DOLOMITES AND DOLOMITIZATION OF THE LOWER ORDOVICIAN ST. GEORGE GROUP OF WESTERN NEWFOUNDLAND[1]

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Abstract

Dolomite makes up approximately one third of the carbonates in the St. George Group of western Newfoundland and six varieties are now recognized.

Dololaminites are ubiquitous, composed of very fine crystals, characteristically laminated and thought to have been formed in shallow marine to supratidal environments. Intramuros dolomite preferentially replaces trace fossil walls as well as certain fossilized shells, is concentrated along stylolites, and is responsible for the dolomitic mottling so prevalent within the St. George Group. Pervasive dolostone is also mottled, but is the result of two different types of dolomite, one with finer crystallinity than the other. Matrix dolomite replaces carbonate mud between allochems and burrows and when extensive, expands to replace the whole rock. Cavity-filling dolostone is finely crystalline and has filled dissolution cavities or voids within pre-existing dolostone and may be related to unconformities. Saddle dolomite fills late stage fractures and voids and in combination with pervasive dolostone, is responsible for "pseudo breccia" beds associated with economic deposits of sphalerite.

Dololaminites are the earliest, probably synsedimentary, dolostones whereas saddle dolomite, because it cuts across most other varieties, is clearly the latest. The fact that saddle dolomite is restricted to areas in the northern portion of Great Northern Peninsula implies that this area was affected by a later dolomitization event which did not occur in more southern regions.

Résumé

La dolomite forme environ le tiers des carbonates dans le groupe de St. George de l'ouest de Terre-Neuve; on en reconnaît actuellement six variétés.

Les laminites dolomitiques sont omniprésentes; composées de cristaux très fins, elles ont des laminations caractéristiques et se seraient accumulées dans des milieux marins allant de peu profonds à supratidaux. La dolomite intra-muros remplace de préférence les murs des empreintes fossiles ainsi que certains coquillages fossilisés; elle est concentrée le long de stylolites et cause le mouchetage dolomitique si commun dans le groupe de St. George. La dolomie pénétrante, également mouchetée, est produite par deux types différents de dolomite, l'une plus fine que l'autre. La dolomite matricielle remplace la boue carbonatée entre les allochèmes et les terriers; lorsqu'elle se présente en vastes quantités, elle prend de l'expansion et remplace la roche entière. La dolomie de remplissage est finement cristalline et remplit les trous ou les vides laissés par le processus de dissolution dans les dolomies déjà existantes; elle pourrait être liée à des discordances. La dolomite anticlinale remplit des fractures et des vides récents et, conjugué avec la dolomie pénétrante, est à l'origine des lits de pseudobrèches associés aux gisements économiques de sphalérite.

Les laminites dolomitiques, de nature vraisemblablement synsédimentaires, sont les dolomies les plus anciennes, tandis que la dolomite anticlinale est évidemment la plus récente, puisqu'elle recoupe la plupart des autres variétés. En raison du fait que la dolomite anticlinale est limitée à des régions dans le nord de la Grande presqu'île du Nord, il se peut que cette région ait subi une phase de dolomitisation plus récente qui ne se soit pas produite plus au sud.

INTRODUCTION

The Lower Ordovician St. George Group of western Newfoundland has been extensively studied over the past few years (Levesque, 1977; Knight, 1977a, b, 1978; Pratt, 1979; Smyth, 1982a, b, c) with the result that the stratigraphy, sedimentology, and paleontology of these rocks are relatively well documented. However, little is known about the dolomites which account for approximately one third of the St. George Group. The purpose of the study is threefold; to fully document the various textures exhibited by the dolomites, to determine their stratigraphic and geographic distribution, and to examine possible mechanisms to explain the modes of dolomitization. This preliminary report addresses the first two objectives.

The St. George Group outcrops semi-continuously along the west coast of Newfoundland from the Port au Port Peninsula in the south to Cape Norman in the north. Five sections were studied in the vicinity of the Port au Port Peninsula and a further four sections were studied at specific points along the Great Northern Peninsula during the summer of 1983. In addition, several key locations which contained interesting dolomite relationships, but where sections could not, or were not measured, were also investigated.

