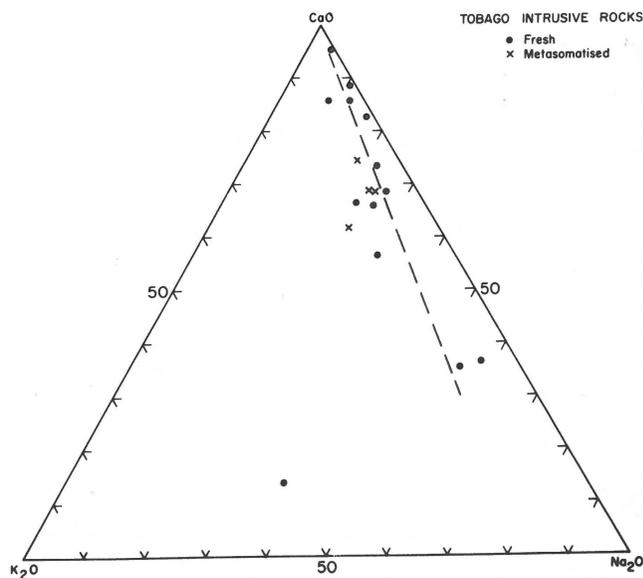
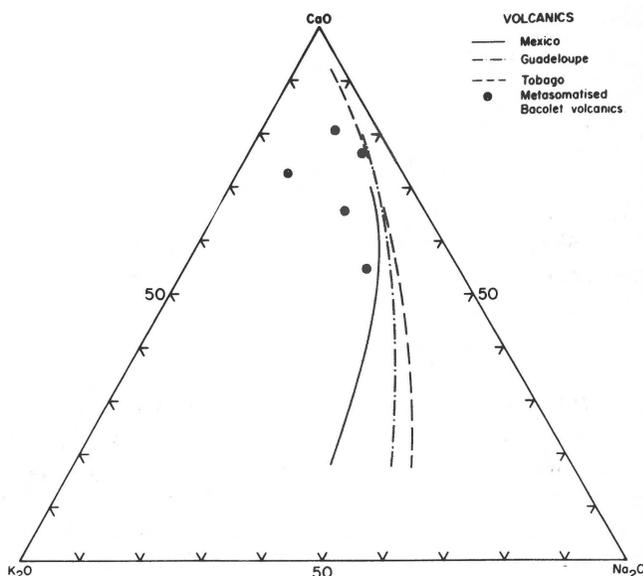


Fig. 5
CaO-Na₂O-K₂O diagrams.

crystalline phases contain epidote, chlorite, calcite, chalcidony and zeolites. XRD studies on the zeolite from the Bacolet Formation show it to be laumontite in its partly dehydrated form leonhardtite. The presence of laumontite indicates that metasomatic alteration is associated with this lower zeolite facies metamorphism. According to SANTAMARIA & SCHUBERT (1974) similar low-grade metamorphism has affected the igneous rocks of the Venezuelan Islands and Venezuelan Caribbean Mountains. Whereas the volcanic samples have undergone significant degrees of alteration, the plutonic rocks are invariably much fresher.

Plots of K₂O + Na₂O/SiO₂ (Fig. 4), unlike those of Al₂O₃, Fe₂O₃, show significant fluctuations along a general trend. It is this suggestion of possible K₂O migration which raises doubts as to the validity of K-Ar whole-rock dates from these and similar metasomatized rocks. One dacite sample with 5.75% Na₂O is believed to be almost certainly soda metasomatized. GUNN & ROOBOL (1976) have compared altered and unaltered rocks from the Limestone Caribbees and have shown that metasomatism here involves migration of K₂O, Na₂O, CaO, Rb, Sr and Ba. Similar migrations appear to have taken place mainly in the volcanic rocks of Tobago.

In the CaO-Na₂O-K₂O diagram (Fig. 5) the trends of both the volcanic and intrusive suites are similar to that for the islands arc volcanics of Basse-Terre, Guadeloupe rather than the continental calc-alkaline types of Mexico. The Tobago igneous rocks are largely high-Al, calc-alkaline types similar to those of the younger Lesser Antilles. A few lava flows with tholeiitic affinities are present. However, the two distinct groups of young calc-alkaline and older ocean-floor tholeiites described for the neighbouring Venezuelan Islands and Caribbean Mountains (SANTAMARIA & SCHUBERT, 1974) are not identified.

