DECREPITOMETRIC STUDIES ON SOME GRANITES AND PARAGNEISSES FROM SOUTHEASTERN ONTARIO

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ABSTRACT

Samples of granite from Wollaston and Chandos Lake plutons (Southeastern Ontario) and of associated paragneiss and granitized paragneiss show, on heating, complex decrepigraphs. Of the several observed stages of decrepitation, believed to be due to misfit of solid inclusions, the highest temperature stage was taken to represent the temperature of formation of the rocks (uncorrected for pressure). The average temperatures of formation are 680°C (Wollaston granite), 657°C (biotite paragneiss), and 710°C (Chandos Lake granite, and syenite). The peak heights of the anomalous stage of decrepitation (410°–480°C) are suggested as a criterion for distinguishing certain metasomatic granites from magmatic granites.

In the course of detailed structural and petrological work on some granitic plutons in southeastern Ontario, (Saha, 1957) a brief study of the decrepitation of quartz and feldspar from the granitic rocks and the associated paragneiss was undertaken. The specimens studied are as follows:

1. Five samples of granite from the Wollaston pluton, and one granite and one syenite from the Chandos Lake pluton. (Petrological and structural studies had indicated that these rocks are of magmatic origin.)
2. Three samples of paragneiss in and around the Wollaston pluton.
3. Four samples of granitized paragneiss from the Wollaston pluton.

Method of Study

The specimens were crushed and sieved and the (−40+80) mesh fractions were treated with hot concentrated HCl, washed with water and acetone, dried, and the mafics separated out from quartz and feldspar using the Frantz isodynamic separator. In a few of the specimens, pure quartz was separated out from this (quartz+feldspar) fraction by treatment with hydrofluoric acid for about 30 seconds, washing the acid off with water and then treating the material with dilute HCl, in order to remove the insoluble decomposition products produced by the treatment with HF. The clean material so obtained was found to consist exclusively of quartz.

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One cc. each of the samples of quartz+feldspar or quartz was used for the measurement of the rate of decrepitation with rising temperature by means of the electronic decrepitaion apparatus at the University of Toronto (Peach, 1949; Smith, 1952). The arrangement of apparatus used in the present study is essentially the same as that used and described in detail by Blais (1954). After a few trial runs using various settings of the controls of the apparatus, a fixed rate of heating (15° ± 5°C per minute) and fixed settings of the other controls were maintained for all the samples and the average frequencies of pops per 20°C rise of temperature at 10°C temperature intervals were plotted in the form of histograms.

Interpretation of the Data

Multiple stages of decrepitation can be detected in the decrepigraphs of all the samples. Often two or three adjacent stages of decrepitation overlap partially, so that the exact temperatures of beginning of the