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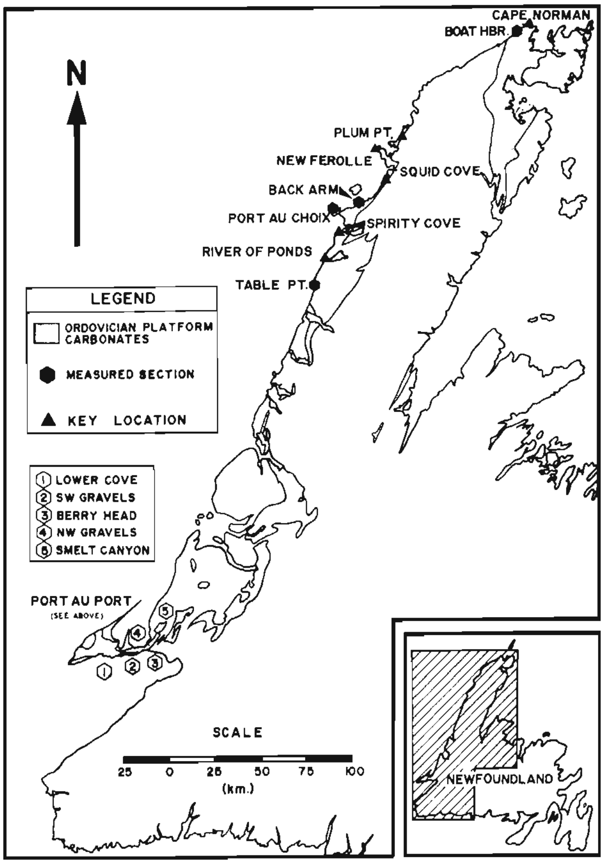

Figure 1. Location map of Lower Ordovician platformal carbonate rocks along the west coast of Newfoundland. The position of measured sections and key locations investigated during this study are also indicated.

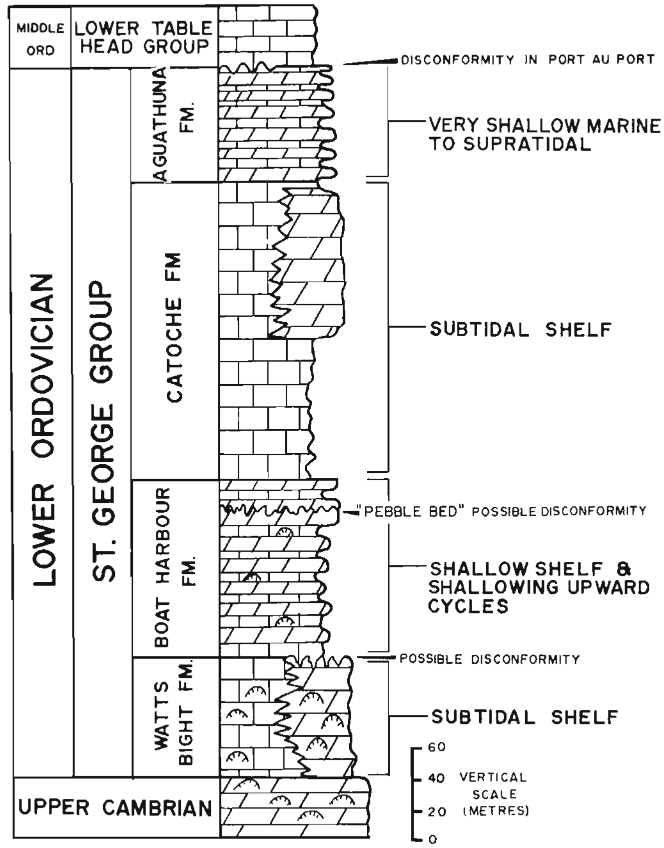

Figure 2. Schematic stratigraphic section of the Lower Ordovician St. George Group. Proposed depositional environments (in heavy type) and the locations of disconformities within the St. George Group are summarized on the right side of the section. Coarsely crystalline dolomitization of parts of the Watts Bight and Catoche formations are indicated by the cross hatched pattern. (Data from Knight, 1977b, 1978).