AGE OF THE TOBAGO ROCKS

We are in agreement with MAXWELL (1948) that the North Coast Schist Group is the oldest, but it may be that the ser-

pentinites associated with this group are even older. The next oldest would be the Volcanic Group followed by the intrusive complex.

Before this study two K-Ar age determinations were obtained for the igneous rocks, both of which are reported by TOMBLIN (1970) and one is quoted by MEYERHOFF & MEYERHOFF (1972). The relevant hand specimens and thin sections from the collection of the Seismic Research Unit have been re-examined in order to note the effects of possible metasomatic alteration.

A whole-rock K-Ar determination on dacite No. 29002 from the Hawks Bill Formation yielded an age of 80 ± 4 m.y. (TOMBLIN, 1970). This rock is lightly metasomatized with turbid plagioclase, epidote porphyroblasts and partly chloritized pyroxenes. Another K-Ar determination on hornblende separated from a diorite specimen No. 29021 yielded an age of 113 ± 6 m.y. (TOMBLIN, 1970). This rock is relatively unaltered and contains clear plagioclase, very slightly chloritized pyroxenes and apparently unaltered brown-green amphibole.

MAXWELL (1948) regarded the Hawks Bill Formation as the youngest volcanic rocks on the island, probably of Upper Cretaceous Age. This view was supported by the age of 80 ± 4 m.y. obtained from sample number 29002 (TOMBLIN, 1970). He also believed that the network of dykes in the southwestern corner of the pluton may also be related to the Hawks Bill volcanism. The new date for the microdiorite dyke (327) appears to be in agreement with the age of the dacite and therefore with Maxwell's views. However, it is our contention that the age of all the volcanics as determined by K-Ar methods on whole-rock, be subjected to greater scrutiny in view of the fact that there is geochemical and petrographic evidence of metasomatic alteration of these rocks.

Our analyses show some of the Hawks Bill lavas to be keratophyres with almost 6% Na_2O and the K_2O values are also quite variable. It is probable that the 80 ± 4 m.y. age is

artificially low due to the metasomatic loss of some K_2O . The lava flows 29002, 304 and 302 (Table I) are metasomatically altered. The samples obtained from within the pluton, especially the mineral 332, are much more reliable since this body is hardly metasomatized and these samples are quite fresh. They show a gabbroic intrusion in the Lower Cretaceous (127 ± 7 m.y.) followed by diorite (113 ± 6 m.y.) and granodiorite (102 ± 4 m.y.). Upper Cretaceous dyke intrusions into the plutonic body are represented by samples 333 and 327.

The field evidence shows the Bacolet Volcanics to be clearly intruded by the diorite; therefore, the Upper Cretaceous age obtained for these volcanics is unacceptable. They may be artificially low due to the effects of metasomatism. The Lower Cretaceous age of the pluton puts a minimum age on the Bacolet Volcanics. This being so, it follows that the very deeply weathered, Goldsborough volcanics which are even older than the overlying Bacolet Formation may even be of Jurassic age. On the basis of the age of the igneous rocks, the North Coast Schist Group which is older than the igneous suite (MAXWELL, 1948) is now regarded as Jurassic. This allows these metamorphics to be directly correlated with similar rocks of the Northern Range of Trinidad which have an accepted Jurassic age (KUGLER, 1953; BARR ET AL., 1965).

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Table I
List of K-Ar dates.

Sample No.	Sample Description	Locality	Age
*304	Basalt lava flow	Bacolet Formation	62 ± 3
*333	Micro-diorite Dyke	Alma Diorite	69 ± 3
*322	Finegrained basalt flow	Bacolet Formation	75 ± 3
*327	Microdiorite dyke	Anse Fromager Diorite	81 ± 4
**29002	Fine grained dacite	Hawks Bill Formation	80 ± 4
*332	Biotite	Les Coteaux Granodiorite	102 ± 4
**29021	Hornblende from diorite	Military Hill	113 ± 6
*328	Gabbro	Franklin Gabbro	127 ± 7

* New Data

** Data of Snelling N.J. (published by Tomblin J., 1970).