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THE

CANADIAN RECORD

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Canadian Stromatoporoids.

By J. F. Whiteaves.[1]

In Canada, as elsewhere, only the more obvious characters of the Stromatoporoidea were examined by the first students of this difficult group of fossils, and it is probable that some of the earlier species proposed will have to be abandoned, as inadequately defined.

Of late years, however, these organisms have been studied much more systematically, especially by Professor H. Alleyne Nicholson, of the University of Aberdeen, and the minute structure of the different species has been elucidated and their probable affinities ascertained by means of thin microscopic sections.

While engaged in the preparation of his monograph of the British species for the Palæontographical Society, Professor Nicholson kindly examined and either identified or described, specimens of most of the Canadian species of Stromatoporoids that were then represented in the Museum of the Geological Survey at Ottawa, but some additional material has since been received at that Museum, especially an interesting series of specimens

1 Communicated by permission of the Director of the Geological Survey of Canada.

from the (Galena) Trenton of Lake Winnipeg and its vicinity, which has yet to be examined. The determinations and descriptions of Canadian Stromatoporoids are scattered through many publications that are not always easily accessible, and the present paper, therefore, will consist of a stratigraphical and systematic list, with references, etc., of all the species that have either been recognized or even supposed to have been recognized in Canada, or described from Canadian localities, commencing with those that have been examined microscopically.

A. Species that have been examined with the microscope.

(*Cambro-Silurian species.*)

Clathrodictyon variolare, Rosen. (Sp.)

Stromatopora variolaris, Von Rosen. 1867. Ueber die Natur der Stromatop., p. 61, pl. 2, figs. 2-5.

Clathrodictyon variolare, Nicholson. 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 4, pl. 1, figs. 4-6.

" " Nicholson. 1889. Mon. Brit. Stromatop., pt. 2, p. 150, pl. 18, figs. 1-5, and pl. 17, fig. 14.

Specimens which appear to be referable to this species were collected from the Hudson River formation at the Jumpers, Anticosti, by J. Richardson in 1856, and at Cape Smyth, Lake Huron, by Dr. R. Bell in 1859. It is the species referred to on page 304 of the Geology of Canada as *Stromatopora concentrica*, which, according to Professor Nicholson, "so far as at present known" (in 1891), "is a purely European species and entirely confined to the Devonian rocks."

LABECHIA CANADENSIS, Nicholson and Murie. (Sp.)

Stromatocerium Canadense, Nicholson and Murie. 1878. Journ. Linn. Soc., Zool., vol. XIV., p. 223, pl. 3, figs. 9 and 10.

Labechia Canadensis, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, pl. 2, figs. 3-5: and Ann. and Mag. Nat. Hist., ser. 5, vol. XVIII., pl. 14, pl. 2, fig. 5.

" " Nicholson, 1891. Mon. Brit. Stromatop., pt. 3, p. 163, pl. 20, fig. 9.

In Canada, so far as the writer is aware, this species has only been found in the Trenton limestone at Peterborough and Lake Couchiching, Ontario. At present it is not represented in the Museum of the Geological Survey at Ottawa.

LABECHIA HURONENSIS, Billings. (Sp.)

Stenopora Huronensis, Billings. 1865. Geol. Surv. Canada, Pal. Foss., vol. I., p. 185.

Tetradium Huronense, Foord (partim). 1883. Contr. Micro-Palæont. Silur. rocks of Canada, pl. 7, figs. 1 and 1*a*, but not figs. 1, *b-e*.

Labechia Ohioensis, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, p. 32, foot-note, pl. 2, figs. 1 and 2: and Ann. and Mag. Nat. Hist., ser. 5, vol. XVIII., p. 13, pl. 2, figs. 1 and 2.

Labechia montifera, Ulrich. 1886. Contr. Amer. Palæont., vol. I., p. 33, pl. 2, figs. 9 and 9*a*.

The types of *Stenopora Huronensis* are from the Hudson River formation at Cape Smyth, Lake Huron, where several fine specimens were collected by Dr. R. Bell in 1859, and not by Mr. A. H. Foord as supposed by Professor Nicholson. Mr. L. M. Lambe, who has recently studied these specimens somewhat exhaustively, is convinced that

Labechia Ohioensis, Nicholson, is identical with *Stenopora Huronensis*, and that the species ought to be called *Labechia Huronensis.* Most of the specimens of this coral from Cape Smyth are large and some of them are massive, but one encrusts a colony of *Tetradium fibratum* and another nearly covers a shell of *Cyrtoceras Postumius.* Of the six specimens figured by Foord under the name *Tetradium Huronense* (op. cit., pl. 7), Mr. Lambe finds that while fig. 1 represents a portion of a specimen of *Labechia Huronensis* encrusting *Tetradium fibratum*, and fig. 1*a* a portion of a massive specimen of *L. Huronensis*, that figs. 1, *b-e* are sections of *Tetradium fibratum*, Safford.