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GENERAL GEOLOGY AND STRATIGRAPHY

The Lower Ordovician St. George Group is part of the Cambro-Ordovician platformal sequence (the ancient continental margin of North America) that was assigned by Williams (1978, 1979) to the Humber Zone of the Newfoundland Appalachians (Fig. 1). Although the formational nomenclature has been modified extensively since Schuchert and Dunbar's pioneer work published in 1934, it is now generally agreed that the St. George Group can be subdivided into four formations (I. Knight and N.P. James, personal communication, 1983).

The lowermost unit, the Watts Bight Formation conformably overlies upper Cambrian peritidal and stromatolitic dolostones and is characterized by dark grey to black, vuggy and often cherty stromatolitic dolostone (Fig. 2). In some regions, particularly Hare Bay and possibly on Port au Port Peninsula, the Watts Bight Formation is a bioturbated and often fossiliferous mudstone to wackestone. This suggests that prior to dolomitization, the rocks of the Watts Bight Formation were subtidal shelf deposits (Knight, 1977a, b, 1978).

A breccia bed, possibly indicating a disconformity, separates the Watts Bight Formation from the overlying Boat Harbour Formation along the Great Northern Peninsula (Knight, 1977b). This breccia bed appears to be somewhat localized as the contact seems conformable where exposed in the Port au Port area.

The Boat Harbour Formation is a series of thick bedded, bioturbated or laminated dolostones and thin- to thick-bedded stromatolitic and/or bioturbated limestones. Levesque (1977), Knight (1977a, b), and Pratt (1979) regarded this formation as being the result of repeated shallowing upward sequences.

A possible break in sedimentation near the top of the Boat Harbour Formation has been suggested by Knight (1978) and Pratt (1979) who cited a layer of chert pebbles and silicified ooids and intraclasts as evidence of an exposure surface. Locally referred to as the "pebble bed", this horizon appears to be of wide extent ranging from the Port au Port vicinity to Cape Norman (Pratt, 1979).

The Boat Harbour Formation is conformably overlain by the Catoche Formation, a bioturbated, fossiliferous mudstone to wackestone of which the faunal content suggests a predominantly subtidal depositional environment (Levesque, 1977; Knight, 1977a, b, 1978; Pratt, 1979).

Table 1. Summary of distinguishing characteristics and the proposed paragenetic sequence of the six varieties of dolomite and dolostone observed within the St. George Group

	DOLOMITE TYPE	CRYSTAL SIZE	COLOUR	PERCENT OF HOST ROCK	DISTINGUISHING CHARACTERISTICS	DISTRIBUTION	
						STRATIGRAPHIC	GEOGRAPHIC
EARLY	1) DOLO-LAMINITES	VERY FINE	BUFF to WHITE	100%	CONTAINS ABUNDANT SHALLOW WATER SEDIMENTARY STRUCTURES (ie. MUDCRACKS, PRISM CRACKS, LAMINATIONS)	AGUATHUNA & BOAT HARBOUR FMS.	WIDESPREAD
↓	2) INTRA-MUROS DOLOMITE	0.1 mm.	BUFF to DOVE GREY	tr. to 40%	SELECTIVELY REPLACES ICHNOFOSSIL WALLS AND SOME FOSSILIZED SHELLS. CAN BE LOCALIZED ALONG STYLOLITES	WIDESPREAD	WIDESPREAD
↓	3) MATRIX DOLOMITE	0.1 mm.	BUFF	5 to 100%	REPLACES CARBONATE MUD BETWEEN ALLOCHEMS AND ICHNOFOSSILS.	CATOCHE, BOAT HARBOUR & WATTS BIGHT FMS.	PORT AU PORT
↓	4) PERVASIVE DOLOSTONE SUB-TYPE (A)	0.1 & 0.3 mm.	MED. GREY	95 to 100%	FINER CRYSTALLINE DOLOMITE IS LOCALIZED IN ICHNOFOSSILS, FOSSILS AND GASTROPOD SHELL WALLS. COARSER CRYSTALLINE DOLOMITE OCCURS IN THE INTERAREAS BETWEEN THESE FEATURES.	WIDESPREAD	WIDESPREAD
↓	4) PERVASIVE DOLOSTONE SUB-TYPE (B)	0.1 to 0.3 mm. & 1.0 mm.	MED. GREY to WHITE	100%		CATOCHE, BOAT HARBOUR & WATTS BIGHT FMS.	NORTHERN PENINSULA
↓	5) CAVITY FILLING DOLOSTONE	VERY FINE	BUFF	100%	TYPICALLY GEOPETAL. HAS FILLED DISSOLUTION CAVITIES AND VOIDS IN PRE-EXISTING DOLOSTONE.	BOAT HARBOUR & WATTS BIGHT FMS	LOCALIZED OCCURRENCES PORT AU PORT & NORTHERN PENINSULA
LATE	6) SADDLE DOLOSTONE	0.5 to 15.0 mm.	WHITE to PINK	100%	FILLS IN FRACTURES AND VOIDS WITHIN PRE-EXISTING DOLOSTONE.	CATOCHE, BOAT HARBOUR & WATTS BIGHT FMS.	NORTHERN PENINSULA

