Dolomitization Processes in the Paleozoic Horizons of Manitoba.

by

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Presented in partial fulfillment of the requirements for the Master of Science degree in the University of Manitoba.

April 1928.

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Introduction.

The material contained in this thesis is the result of an investigation made on rocks from certain Manitoba palaeozoic horizons in which dolomitization processes have been active. A note has also been added on a mottled drift boulder from Gimili, Manitoba.

Normal dolomite, $CaMg(CO_3)_2$ consists of 54.35% calcium carbonate, and the remainder, 45.65%, magnesium carbonate. Pure dolomite has rarely been found, dolomite with impurities of siliceous and argillaceous material together with iron and related minerals more commonly occuring. In a great many dolomites the percentage of calcium is far in excess of the normal amount and at times it is difficult to draw the boundary between limestone and dolomite.

This paper will refer to those rocks composed entirely of dolomite crystals as "dolomites", those with dolomite and calcite crystals as "dolomitic limestones", and those with approximately 2% of magnesium carbonate, but with no dolomite crystals developed, as "magnesian limestones."

Historical Summary: In 1779 Arduino, an Italian Geologist, called attention to the "magnesian limestones" of the Tyrol which occur associated with rocks of volcanic origin. Two years later Dolimeu described some of their properties. In 1792 de Saussure recognized the rock as being a species distinct from limestone and gave to it the specific name "dolomite", in honor of its first describer. From that time on to the time of Clifton Sorby(1879) the investigation was of a chemical geological nature. Since 1879 dolomite has been found to constitute one of the most important rocks of the earth's crust. Much has been written on the subject and certain facts have been established regarding its origin.

Dolomite has been formed by the dolomitization of limestones after emergence from the sea; such(subsequent) dolomitization having been effected by percolating ground waters carrying magnesium carbonate in solution.

Limestones have also been dolomitized before emergence from the sea; such(contemporaneous) dolomitization having taken place by secondary changes in the calcareous ooze.

The possibility of the formation of dolomite by chemical precipitation in the sea has been considered and at present there exists a wide divergence of opinion among geologists as to the importance of such a process in dolomite building.

The occurrence of clastic dolomites derivied from pre-existing rocks of a similar mature, although well known, is unimportant, as it has no bearing on the ultimate origin.

Experimental Data: Considerable experimental work has been carried out on the production of dolomite but the information obtained is of very little value in determining the conditions under which the rock has been formed in nature. All the experiments have been carried out either at high temperature or pressure, or both, but only rarely at ordinary temperature and pressure. In the last case only minute amounts of dolomite have been formed and that under conditions that doubtfully obtain in nature. Recent work by Wyckoff and Merwin[1] indicates that ferrous carbonate may be a medium through which dolomite

1. Wyckoff, R.W.G., and Merwin, H.G., Am. Jl. Sc. 5, Vol. 8, 1924, p. 447.

can be prepared experimentally.

Palaeozoic Stratigraphy in Manitoba: The Devonian and Silurian succession were worked out by Kindle[2] and the Ordovician by Dowling[3].

	Manitoba Limestone	185 feet.
Devonian	Winnipegosan Dolomite	168 " .
	Elm Point Limestone	25 " .
	Leperditia hisingeri zone	100 " .
Silurian	Gypsum Beds	150 " .
	Virgiana decussata zone[4]	135 " .
	Stony Mountain Shales	190 " .
	Upper Mottled Limestone	130 " .
Ordovician	Cat Head Limestone	70 " .
	Lower Mottled Limestone	70 " .
	Winnipeg Sandstone	100 " .

The Winnipeg Sandstone consists of beds of soft friable white sandstone, containing few fossils.

The Lower Mottled Limestone rests on the shaly upper beds of the Winnipeg Sandstone. Near its base the formation is argillaceous but elsewhere it is a yellowish or buff colored

2. Kindle, E.M., G.S.C. Sum. Rept. 1912.
3. Dowling, D.B., G.S.C. Ann. Rept., 1900.
4. Savage, T.E., and Van Tuyl, F.M., Bull. G.S.A., Vol. 30, 1919, p. 339.

limestone characterized by dark brown spots which give to the rock a mottled appearance. The formation contains many fossils.

The Cat Head Limestone is more dolomitic than the Upper and Lower mottled formations that lie above and below it respectively. In no place has the rock a mottled appearance. The formation is highly fossiliferous.

The Upper Mottled Limestone is a mottled light grey limestone, the mottling being of a blue or buff colored character. Lithologically this rock differs from the Lower Mottled rock in the presence of chalky nodules which can be picked out with the fingers from the lighter colored parts of the rock. Seventy-five fossil species have been identified from this formation.