A few specimens of *L. Huronensis* were collected from the Hudson River formation at Club Island, Lake Huron, by Dr. R. Bell in 1865, and from rocks of the same geological horizon on the Credit River at Streetsville, by Mr. J. B. Tyrrell in 1888.

BEATRICEA NODULOSA, Billings.

Beatricea nodulosa, Billings. 1857. Geol. Surv. Canada, Rep. Progr. 1853-56, p. 344.
" " Hyatt. 1865. Am. Journ. Sc., vol. XXXIX., p. 266.
" " Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, pp. 86, 88 and 89, pl., 8, figs. 1-8.

In his "Catalogues of the Silurian fossils of the Island of Anticosti," Mr. Billings says that this species was collected by Mr. James Richardson in 1855, from the Hudson River formation at Wreck Point, Salmon River, and Battery Point, Anticosti, and from Division 1 of the Anticosti group at Macastey Bay. Specimens of the same species in the Museum of the Geological Survey at Ottawa are labelled as having been collected by Mr. T. C. Weston, in 1865, from the same formation at and near the West end lighthouse, at English Head, and at Gamache (or

Ellis) Bay, Anticosti. Professor A. Hyatt, who has collected many specimens of *B. nodulosa* at various localities on the same island, says that the size of the species, "as nearly as could be inferred from fragments, is not over four feet long, by from three to five inches in diameter at the larger end." To the naked eye some of the specimens look as if they were encrusted by a parasitic species of *Labechia.*

A silicified specimen which appears to be referable to this species, though its internal structure is almost obliterated, was collected by Mr. Weston in 1884 from the upper beds of the Hudson River formation at Stony Mountain, Manitoba.

BEATRICEA UNDULATA, Billings.

Beatricea undulata, Billings. 1857. Geol. Surv. Canada, Rep. Progr. 1853-56, p. 344.

" " Hyatt. 1865. Amer. Journ. Sc., vol. XXXIX., p. 266.

" " Billings. 1865. Can. Nat. and Geol., ser. 2, vol. II., p. 405, fig. 1.

" " Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, pp. 86 and 89.

Numerous specimens of this remarkable fossil were collected from the Hudson River formation and from Divisions 1 and 2 of the Anticosti group, at several localities on the island of Anticosti, by Mr. J. Richardson in 1856, by Messrs. Verrill, Shaler and Hyatt in 1861, and by Mr. Weston in 1865. Characteristic examples of *B. undulata* have since been collected from the Hudson River formation at Snake Island, Lake St. John, P.Q., by Mr. Richardson in 1857; at Rabbit and Club islands, Lake Huron, by Dr. R. Bell in 1859; and in the "Upper beds" at Stony Mountain, Manitoba, by T. C. Weston, and A. McCharles in 1884. A specimen in the Museum of the Geological Survey at Ottawa, collected by Mr. Richardson at Gamache Bay, Anticosti, which is imperfect at both ends, is ten feet five inches in length, as stated by Mr. Billings, and a similarly imperfect specimen collected by Messrs. Verrill, Shaler and Hyatt, is said to be thirteen feet and a half in length. Professor Hyatt is of the opinion that the length of an entire and adult specimen of this species was " certainly not less than twenty feet."

(*Silurian species.*)

ACTINOSTROMA MATUTINUM, Nicholson.

Actinostroma matutinum, Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 322, pl. 9, figs. 1 and 2.

L'Anse au Gascon, five miles and a half east of Port Daniel, in the Baie des Chaleurs, Dr. R. Bell, 1862: one specimen, from Division 1 of the Chaleur group, which is supposed to be " about the horizon of the Niagara limestone." The *Stromatopora concentrica* of the list of Port Daniel fossils on page 444 of the Geology of Canada is almost certainly this species.

CLATHRODICTYON VESICULOSUM, Nicholson and Murie.

Clathrodictyon vesiculosum, Nicholson and Murie. 1878. Journ. Linn. Soc., Zool., vol. XIV., p. 220, pl. 2, figs. 11-13.
" " Nicholson and R. Etheridge, jun., 1880. Mon. Silur. Foss. Girvan, p. 238, pl. 19, fig. 2.
" " Nicholson, 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 1, pl. 1, figs. 1-3: 1889, Mon. Brit. Stromatop., pt. 2, p. 147, pl. 17, figs. 10-13, and pl. 18, fig. 12.

Specimens which have been recently identified with this species were collected from the Niagara limestone at

Lake Temiscaming by Sir W. E. Logan in 1845, at Thorold, Ontario, by E. Billings in 1857, and in the Anticosti group at Junction Cliff and the west side of Gamache or Ellis Bay, Anticosti, by T. C. Weston in 1865. It appears to be very abundant at Lake Temiscaming, where specimens were recently collected by Dr. R. Bell in 1887, and by Mr. A. E. Barlow in 1893 and 1894.

CLATHRODICTYON FASTIGIATUM, Nicholson.