North of Table Point (Fig. 1 1), much of the limestone of the Catoche Formation has been replaced by white, sparry dolomite. This dolomite is host to economic sphalerite mineralization in the Daniel's Harbour area.

The Aguathuna Formation conformably overlies the Catoche Formation and is the uppermost division of the St. George Group. A unit of interbedded finely crystalline and laminated dolostones, dolomitic shales and limestones, the Aguathuna Formation was probably deposited in a shallow water to supratidal environment much like the Boat Harbour Formation below (Levesque, 1977; Knight, 1978; Pratt, 1979).

The Aguathuna Formation is extremely variable in thickness. In the Port au Port area, the interbedded limestones and dolostones are a minimum of 50 m thick. Farther north at Table Point, the Aguathuna Formation is exclusively dolostone and is approximately 75 m thick (Levesque, 1977). Still farther north at Port au Choix, the formation is a mere 10 m thick and consists only of a few dolostone beds. The Aguathuna Formation does not seem to be present at all in the Cape Norman area.

This Lower Ordovician sequence is overlain by the Middle Ordovician Table Head Group whose basal limestones are thought to have been deposited in an intertidal to subtidal setting (Klappa et al., 1980). The contact between the St. George and Table Head groups has been well documented as a disconformity on the Port au Port Peninsula along which up to several metres of strata have been removed (Schuchert and Dunbar, 1934; Cumming, 1968). In recent years, however, the importance of this disconformity has been questioned, especially along the west coast of the Great Northern Peninsula where strata appear to be continuous across the boundary.

The basal limestones of the Table Head Group pass upwards into deep water carbonates, shales and finally flysch recording the collapse of the stable continental margin (Klappa et al., 1980).

TEXTURAL TYPES OF DOLOMITE AND DOLOSTONE

The various dolomites and dolostones within the St. George Group can be separated into six distinct types. At this stage of investigation, the principal distinguishing criteria are limited to dolomite crystal size, sedimentary structures and textural relationships. The characteristics of the six varieties of dolomite and dolostone as well as their approximate paragenetic sequence, are summarized in Table 1.

Type 1: dololaminites

Dololaminates are dolostones characterized by a very fine crystal size and numerous fine laminations (Plate 1) (Wanless, 1979). They contain an abundance of sedimentary structures which include mudcracks, prism cracks, tepees, small-scale crossbedding and flat-pebble breccias. Colourless or white chert is commonly present in dololaminites, either as individual nodules or in discontinuous horizons. Both ichnofossils and body fossils are noticeably absent.