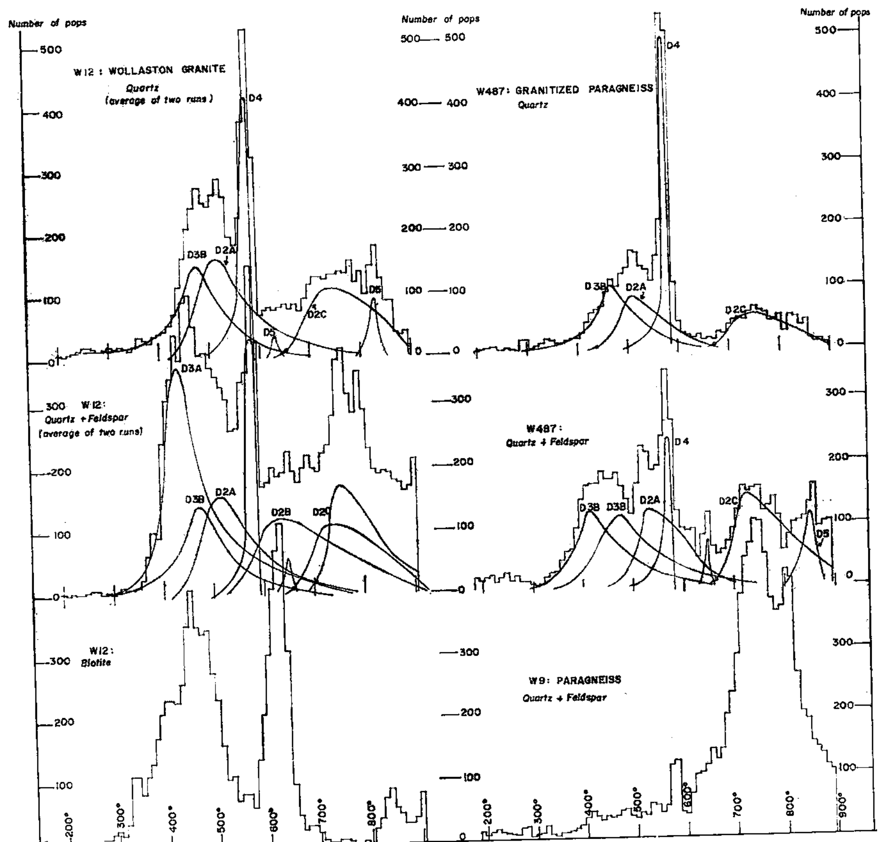

FIG. 1. Typical decrepigraphs of granite, granitized paragneiss and biotite paragneiss.

individual stages are not determinable. However, analyses of the decrepigraphs of single minerals, *viz.* quartz and biotite in some of the samples (*e.g.* W 487, Fig. 1), have facilitated fixing of the starting points of the various stages with a reasonable accuracy (±20° to 30°C). Results of the analyses of the decrepigraphs are given in Table 1.

TABLE 1. RESULTS OF DECREPITATION STUDY
(Temperatures in °C)

Sample No.	Rock-type and locality	Minerals decrepitated	D1	D3A (peak)	D3B (peak)	D2A	D4	D2B	D2C	D5
W 12	Biotitegranite (Wollaston pluton)	Quartz	—	—	470	430	580	—	660	630
		Quartz+feldspar	—	430–450	470	430	580	550	660, 700	640, 830
		Biotite	—	450	—	—	—	—	—	640 840
W 105	do.	Quartz	—	—	460	470	575	—	650	—
		Quartz+feldspar	—	410	460	—	575	—	—	—
W 472	do.	Quartz+feldspar	—	410	460	—	570	620	730	—
W 946 (45)	Biotite-granite (dyke off-shoot from Wollaston pluton)	Quartz	—	—	470	490	575	—	650	—
		Quartz+feldspar	—	420	460	—	575	—	660	—
W 946 (O)	do.	Quartz+feldspar	200	—	460	430	575	—	690	—
L 27	Biotite-granite (Chandos Lake pluton)	Quartz	280	400	470	470	575	—	710	—
		Quartz+feldspar	300	420	460	470	575	640	720	—
L 126	Biotite-syenite (Chandos Lake pluton)	Feldspar+little quartz	240	420	460	460	—	640	700	620
W 487	Granitized paragneiss (Wollaston pluton)	Quartz	—	—	460	450	570	—	670	
		Quartz+feldspar	—	420	470	460	570	—	670	650, 860
W 478	do.	Quartz+feldspar	—		430–450	460	570	—	690	630, 680
W 305	do.	Quartz+feldspar	—	—	460–470	450	575	650	710	640, 830
W 1161	do.	Quartz+feldspar	200	450–480	—	460	575	640	670	830
W 9	Biotite paragneiss (off Wollaston pluton)	Quartz	—	—	—	—	570 (weak)	590	640	—
		Quartz+feldspar	—	—	—	—	575 (weak)	590	640	—
W 908	do.	Quartz	—	420	—	—	570	—	660	—

A typical decrepigraph shows the following stages of decrepitation (using the nomenclature of Smith, 1953, 1957):

(i) A D1 stage due to fluid inclusions, between 200° and 300°C.

(ii) Two stages of "anomalous" decrepitation (D3)—one due to feldspars (with a peak at 410°C–440°C) and the other due to quartz (with a peak at 430°C–480°C).

(iii) A D4 stage of α–β quartz inversion (573°C±).

(iv) Three stages of decrepitation due to misfit of solid inclusions:—(a) D2A at 430°C–490°C due to decrepitation of quartz only: (b) D2B at 550°C–640°C, due to decrepitation of both feldspar and quartz: (c) D2C at 640°C–740°C, due to decrepitation of both quartz and feldspar.

Geological Implications

1. *Temperature of crystallization and recrystallization.* The multiple stages of D2 decrepitation of both quartz and feldspar are of some interest. While the D2C temperature probably represents the original temperature of crystallization or recrystallization, the other stages are presumably due to subsequent recrystallization. The possibility of the D2B temperature representing the temperature of crystallization of microcline (which appears to be later than plagioclase in the paragenetic sequence) is interesting, but rather doubtful, because this stage is also found in a few cases in the quartz from the same specimens. Another interesting point noted is that the D2A stage (due to quartz only) is absent in the paragneiss (W9, W908) as well as in the slightly granitized paragneiss (W321) and is usually less prominent in the samples of granitized paragneiss than in those of granite. This strongly suggests recrystallization of quartz during the cooling stages of the materials that crystallized out of the granitic magma—a process that did not operate in the paragneiss unaffected by the granitic magma.