Clathrodictyon fastigiatum, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1. p. 43, figs. 3, *a-b*: and, 1887, Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 8, pl. 2, figs. 3 and 4: also, 1888, Mon. Brit. Stromatop., pt, 2, p. 152, pl. 19, figs. 1-5.

In the Guelph formation at Glenelg Township, six miles from Durham, where a few specimens were collected by Mr. Townsend in 1884.

CLATHRODICTYON OSTIOLATUM, Nicholson.

Stromatopora ostiolata, Nicholson. 1873. Ann. and Mag. Nat. Hist., ser. 4, vol. XII., p. 90, pl. 5, figs. 1 and 1*a*: 1874, Rep. Pal. Prov. Ont., pl. 1, figs. 1 and 1*a*: 1875, Rep. Pal. Prov. Ont., p. 63: and, 1878, Journ. Linn., Soc. Zool., vol. XIV., pl. 2, figs. 1 and 2.

Clathrodictyon (*Stromatopora*) *ostiolata*, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, p. 14.

Clathrodictyon ostiolatum, Nicholson. 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 11, pl. 3, figs. 1-3.

The type of this species was collected at Guelph, in the Guelph formation, by Mr. John Wilkie, not later than the year 1873, and specimens have since been obtained at

Elora by Mr. David Boyle in 1880, and at Durham by Mr. Joseph Townsend in 1884.

STROMATOPORA ANTIQUA, Nicholson and Murie.

Pachystroma antiqua, Nicholson and Murie. 1878. Journ. Linn. Soc., Zool., vol. XIV., p. 224, pl. 4, figs. 2-5.

Stromatopora antiqua, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, p. 17, pl. 5, figs. 8-11.

The types of this species were collected by Professor Nicholson from the Niagara limestone at Thorold, and there is a single specimen in the Museum of the Geological Survey at Ottawa, which was collected from the Guelph formation at Durham, by Mr. Townsend in 1884.

STROMATOPORA GALTENSIS, Dawson. (Sp.)

Cœnostroma Galtense, Dawson. 1875. Life's Dawn on the Earth, p. 160: and, 1879, Quart. Journ. Geol. Soc. Lond., vol. XXXV., p. 52.

Stromatopora Galtensis, Nicholson. 1891. Mon. Brit. Stromatop., pt. 3, p. 173.

Hespeler, T. C. Weston, 1867: one specimen. Professor Nicholson, who has examined a portion of this specimen, says (op. cit.) that its minute structure "is practically destroyed by dolomitization, but all its general characters would lead to the belief that it is very closely related to *Stromatopora typica*, Rosen, and is probably identical with it." He further states that *Cœnostroma constellatum* of Spencer, from the Niagara limestone near Hamilton, does not appear to be in any way distinguishable as regards its general characters from *C. Galtense*, Dawson, and that he is "strongly disposed to think that it is really identical with *S. typica*, Rosen. If the above view should prove to be correct, then *Cœnostroma Galtense*, Dawson, and *C.*

constellatum, Spencer, must be considered as synonyms of *S. typica*, Rosen."

It remains to be seen whether Spencer's *C. constellatum* is the same as Hall's *Stromatopora constellata* (Pal. N. York, vol. II., 1852, p. 324, pl. 72, figs. 2, *a-b*), which latter species has not been examined microscopically.

STROMATOPORA CONSTELLATA, Spencer. (Sp.)

Cænostroma constellata, Spencer. 1884. Bull. Mus. Univ. St. Missouri, vol. I., No. 1, p. 48, pl. 6, fig. 11.

"Near the top of the Niagara series, at Carpenter's lime-kiln, two miles and a half south of Hamilton, where it is abundantly found associated with *Cænostroma botryoideum*." Spencer. See the remarks on the preceding species.

STROMATOPORA HUDSONICA, Dawson. (Sp.)

Caunopora Hudsonica, Dawson. 1879. Quart. Journ. Geol. Soc. Lond., vol. XXXV., p. 52, pl. 4, fig. 9, and pl. 5, fig. 10.

Stromatopora Hudsonica, Nicholson. 1891. Mon. Brit. Stromatop., pt. 3, p. 172: and Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 312, pl. 8, figs. 1-3.

The type of this species was collected by Dr. R. Bell in 1878 on the Albany River, Hudson's Bay, in rocks which are said to be of Upper Silurian age, though upon what evidence is not stated. Another specimen, which has since been identified with *S. Hudsonica*, was obtained by Dr. R. Bell in 1878 at Cape Churchill.

STROMATOPORA CARTERI, Nicholson.

Stromatopora Carteri, Nicholson. 1891. Mon. Brit. Stromatop., pt. 3, p. 174, pl. 1, figs. 6-7: and Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 314, pl. 9, figs. 5 and 6.

"The only Canadian example I have seen is from a loose boulder of Silurian age, from Hayes River, Hudson's Bay," collected by Dr. R. Bell in 1878. Nicholson, on page 315 of the paper in the Annals and Magazine of Natural History indicated in the preceding reference.

SYRINGOSTROMA RISTIGOUCHENSE, Spencer. (Sp.)