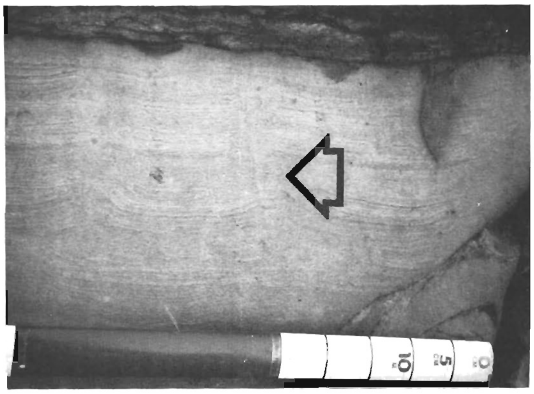
Sedimentologial studies by Levesque (1977), Knight (1977a, b, 1978) and Pratt (1979) have concluded that these dolostones probably formed early in very shallow marine to supratidal environments.

A common component of both the Boat Harbour and Aguathuna formations, dololaminites are widespread and are found in most sections and outcrops examined in this study.

Type 2: intramuros dolomite

The second textural type of dolomite is responsible for the mottling which is so common in most of the limestones within the St. George Group (Plate 1). The dolomite is finely crystalline and preferentially replaces trace fossils walls, the shells of some fossils, laminations and/or stylolites. Because of its affinity for burrow walls, this type of dolomite is referred to as intramuros (Latin for "within the walls").

A



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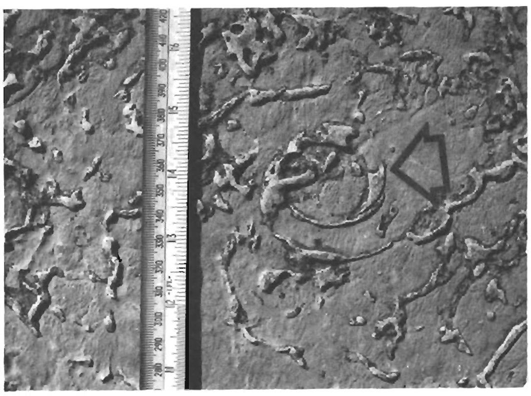

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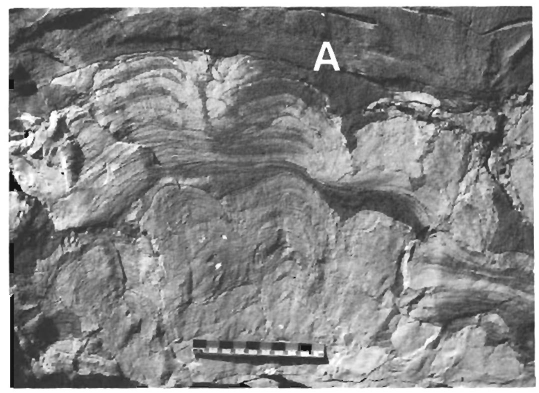

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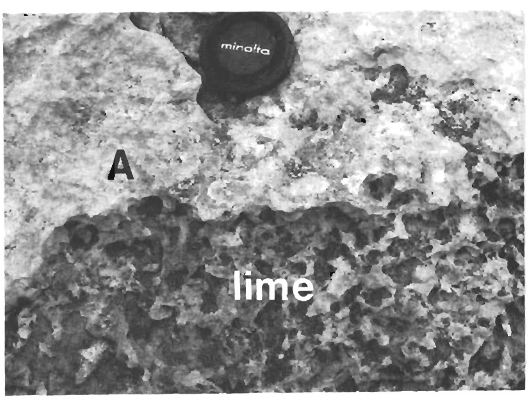

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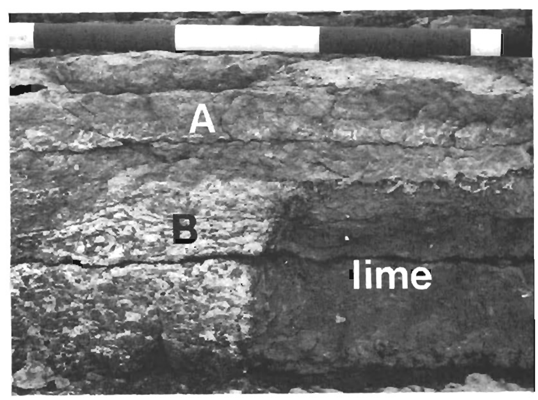

