XENOLITHS AND CONTACTS NEAR HALIFAX, NOVA SCOTIA

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(Received March 1, 1945)

ABSTRACT

The ancient, probably Precambrian, sediments known as the Halifax and Goldenville Series were intruded by granites in the Devonian. The granites advanced by stoping. Along the St. Margaret's Bay Road, within a few miles of Halifax, a number of granitic tongues can be seen in the road cuttings. Adjacent to the sediments but in the granites there are numerous xenoliths which range from those with sharp angular boundaries to those in which there is apparently no sharp line delineating the original boundary. In the first kind the rock is a dense, metamorphosed sediment, usually a quartzite, but sometimes a slate. In the others, the original sedimentary grains are giving place to a mosaic which has a granitic texture. In fact, in some of the extreme cases the material is granite with only the barest remnants of the sediments retained.

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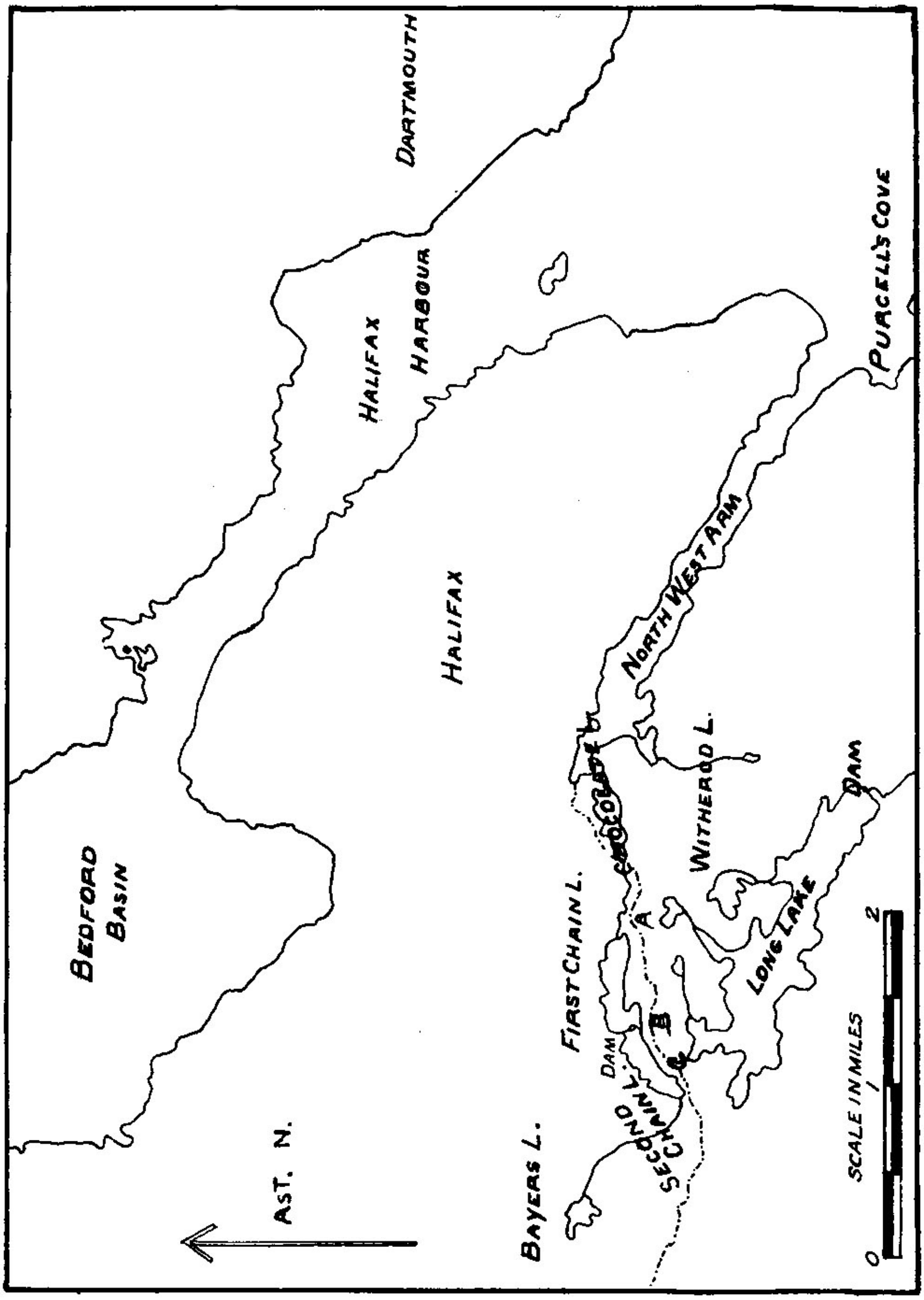