Cœnostroma Ristigouchense, Spencer. 1884. Bull. Mus. Univ. Missouri, vol. I., No. 1, p. 49, pl. 6, fig. 12.

Syringostroma Ristigouchense, Nicholson. 1886. Mon. Brit. Stromatop., pt. 1, p. 97, pl. 11, figs. 11 and 12: and, 1891, Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 324, pl. 8, figs. 6-8.

In rocks believed to be of the age of the Lower Helderberg limestone of the State of New York, at Dalhousie, N.B., where specimens were collected by Sir J. W. Dawson and A. H. Foord in 1881.

(Devonian species.)

ACTINOSTROMA EXPANSUM, Hall and Whitfield. (Sp.)

Stromatopora expansa, Hall and Whitfield. 1873. Twenty-third Reg. Rep. N. Y. St. Cab. Nat. Hist., p. 226, pl. 9, fig. 9.

Actinostroma expansum, Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 316, pl. 10, figs. 1 and 2.

Lake Winnipegosis, in limestone holding *Stringocephalus Burtini*, at a small island on the south-east side of Dawson Bay, where two specimens were collected by Mr. J. B. Tyrrell in 1889.

ACTINOSTROMA TYRRELLII, Nicholson.

Actinostroma Tyrrellii, Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 317, pl. 8, figs. 4 and 5.

Apparently not uncommon and in fine condition in the Stringocephalus limestone at five different localities on the shore and islands of the southern portion of Dawson Bay, Lake Winnipegosis, where specimens were collected by J. B. Tyrrell and D. B. Dowling in 1889.

ACTINOSTROMA WHITEAVESII, Nicholson.

Actinostroma Whiteavesii, Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 320, fig. 2, and pl. 9, figs. 3 and 4.

Peace River, near the mouth of Little Red River, Professor Macoun, 1875: two specimens.

ACTINOSTROMA FENESTRATUM, Nicholson.

Actinostroma fenestratum, Nicholson. 1889. Mon. Brit. Stromatop., pt. 2, p. 146, pl. 17, figs. 8 and 9: and, 1891, Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 322, pl. 10, figs. 3 and 4.

North-west shore of Lake Manitoba, at Pentamerus Point, three miles and a half north of the mouth of Crane River, J. B. Tyrrell and J. F. Whiteaves, 1888; several specimens. Lake Winnipegosis, on two small islands at the southern end of Dawson Bay; also on the south-western shore of Dawson Bay a little to the west of Salt Point, and at the south end of Rowan Island, in the western portion of the bay, J. B. Tyrrell, 1889: one specimen from each of these localities.

CLATHRODICTYON CELLULOSUM, Nicholson and Murie.

Clathrodictyon cellulosum, Nicholson and Murie. 1878. Journ. Linn. Soc., Zool., vol. XIV., p. 221, pl. 2, figs. 9 and 10. Nicholson, 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 11, pl. 2, figs. 7 and 8.

"Not uncommon in the Corniferous Limestone (Devonian) of Port Colborne and other localities in Western Canada." Nicholson.

CLATHRODICTYON LAXUM, Nicholson.

Clathrodictyon laxum, Nicholson. 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 12, pl. 3, figs. 4 and 5.

"Corniferous limestone, Port Colborne, Ontario," Nicholson. A fine specimen in the Museum of the Geological Survey at Ottawa, which was identified with this species by Professor Nicholson, was collected from the Corniferous limestone at Pelee Island, Ont., by the Rev. W. Minter Seaborn in 1884.

CLATHRODICTYON RETIFORME, Nicholson and Murie. (Sp.)

Stylodictyon retiforme, Nicholson and Murie. 1878. Journ. Linn. Soc., Zool., vol. XIV., p. 222, pl. 2, fig. 14, and pl. 3, figs. 1-3.
Clathrodictyon retiforme, Nicholson. 1887. Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 13, pl. 3, figs. 6-8.

"Rare in the Hamilton formation (Devonian) at Arkona, Ontario," where it was discovered by Dr. G. J. Hinde. Nicholson.

STROMATOPORA. (Sp.)

"Cfr. *S. büchcliensis,* Bargatzky, sp." Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 313.

According to Professor Nicholson (op. cit.) two specimens collected by Mr. Tyrrell in 1889 from the Stringocephalus limestone of two small islands in Dawson Bay, Lake Winnipegosis, "have the general aspect of *Stromatopora buchcliensis,* Barg. sp., and are probably referable to this species. Unfortunately the specimens in question are dolomitized, and their internal structure is so far altered that this reference cannot be regarded as free from doubt."

STROMATOPORA. Sp.

"Cfr. *Stromatopora Hüpschii,* Barg., sp." Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., p. 314.

Lake Winnipegosis, at the south end of Snake Island (one specimen), and on a small island on the south-east side of Dawson Bay (one specimen); J. B. Tyrrell, 1889.