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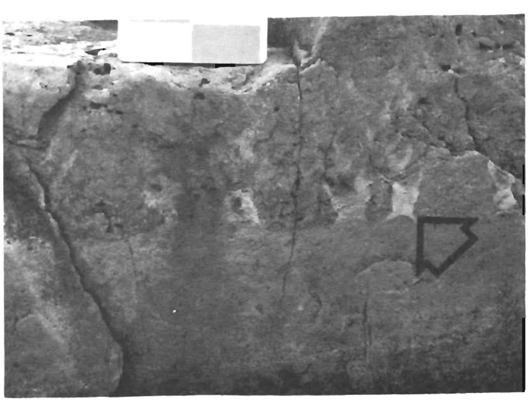

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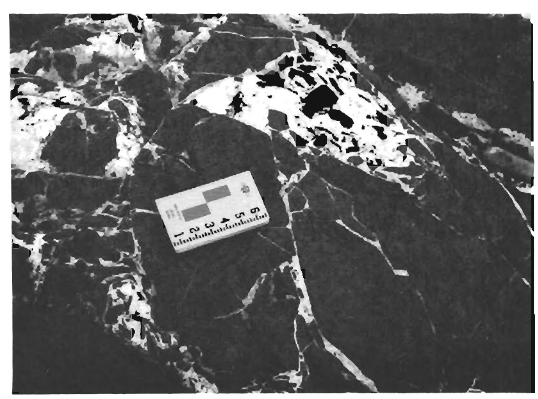

There are variable degrees of intramuros dolomite, ranging from instances of exclusive trace fossil-mottling to instances of exclusive stylolite-mottling. It is tempting to separate out several subtypes to account for the variability observed within this type of dolomite, but even within a single limestone bed, there are zones favouring one "subtype" over another, and consequently a complicated classification scheme for intramuros dolomite would probably cause more confusion than clarification. For the present time, therefore, intramuros dolomite will not be subdivided.

Plate 1

Various textures of dolomite and dolostone observed within rocks of the St. George Group

A. Dololaminites are characterized by a very fine crystal size and by shallow water sedimentary structures. This dololaminite from the Boat Harbour Formation on Port au Port Peninsula clearly shows prism cracks (arrow) and fine laminations.

B. Limestone mottled with buff coloured intramuros dolomite from the Boat Harbour Formation, Port au Port. The white portion of the scale bar is 25 cm long.

C. Bedding plane view of the intramuros dolomite displayed in B. The dolomite is localized within gastropod shell walls (arrow) and ichnofossils.

D. Matrix dolomite, unlike intramuros dolomite, does not preferentially replace trace or body fossils so that often the original fabric of the rock is lost. In some instances however, such as this example from the Aguathuna Formation in the Port au Port area, dolomite (labelled A) replaces the matrix between stromatolites but not the stromatolites themselves. As a result, part of the original fabric is preserved.

E. Pervasive dolostone, subtype A (labelled A) in contact with a limestone containing intramuros dolomite (labelled lime) within the Watts Bight Formation, Port au Port. Weak mottling within the dolostone is due to the presence of two crystal sizes; finer dolomite being localized within ichnofossils and coarser dolomite being localized between ichnofossils. The camera lens cap is 6 cm in diameter.

F. Pervasive dolostone, subtype A (labelled A) in contact with pervasive dolostone subtype B (labelled B) and limestone (labelled lime) within the Catoche Formation, Cape Norman. The two subtypes of pervasive dolostone can be distinguished from one another by the appearance and crystal size of the dolomite that occupies the interareas between ichnofossils. The dolomite within the interareas in subtype B is usually much lighter in colour and more coarsely crystalline than that found between ichnofossils in subtype A. Scale bar divisions are 25 cm across.

G. Cavity-filling dolostone (arrow) is typically geopetal and infills voids or cavities within pre-existing dolostone. This example occurs within a stromatolite-rich portion of the Watts Bight Formation near Boat Harbour. The field book is 19 cm across.

H. Saddle dolomite is the latest phase of dolomite observed in the St. George Group. It is localized within fractures and veins that cut across most of the other varieties of dolomite and dolostone. This example is from the Catoche Formation, Table Point.