Fig. 1. Sketch Map of Area. Showing position of A, B, C.

area. These patches have been called ghost xenoliths. Between the sharp dark xenoliths and these ghosts there are all gradations.

At one place in the road, near one of the granitic tongues, there are a series of dyke and sill-like intrusions emanating from the granite and cutting a roof pendant of the sedimentary series.

Fifteen samples were taken of the xenoliths and sills, and a study of these constitutes the subject of this paper. Similar studies are described by Shand (1927, p. 62), Tyrrell (1926, p. 296), Thomas and Campbell Smith (1932).

The sediments which have been intruded by the granite have the compositions given by Douglas, Milner and MacLean (1936), as in the following table:

CHEMICAL COMPOSITION OF THE SEDIMENTS

	1	2	3
SiO_2	61.05	56.99	77.84
A_2O_3	22.36	19.79	10.72
Fe_2O_3	4.98	9.28	4.03
MgO	0.73	2.67	0.80
CaO	0.43	1.16	1.74
Na_2O	3.14	5.65*	4.31*
K_2O	3.25	2.44	1.06
H_2O-	0.36	0.36	0.09
H_2O+	2.90	3.50	0.82
	99.20	101 84	101.41

1. Average of two slates—Halifax Series.
2. Average of two siltstones—Halifax Series.
3. Goldenville Quartzites.

* Probably high.

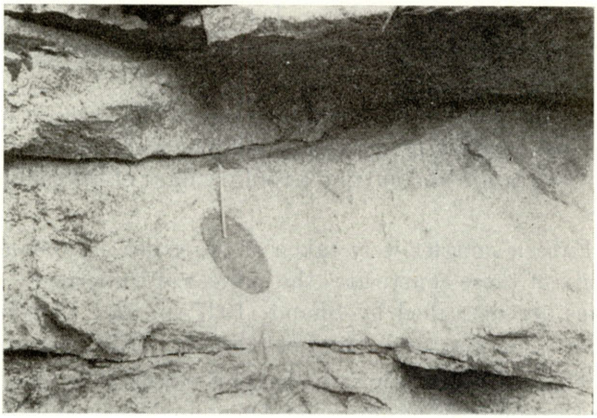

Fig. 2. Partially granitized Xenolith from "C" on map.

Fig. 3. Albite porphyroblast (Fp) growing in a matrix of quartz (Q), orthoclase (Fo) and biotite (Bi), X20.

The quartzites are made up of quartz, feldspar and biotite with grain size less than a millimetre. The slates are very similar in mineral composition but finer grained.

In the xenoliths which have sharp boundaries the granite has not penetrated the contacts. The metamorphic effects appear to be confined to a development of biotite, some of which contains pleochroic haloes often with inclusions of zircon. Figure (2) shows one of these sharp xenoliths which can be seen at "C" on the accompanying map.

In those xenoliths which show less sharp boundaries the metamorphic effects are more pronounced. Porphyroblasts of both orthoclase and plagioclase are well developed within the xenolith. In some of the sections examined garnets, sillimanite, zircon and biotite have developed. The growth of the feldspars can be so pronounced that the xenolith takes on the appearance of a granite. Figure (3).

In one specimen taken from "A" on the map, the xenolith was characterized by a considerable growth of andalusite. Figure (4).

The metamorphic effects found in the sediments at their contacts with the granite and in the wall rock of the granite sills, Figure (5), are of a higher order. Here we find abundant andalusite and cordierite. Figures (6), (7).

As the xenoliths in the granite occur within a few feet of the contacts and sill, the temperatures must have been approximately the same in both places. The metamorphic differences which have been noted are therefore due to some factor, other than heat. The suggestion is here advanced that the difference is due to the movement of the xenolith as it sank in the magma.