In reference to these two specimens Professor Nicholson observes (op. cit., p. 314) that they "belong to a species of *Stromatopora* in many respects similar to *S. Hüpschii,* Barg. Structurally they agree with the latter common European and British type, and differ from *S. Buchcliensis,* Barg., in their coarse skeleton fibre, the lax reticulation of the skeleton, and the loose spreading form of the astrorhizæ. The internal structure of these specimens is, however, very poorly preserved, and it would be rash to refer them unreservedly to *S. Hüpschii.*"

STROMATOPORELLA GRANULATA, Nicholson.

Stromatoporclla granulata, Nicholson. 1873. Ann. and Mag. Nat. Hist., ser. 4, vol. XII., p. 94, pl. 4, figs. 3 and 3*a*: and, 1886, Mon. Brit. Stromatop., pt. 1, pp. 93, 94, pl. 1, figs. 4, 5 and 15, pl. 4, fig. 6, and pl. 7, figs. 5 and 6: also, 1891, Ibid., pt. 3, p. 202, pl. 26, fig. 1.

Hamilton formation at Arkona and near Thedford, Ontario. According to Professor Nicholson (Mon. Brit. Stromatop., p. 203), this species has been found only in the Hamilton formation and *S. Selwynii* in the Corniferous.

STROMATOPORELLA SELWYNII, Nicholson.

Stromatoporella Selwynii, Nicholson. 1892. Mon. Brit. Stromatop., pt. 4, p. 205, pl. 1, fig. 14, and pl. 26, figs. 2-4.

"Not uncommon in the Corniferous limestone of Port Colborne, Ontario." Nicholson, op. cit., p. 205.

STROMATOPORELLA INCRUSTANS, Hall and Whitfield. (Sp.)

Stromatopora (Cœnostroma) incrustans, Hall and Whitfield. 1873. Twenty-third Rep. Reg. N.Y. St. Cab. Nat. Hist., p. 227, pl. 9, fig. 3.

Stromatopora nulliporoides, Nicholson. 1875. Rep. Pal. Prov. Ont., p. 78.

Stromatoporella incrustans, Nicholson. 1891. Ann. and Mag. Nat. Hist., ser. 6, vol. VII., pp. 309 and 310, footnote.

"Hamilton formation at Arkona, and Corniferous limestone, at Port Colborne, Ontario." Nicholson. It is also abundant in the neighborhood of Thedford, Ontario, in the Hamilton formation.

STROMATOPORELLA (?) TUBERCULATA, Nicholson.

Stromatopora tuberculata, Nicholson. 1873. Ann. and Mag. Nat. Hist., ser. 4, vol. XII., p. 92, pl. 4, figs. 2 and 2*a*:

1874, Ibid., ser. 4, vol. XIII., p. 8, figs. 1, *a-c*: Rep. Pal. Prov. Ont., p. 14, pl. 1, figs. 2 and 3, and figs. 2, *a-c*, on p. 15: and, 1887, Ann. and Mag. Nat. Hist., ser. 5, vol. XIX., p. 15, pl. 3, figs. 9-11.

Common in the Corniferous limestone at Ridgeway and Port Colborne. Nicholson.

B. Species of doubtful affinities, that have not yet been examined with the microscope.

(*Cambro-Silurian species.*)

Stromatocerium rugosum, Hall.

Stromatocerium rugosum, Hall. 1847. Pal. N. York, vol. I., p. 48, pl. 12, figs. 2, 2, *a-b*.

Stromatopora rugosa, Billings. 1873. Geol. Canada, p. 140, fig. 72.

According to Professor Hall, "this coral, so far as known, is confined to the Black-river limestone, and to the dark layers alternating with the Bird's-eye limestone." (op. cit., p. 48). In the Province of Quebec, specimens of this species were collected at Lake St. John, two miles west of the Metabechouan River by Mr. James Richardson in 1857. In Ontario, specimens were collected at Paquette's Rapids, on the Ottawa River, by Sir W. E. Logan in 1845; at Balsam Lake, Victoria Co., by Mr. Alexander Murray in 1853; and on Lot 13, Con. 4, of Stafford, by Mr. Richardson in 1853. In the "Geology of Canada" for 1863 the species is recorded as occurring on the Moira River, Hastings Co.; in the township of Douro, near Peterborough; and on Lacloche Island, Lake Huron. The specimens are usually silicified and their minute structure seems to be obliterated. At Paquette's Rapids there are two forms (the one with a massive and the other with an encrusting cœnosteum), both of which have been identified with this species by J. W. Salter and E. Billings. The encrusting form, which often almost entirely covers the exterior of shells of *Maclurea Logani*, has somewhat the appearance of a *Labechia*.

(*Silurian species.*)

STROMATOPORA HINDEI, Nicholson.