It is unclear at this time as to the role stylolites have played in the development of intramuros dolomite. Some clearly have acted as zones where dolomitization was initiated (Wanless, 1979), but many also appear to have simply entrapped the more resistant dolomite rhombs during periods of pressure solution. The role that ichnofossils and some shells (especially gastropods) have played is more straightforward. Dolomitization was initiated in the walls of the ichnofossils and shells and spread both inward and outward into the neighbouring limestone once the walls had been completely replaced. This dolomitization occurred relatively early in the diagenetic history of the rock, but probably postdates the event responsible for the dololaminites. This is evidenced by field relationships observed in and between the two dolomite varieties.

The percentage of intramuros dolomite within a host limestone reflects both the intensity of bioturbation and the degree of replacement of the trace fossils. Proportions range from trace quantities to approximately 40 per cent and average overall to approximately 10 per cent.

Intramuros dolomite is widespread, both stratigraphically and geographically. It is present in particularly every limestone bed in every formation of the St. George Group and in all outcrops studied.

Type 3: matrix dolomite

Type 3 is best described as matrix-selective dolomite (Plate 1). In packstone and grainstone beds, finely crystalline dolomite rhombs can often be observed replacing the matrix between grains, but not the grains themselves. In the finer grained mudstones and wackestones, dolomite rhombs are randomly distributed over the entire volume of the bed.

Primarily features such as trace fossils are not preferentially dolomitized, and thus commonly a great deal of the original fabric is lost. Occasionally, however, matrix dolomite will selectively replace some parts of a limestone over others with the result that some of the original fabric (usually stromatolitic) is preserved.

Dolomite-mottled stylolites are present in finer grained limestones containing matrix dolomite, but they do not appear to be directly responsible for the dolomitization. They have more likely entrapped dolomite rhombs during a period of pressure solution. Stylolites do, however, tend to mark boundaries between regions of higher and lower proportions of matrix dolomite. This variability can be intense, ranging from approximately 5 per cent to close to 100 per cent within a single bed.

Matrix dolomite probably developed early in the diagenetic history of the rocks. Exact timing is not yet possible, however, on the basis of similar crystal size and field relationships, it is likely that this type of dolomite formed at about the same time as intramuros dolomite.

Matrix dolomite is not abundant in the St. George Group being restricted to the limestones of the Watts Bight, Boat Harbour, and Aguathuna formations in the Port au Port area only.

Type 4: pervasive dolostone

Pervasive dolostone is composed of two generations of dolomite, each generation being characterized by a distinct crystal size. Superficially, this bimodal distribution has resulted in a mottled appearance to the rock.

Two subtypes of pervasive dolostone are recognized within the St. George Group (Plate 1). In both cases, finer dolomite is localized within ichnofossils, stylolites and gastropod shell walls, much the same as intramuros dolomite. However, unlike intramuros dolomite where interareas between ichnofossils, stylolites, and gastropod shell walls are undolomitized, the interareas in pervasive dolostone have been dolomitized. The two subtypes of pervasive dolostone can be distinguished from one another by the nature of the dolomite crystals that occupy these interareas. In subtype A, the crystals are medium grey and are finely crystalline. In subtype B, the crystals within the interareas are white to pink and are coarsely crystalline.

Both varieties of pervasive dolostone are common components of the Watts Bight, Boat Harbour and Catoche formations, but differ in their geographic distribution. Subtype B is found only in areas north of Table Point, whereas subtype A is widespread. Textural evidence suggests that subtype B is the result of a dolomitization event later than the one responsible for subtype A. The fact that subtype B is restricted to the Great Northern Peninsula implies that the northern part of the study area was subjected to a late phase of dolomitization which did not affect more southerly areas.

Type 5: cavity-filling dolostone

This dolostone is best described as cavity-filling (Plate 1). It occurs in small (less than 30 cm), irregularly shaped cavities within preexisting pervasive dolostone and is finely crystalline, faintly laminated and usually geopetal.