Assuming that the D2C stage represents the original crystallization temperature of the minerals in the different rocks, the average temperature of formation of the rocks (uncorrected for the pressure at the time of formation) are as given in Table 2. The actual temperatures of formation may be higher than those indicated here by about 25°–50°C, as the effect of pressure at the time of formation of these rocks is neglected in the present study.

2. *D3 peak height as a criterion for distinction between magmatic and metasomatic granite.* All the samples of granite show high D3 peaks; in fact, except L27, the quartz+feldspar fractions of all the granite samples studied show over 300 pops per cc. per 20°C rise of temperature. The paragneiss, on the other hand, shows consistently low D3 peaks (<100

TABLE 2. AVERAGE TEMPERATURES OF FORMATION
(Uncorrected for pressure at the time of formation)

	Number of specimens studied	Average D2C temperature	Range
Wollaston granite	5	680°C	650°–730°C
Granitized paragneiss in Wollaston pluton	4	685°C	670°–730°C
Biotite paragneiss	3	657°C	640°–670°C
Chandos Lake granite and syenite.	2	710°C	700°–720°C

pops); in fact in most of them there is no real peak. Samples of granitized paragneiss show D3 peaks of intermediate heights (184–304 pops).

An approximate correlation between the degree of granitization and the heights of the D3 peaks was found to exist among the samples of granitized paragneiss from the Wollaston pluton. Petrological studies (Saha, 1957) indicated that the chief mineralogical effects of granitization in this group of rocks are: (i) gradual increase in the microcline content, and (ii) concomitant decrease in the proportion of the mafics. In Table 3, where the samples of granitized paragneiss are arranged in order of increasing degree of granitization, as suggested by mineral composition as well as texture, the correlation between the heights of the D3 peaks and the degree of granitization is indicated clearly. Considering the fact that the heights of the peaks depend not only on the composition and number of inclusions, but also on the various textural characteristics of the rock, this correlation is indeed remarkable.

The peak heights of the anomalous stage of decrepitation may thus be used as a criterion for distinguishing between certain metasomatic rocks of granitic composition and the magmatic granites. This, however, has two serious limitations:

TABLE 3. MINERAL COMPOSITIONS AND D3 PEAK HEIGHTS OF SAMPLES OF BIOTITE-HORNBLENDE PARAGNEISS AND GRANITIZED PARAGNEISS
(Compositions in volume per cent)

	Sample number	Plagio-clase	Micro-line	Quartz	Biotite	Horn-blende	Opaque acces-sories	Non-opaque acces-sories	D3 peak (number of pops)
Paragneiss	W9	35.6	1.6	30.4	29.5	—	0.4	2.5	45
	W321	35.5	10.9	30.3	20.8	1.6	0.2	0.6	85
Granitized paragneiss	W305	31.1	12.9	27.0	19.0	7.1	0.1	2.9	200
	W478	40.7	14.4	31.3	10.5	2.7	—	0.4	250
	W487	40.8	17.2	30.3	10.4	—	—	1.3	184
	W1161	36.0	22.5	31.4	8.4	0.7	—	1.1	304

(i) It can not apparently distinguish between magmatic granite and rocks granitized considerably, because with progressive granitization, the peak heights approach those of magmatic granites.

(ii) The rate of decrepitation depends on various textural factors, besides the number and composition of the inclusions, so that the heights of the peaks, as found for the rocks of the present area, may not hold true for similar rocks in other areas. It would be rather risky to decide on a magmatic or metasomatic origin of a particular granitic body, based solely on this evidence.

3. *Reason for the variations of D3 peak heights.* The reason or reasons for the variations in the D3 peak heights among the three groups of rocks can only be guessed in the present state of our knowledge of the cause of "anomalous" decrepitation. There is, however, some evidence to show that this stage is caused by the decrepitation of water in the imperfections of minerals or minute liquid inclusions, that can not get out at the D1 stage because of the strength of the host mineral. Smith & Little (1953) found that fluid inclusions in artifical rock salt crystals (which are soft) show anomalous decrepitation starting at about 300°C, with a peak at about 400°C. In the present samples, quartz shows D3 peaks at 460°–480°C, while the feldspar with its good cleavages shows it at 410°–440°C.

Tentatively, then, the progressively lower rate of anomalous decrepitation in the granite, granitized paragneiss and paragneiss respectively, may be considered as due to the presence of progressively lower amount of fluid inclusions in these groups of rocks.

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