Stromatopora Hindei, Nicholson. 1874. Ann. and Mag. Nat. Hist., ser. 4, vol. XIII., p. 12, and p. 13, figs. 3, *a-c.* : also Rep. Pal. Prov. Ontario, p. 13, figs. 1, *a-c.*

"Common in a magnesian limestone of the age of the Niagara limestone (Upper Silurian), at Owen Sound, Ontario. Collected by Mr. G. J. Hinde." Nicholson. This species must be abandoned, as, in a letter recently received by the writer, Professor Nicholson says that "it was founded on a weathered *Cœnites* perforated by some boring organism."

STROMATOPORA STRIATELLA, Nicholson.

Stromatopora striatella (D'Orbigny), Nicholson. 1875. Rep. Pal. Prov. Ont., p. 49.

"Common in the Niagara Limestone of Thorold. Rare at Rockwood." Nicholson. This identification, however, is not confirmed, as the occurrence of *S. striatella*, D'Orbigny (which is now known to be a *Clathrodictyon*) at these localities, is omitted by Professor Nicholson in his most recent references to that species.

CAUNOPORA WALKERI, Spencer.

Caunopora Walkeri, Spencer, 1884. Bull. Mus. Univ. St. Missouri, vol. I., No. 1, p. 46, pl. 6, figs. 9 and 9*a*.

Lower beds of the Niagara formation at Hamilton, Ontario. "In the specimens that I have seen, the original matter is all silicified" Spencer.

CAUNOPORA MIRABILIS, Spencer.

Caunopora mirabilis, Spencer. 1884. Bull. Mus. Univ. St. Missouri, vol. I., no. 1, p. 47, pl. 6, figs. 10, 10, *a-b*.

"Only one specimen has been obtained from the Niagara formation at Hamilton, so far as I am aware." Spencer.

CÆNOSTROMA BOTRYOIDEUM, Spencer.

Cœnostroma botryoideum, Spencer. 1884. Bull. Mus. Univ. St. Missouri, vol. I., no. 1, p. 50, pl. 6, figs. 13, 13, *a-b*.

Abundant "in the Upper Niagara beds at Carpenter's limekilns, about two and a half miles south of Hamilton, Ontario." Spencer.

DICTYOSTROMA RETICULATUM, Spencer.

Dictyostroma reticulatum, Spencer. 1884. Bull. Mus. Univ. St. Missouri, vol. I., no. 1, p. 51, pl. 6, figs. 14 and 14*a*.

"It occurs in the cherty beds of the Niagara formation at Hamilton, Ontario." Spencer.

(*Devonian species.*)

STROMATOPORA PERFORATA, Nicholson.

Stromatopora perforata, Nicholson. 1874. Ann. and Mag. Nat. Hist., ser. 4, vol. XIII., p. 11, and p. 12, figs. 2, *a-c*; also Rep. Pal. Prov. Ont., p. 15, and p. 16, figs. 3, *a-c*.

"Rare in the Corniferous limestone of Port Colborne," Ontario. Nicholson.

STROMATOPORA MAMILLATA, Nicholson.

Stromatopora mammillata, Nicholson. 1873. Ann. and Mag. Nat. Hist., ser. 4, vol. XII., p. 94, pl. 4, fig. 4: and, 1874, Rep. Pal. Prov. Ont., p. 17, pl. 1, fig. 4.

"Rare, in a silicified condition, in the Corniferous limestone of Port Colborne." Nicholson.

THE FLORA OF MONTREAL ISLAND.

By ROBERT CAMPBELL, D.D., M.A.

(*Continued from Vol. VI., Number 7, p. 405.*)

The season of 1896 was well fitted to bring into prominent notice the plant life, scattered over the Island of Montreal. Vegetation was very rank, owing to the abundance and frequency of the rainfall. Even those forms of life that usually escape observation and have to be searched for, came forth out of their obscurity and were more easily found than in ordinary years. This will account for the fact that the appended list of the new captures made by the writer during the season just closed is so large, and contains so many varieties that had hitherto not obtruded themselves on his attention. It is especially interesting to note how many of the species in the Holmes Herbarium are here duplicated, showing that they have survived all the changes and chances of seventy-five years.

RANUNCULUS FLAMMULA, L., var. REPTANS, E. Meyer. —(Smaller Spearwort)—In pasture field at St. Michel—August, 1896—(Reported by Dr. Holmes from St. Helen's Island.)

VIOLA PUBESCENS, Ait. var. SCABRIUSCULA, Torr & Gray—(Downy yellow violet)—Bagg's Woods—September, 1896.

HYPERICUM MACULATUM, Watt.—(Spotted St. John's Wort)—Bagg's Woods—August, 1896.

GERANIUM MACULATUM, L.—(Wild Crane's bill)—Westmount—June, 1896.

ILEX VERTICILLATA, Gray.—(Black Alder. Winter berry) Mountain Swamp and St. Michel—June, 1896.

RHAMNUS ALNIFOLIA, L'Her.—(Buckthorn)—St. Michel, June, 1896—(Reported by Dr. Holmes from same district.)

MEDICAGO SATIVA, L.—(Lucerne. Alfalfa)—Near cottage at north-west corner of Mount Royal Cemetery.