The conditions which have produced these results are visualized as follows:—The magma stoped its way into the sediments following cracks and weak beds. In some cases, portions of the roof were pryed off and became the xenoliths. These tended to sink, and in so doing would leave that portion of the magma which had begun to react with the surfaces of the xenolith. The smaller the particle the more rapid the chemical action. The margins of the xenolith at the time they broke away would be the places where the finer material would be formed, and hence the places where chemical action would begin. If the rock fragment began to sink, the smaller fragments would be left behind (Stokes' Law) and the fresh surfaces of the sinking rock would encounter fresh granitic magma. The sinking mass would have to be heated to the temperature at which the metamorphic changes would take place. Obviously, the smaller the mass the more rapidly will it approach the temperature of the magma. There will also be a porosity factor, for as Harker (1939, p. 5) states, water is to be thought of as present in metamorphism. The denser the rock, the slower will be the penetration of the fluids from the magma. Even though there is no addition of material from the magma, the xenolith has to be heated to the temperature required for the recrystallization of its component minerals before it gets frozen in the viscous and cooling magma. The field evidence shows that some xenoliths are fresh and unaltered, even with sharp angular forms; others are rounded and show porphyroblasts of feldspar within them. Still others have almost disappeared, only the faint outline remaining; these are the ghosts.

In contrast with those xenoliths we have the contacts of the sills and tongue of the granite. The sills and dyke feeders are likely to have been injected along fractures or beds in which there has been comminution. In these rocks in Nova Scotia, the competent mud beds are the planes of movement producing drag folds and finely pulverized material, when the whole series was thrown into folded anticlines and synclines. Hence, if these rocks are invaded by a hot magma of low viscosity, the magma can react readily with the pulverized material. This mechanism explains why the minerals such as andalusite and cordierite are formed more abundantly in the granite of the sill and tongue adjacent to the contact, than in the xenoliths.

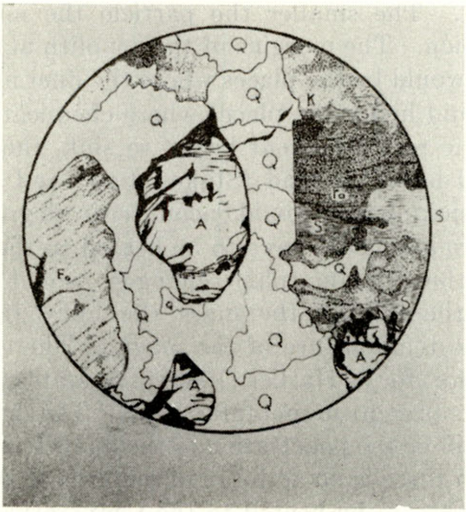

Fig. 6. Highly altered andalusite (A), orthoclase (Fo) showing kaolinization (K) and sericitization (S), quartz (Q). X20.

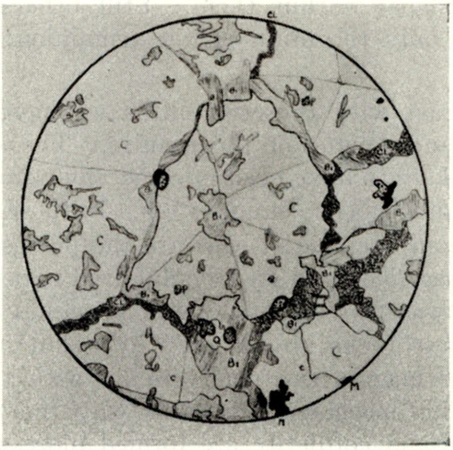

Fig. 7. Cordierite (C) showing pseudo-hexagonal twinning. Chlorite (Cl), biotite (Bi), magnetite (M) and pyrites (P). X20.

Harker (1939, p. 209), in his study of the Scottish Highlands has found various grades of metamorphism. He places the metamorphic rocks in which sillimanite, and andalusite are developed, in the higher grades of metamorphism. In Nova Scotia, sericite and the development of biotite, garnet, staurolite, and andalusite have been previously reported, but as far as the writers know this is the first time in which the higher grade of pure thermal metamorphism has been observed in the xenoliths and apophyses of the Devonian granite.

The authors wish to acknowledge, most gratefully, the suggestions and criticisms of Professor S. J. Shand of Columbia University.

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