Towards the top of the Boat Harbour Formation on Port au Port Peninsula, cavity-filling dolostone occurs immediately beneath the pebble bed, which has been interpreted as a possible exposure surface (Knight, 1978; Pratt, 1979). There are also several occurrences of cavity-filling dolostone within the pervasive dolostones of the Watts Bight Formation in the Boat Harbour and New Ferolle areas. It is unclear, however, whether or not these occurrences are due to as yet undiscovered disconformities.

Type 6: saddle dolomite

The sixth phase of dolomitization is responsible for the white to pink, very coarsely crystalline and typically saddle-shaped dolomite crystals found exclusively north of Table Point. Saddle dolomite is associated with pervasive dolostone and usually occurs in fractures and veins cutting across the host rock (Plate 1). It may also replace the finely crystalline dolomite which marks trace fossils and stylolites in the pervasive dolostone.

In localities where saddle dolomite fractures or veins cut across limestones, there does not seem to be any "dolomite aureole" penetrating the surrounding limestone. It appears then, that this variety of dolomite did not itself cause dolomitization, but simply infilled open fractures. Therefore, saddle dolomite can be thought of as "void-filling."

Saddle dolomite, when associated with the pervasive variety, often develops the texture locally referred to as "pseudobreccia" and it is this pseudobreccia which is associated with sphalerite mineralization in the Daniel's Harbour area of western Newfoundland.

The event, which is responsible for the emplacement of saddle dolomite, is clearly the latest one in the diagenetic history of these rocks. This is evidenced by the fact that saddle dolomite veins cut across most other varieties of dolomite and dolostone. Dololaminites on the other hand are products of the earliest phase of dolomitization. The other varieties formed between the period of time marked by these two end members, probably in the order discussed in this report and summarized in Table 1.

REFERENCES

Cumming, L.M.
1968: St. George-Table Head disconformity and zinc mineralization, western Newfoundland; Canadian Institute of Mining and Metallurgy Bulletin, June, p. 721-725.

Klappa, C.F., Opalinski, P.R., and James, N.P.
1980: Middle Ordovician Table Head Group of western Newfoundland: A revised stratigraphy; Canadian Journal of Earth Sciences, v. 17, p. 1007-1019.

Knight, I.
1977a: The Cambrian-Ordovician platformal rocks of the Northern Peninsula; Mineral Development Division, Newfoundland Department of Mines and Energy Report 77-1, p. 27-34.

1977b: The Cambrian-Ordovician platformal rocks of the Northern Peninsula; Mineral Development Division, Newfoundland Department of Mines and Energy Report 77-6, p. 1-27.

1978: Platformal sediments on the Great Northern Peninsula: Stratigraphic studies and geological mapping of the North St. Barbe district; Mineral Development Division, Newfoundland Department of Mines and Energy Report 78-1, p. 140-150.

Levesque, R.J.
1977: Stratigraphy and sedimentology of Middle Cambrian to Lower Ordovician shallow water carbonate rocks, western Newfoundland; unpublished M.Sc. thesis, Memorial University of Newfoundland, 276 p.

Pratt, B.R.
1979: The St. George Group (Lower Ordovician), western Newfoundland: Sedimentology, diagenesis and cryptalgal structures; unpublished M.Sc. thesis, Memorial University of Newfoundland, 254 p.

Schuchert, C. and Dunbar, C.O.
1934: Stratigraphy of western Newfoundland; Geological Society of America, Memoir 1, 123 p.

Smyth, W.R. (Compiler)
1982a: Geology Blanc-Sablon/St. Anthony; Mineral Development Division, Newfoundland Department of Mines and Energy, Map 82-54.

1982b: Geology Port Saunders; Mineral Development Division, Newfoundland Department of Mines and Energy, Map 82-53.

1982c: Geology Sandy Lake; Mineral Development Division, Newfoundland Department of Mines and Energy, Map 82-54.

Wanless, H.R.
1979: Limestone response to stress: Pressure solution and dolomitization; Journal of Sedimentary Petrology, v. 49, p. 437-462.

Williams, H. (Compiler)
1978: Tectonic lithofacies map of the Appalachian Orogen; Memorial University of Newfoundland, Map 1.

1979: Appalachian orogen in Canada; Canadian Journal of Earth Sciences, v. 16, p. 792-807.