SPIRÆA TOMENTOSA, L.—(Hardhack. Steeplebush)—Montreal Junction—June, 1896—(Reported by Dr. Holmes from Papineau Woods.)

POTENTILLA ARGENTEA, L.—(Silvery Cinque-foil)—Montreal Junction—June, 1896.

CHRYSOPLENIUM AMERICANUM, Schwein.—(Golden Saxifrage)—Mountain Marsh and Back River—May, 1896—(Reported by Dr. Holmes from Mountain.)

MYRICPHYLLUM SPICATUM, L.—(Water milfoil)—St. Lawrence River—Point St. Charles—September, 1896.

CALLITRICHE HETEROPHYLLA, Pursh.—(Water starwort)—Back River Swamp—September, 1896.

LONICERA GLAUCA, Hill.—(Honeysuckle)—Mountain Park, near Keeper's Lodge—June, 1896—(Reported by Dr. Holmes from Mountain as *L. parviflora*.

SOLIDAGO ULMIFOLIA, Muhl.—(Golden-Rod)—St. Michel—September, 1896.

SOLIDAGO CANADENSIS, L., var. SCABRA—(Golden-Rod)—Mount Royal—August, 1896.

ASTER PATULUS, Lam.—(Aster)—Mount Royal, below high reservoir—August, 1896.

ASTER SALICIFOLIUS, Ait.—(Aster)—Mount Royal Park—September, 1896.

ASTER DUMOSUS, L.—(Aster)—Point St. Charles, and foot of Mount Royal—September, 1896.

ASTER JUNCEUS, Ait.—(Aster)—St. Michel—September, 1896.

ASTER LONGIFOLIUS, Lam.—(Aster)—Bagg's Woods—September, 1896.

ASTER TARDIFLORUS, L.—(Aster)—Point St. Charles—August, 1896.

ASTER DIFFUSUS, Ait.—(Aster)—Bagg's Woods and St. Michel—August, 1896—(Holmes names it *divergens.*)

ASTER DIFFUSUS, Ait., var. THYRSOIDEUS, Gray—St. Michel—September, 1896.

ASTER DIFFUSUS, Ait., var. HIRSUTICAULIS, Gray—Point St. Charles—September, 1896.

HELIANTHUS ANNUUS, L.—(Common Sunflower)—Point St. Charles.

ACTINOMERIS SQUARROSA, Nutt.—St. Michel—August, 1896—Now first reported from the district.

BIDENS CONNATA, Muhl. var. COMOSA, Gray—(Swamp Beggar-Ticks)—September, 1896.

LAMPSANA COMMUNIS, L.—(Nipple-Wort)—Montreal Junction and St. Michel—June and August, 1896.

HIERACIUM PANICULATUM, L.—(Hawkweed)—St. Michel —September, 1896—(Reported by Dr. Holmes from Papineau Woods.)

PRENANTHIES ASPERA, Michx.—(Rattlesnake-Root)—St. Michel—September, 1896.

STEIRONEMA CILIATUM, Raf.—(Loose Strife)—St. Michel —August, 1896—(Called *Lysimachia ciliata* by Dr. Holmes.)

ASCLEPIAS INCARNATA, L.—(Swamp Milkweed)—Westmount—June, 1896—(Reported from Recollet suburbs in 1821 by Dr. Holmes.)

EPIPHEGUS VIRGINIANA, Bart.—(Beech drops, Cancer-root)—Mount Royal and St. Michel—September, 1896—(Reported by Dr. Holmes from Papineau Woods as *Orobanche Virginiana.*)

LYCOPUS SINUATUS, Ell.—(Water Horehound)—St. Michel—September, 1896.

POLYGONUM ORIENTALE, L.—(Prince's Feather)—Point St. Charles—September, 1896.

EUPHORBIA MACULATA, L.—(Spurge)—Point St. Charles —September, 1896.

CARPINUS CAROLINIANA, Watter.—(American Hornbeam. Blue Beech)—Canadian Pacific Railway ground, Westmount—August, 1896—(Reported by Dr. Holmes as *C. Americana.*)

QUERCUS BICOLOR, Willd.—(Swamp White Ash)—St. Michel—August, 1896.

CERATOPHYLLUM DEMERSUM, L.—(Hornwort) — Pond near Back River—September, 1896.

ELODEA CANADENSIS, Michx.—(Waterweed)—River St. Pierre—June, 1896.

VALLISNERIA SPIRALIS, L.—(Tape-grass, Eel-grass)—St. Lawrence, near mouth of St. Pierre River—(Reported by Dr. Holmes.)

MICROSTYLIS MONOPHYLLOS, Lindl.—(Adder's Mouth)—Little Mountain—June, 1896.

MICROSTYLIS OPHIOGLOSSOIDES, Nutt.—(Adder's Mouth) St. Michel—August, 1896.