The Stony Mountain formation consists of shales and limestones containing numerous fossils, sixty-one species having been identified.

The Virgiana decussata zone is composed of a harsh dolomite, buff to grey in color, and pitted from the dissolving of fossils. At Stonewall, Manitoba, a cross-bedded sandstone succeeded by a red clay is found at the base of the formation.

The position of the Gypsum beds as given in the stratigraphical table is doubtful being based on limited evidence.

The Leperditia hisingeri zone consists of a fine grained dolomite, greyish in color, and almost lithographic fineness. The top beds are red argillaceous dolomites on which the basal beds of the Devonian rest. Fossil material is not plentiful but in certain beds the ostrocod, Leperditia hisingeri, occurs in great abundance.

The Elm Point Limestone is typically a non-magnesian limestone, with argillaceous and arenaceous phases in its upper beds. The color is light grey to dark brown and shows in the Steep Rock quarry and elsewhere a mottled effect due to the presence of dark brown spots. Stylolytic structures are common. The formation is fossiliferous.

The Winnipegosan dolomite is a harsh porous dolomite of light grey or cream color and full of fossils. At its base is a red shale, and the transition to the Manitoba limestone is represented by a red argillaceous dolomite or shale.

The Manitoba limestone is lithologically similar to the Elm Point limestone. The color is greyish brown and the rock is very friable. No mottling has been noticed but stylolytic markings are common.

A discussion of the above formations has been made by Wallace[5], who gives a list of their fossil content.

The Winnipeg Sandstone, Gypsum beds, and Manitoba Limestone, will not be considered in this paper since dolomitization processes has played no part in their formation.

Discussion of the Formations Studied.

Upper Mottled Limestone.

The limestone of this formation is light grey in color and contains irregular dark brown or blue colored patches which gives to the rock its mottled appearance. These dark colored patches appear to be more strongly developed along the bedding planes than in other sections. A stronger development of them along jointing has nowhere been observed. Figure 1 is a photograph of a slab of the rock cut parallel to the bedding

5. Wallace, R.C., Bull. Ntl. His. Soc. Man., 1925.

and shows the development of the structures in this plane. Figure 2 is a block of the limestone drawn to actual scale which shows more clearly the character of the mottling.

Wallace[6] has shown from a microscopic and chemical examination that the material composing the dark areas is dolomite.

<u>Chemical Investigation:</u> The light and dark areas were separated as completely as possible and subjected to chemical analysis to ascertain their difference chemically. The results obtained are given below with those obtained by Wallace[7] placed in the second column in each case.

<u>Light areas</u>.

SiO_2	1.02 per cent.	1.56 per cent.
Al_2O_3	0.25	0.06
Fe_2O_3	0.03	0.16
FeO	0.00	0.12
$CaCO_3$	94.41	94.02
$MgCO_3$	4.33	4.33

<u>Dark areas</u>

SiO_2	1.85 per cent.	1.56 per cent.
Al_2O_3	4.15	2.27
Fe_2O_3	0.63	1.94
FeO	0.43	0.45
$CaCO_3$	69.81	71.03
$MgCO_3$	23.31	23.35

The results, in both cases, are representative of a number

6. Wallace, R.C., Jl. Geol., Vol. 21, 1913.
7. Loc. Cit. p. 411.

made. Although there appears to be some disagreement in the individual percentages the general results are similar. The disagreement in the individual percentages is possibly explained by a more complete separation of the two materials having been obtained in one case.

The results of the analyses indicate that practically all of the iron and alumina have been introduced with the magnesian solutions, and the invariable presence of ferrous iron accompanying the magnesia suggests a reducing environment. They also substantiate the opinion previously referred to, that the dark colored areas are more dolomitic than the lighter parts of the rock.

The color difference between the blue and buff colored areas was shown by chemical analysis to be due to the percentage of ferrous iron present. The blue colored areas were found to contain almost double the quantity of ferrous iron present in the buff.

Microscopic Investigation: A striking difference in structure is noticed between the light and dark material under the microscope. The dark colored patches are composed of well formed crystals which give dolomitic reaction with Lemberg solution (see figure 3). The dolomite crystals are set close together and any hematite or limonite present is found separate from the dolomite and at the edges of the dolomite crystals. The hematite and limonite accounts for the color of the dolomitized areas and occurs in the light areas only where local dolomitization has taken place. The dolomitic areas show no trace of fossils. The lighter colored parts of the rock show numerous fragments