CORALLORHIZA INNATA, R. Brown.—(Coral-Root)—St. Michel—September, 1896—(Reported by Dr. Holmes from Papineau Woods as *Cymbidium corallorhizum.*)

HABENARIA PSYCODES, Gray.—(Purple Fringed Orchis) —Mountain Swamp—July, 1896—(Reported by Dr. Holmes as *Orchis fimbriata.*)

PONTEDERIA CORDATA, L.—(Pickerel Weed)—St. Lawrence River bank above Point St. Charles—(Reported by Dr. Holmes from River St. Pierre.)

JUNCUS EFFUSUS, L.—(Common or Soft Rush)—Bank of St. Lawrence, Point St. Charles—August, 1896.

SPIRODELA POLYRRHIZA, Schleid.—(Duck Weed)—River St. Lawrence, near mouth of St. Pierre River—August, 1896—(Reported as common by Dr. Holmes by the name of *Lemna polyrrhiza*, L.)

LEMNA MINOR, L.—(Duck Weed, Duck's Meat)—Ditch St. Michel and River St. Pierre—August, 1896.

SAGITTARIA VARIABILIS, Engelm, var. ANGUSTIFOLIA—(Arrowhead)—Bank of St. Lawrence, above Point St. Charles—August, 1896—(Given by Dr. Holmes as *S. gracilis*.)

POTAMOGETON FLUITANS, Tuckerm.—(Pond Weed)—River St. Lawrence, Point St. Charles—September, 1896—(Reported by Dr. Holmes.)

POTAMOGETON HETEROPHYLLUS, Schreb.—(Pond Weed)—River St. Lawrence, Point St. Charles—September, 1896.

POTAMOGETON PERFOLIATUS, L.—(Pond Weed)—River St. Lawrence, Point St. Charles—August, 1896—(Reported by Dr. Holmes from River St. Pierre.)

POTAMOGETON PERFOLIATUS, L., var. LANCEOLATUS, Robbins.—(Pond Weed)—Point St. Charles—September, 1896.

POTAMOGETON ZOSTERÆFOLIUS, Schum.—(Pond Weed)—River St. Lawrence, Point St. Charles—September, 1896.

POTAMOGETON MUCRONATUS, Schrad.—(Pond Weed)—River St. Lawrence, Point St. Charles—September, 1896.

POTAMOGETON PUSILLUS, L.—(Pond Weed)—Point St. Charles—September, 1896.

CHARA FLEXILIS, L.—(Feather Beds)—Pond near Back River—September, 1896.

EQUISETUM SYLVATICUM, L.—(Horse-tail)—St. Michel—August, 1896.

EQUISETUM PALUSTRE, L.—(Horse-tail)—Lachine—June, 1896—(Reported by Dr. Holmes.)

ASPIDIUM SPINULOSUM, Swartz.—(Shield Fern. Wood Fern)—Bagg's Woods—August, 1896.

ASPIDIUM SPINULOSUM, Swartz, var. INTERMEDIUM, D. C. Eaton—(Shield Fern)—Bagg's Woods—September, 1896.

Aspidium Boothii, Tuckerm—(Shield Fern)—St. Michel—August, 1896—(Reported by Dr. Holmes as *A. cristatum.*)

Aspidium Goldianum, Hook.—(Shield Fern)—Bagg's Woods—August, 1896—(Reported by Dr. Holmes from Mount Royal.)

Aspidium acrostichoides, Swartz.—(Christmas Fern)—Bagg's Woods—August, 1896—(Reported by Dr. Holmes from Mount Royal.)

Dicksonia pilosiuscula, Willd.—(Dicksonia)—Bagg's Woods—August, 1896.

Nematophyton crassum.

By D. P. Penhallow.

Since my last summary of the genus Nematophyton, in which eight species were enumerated,[1] additional material has been received, which, on the basis of more ample and more perfectly preserved specimens, serves to extend and confirm our previous knowledge of certain species.

The specimen now under consideration was received from Mr. F. K. Mixer, of the Buffalo Society of Natural Sciences, who reports that it was obtained from the upper part of the water-lime group (Lower Helderberg) of the Upper Silurian. Heretofore the occurrence of this genus, at so low a horizon, has been confined to N. Hicksii, N. Logani and, more recently, N. Storriei, all of which have been from European localities, while N. Logani has also been found sparingly and in fragmentary specimens at Cap Bon Ami, New Brunswick.

This is the first time the species now under consideration has been observed in the Silurian of America, the lowest and only horizon heretofore recorded being Middle Erian. It, therefore, affords important testimony bearing upon the great antiquity of the genus as a whole, and of this species in particular.

[1] Ann. Bot. X., 41, 1896.

The specimen obtained by Mr. Mixer represents the base of the stem or stipe, and in this respect it is similar to the recently described specimen of N. Ortoni.[1] It measures 56 centimeters long. At the top it is 7.5 c.m. broad, while at the base, where the root processes arise, it widens out to 16.5 c.m. Externally the surface is roughened as if from the result of superficial decay, and shows somewhat extended carbonized areas, within which the material separates in small angular fragments. In the transverse section no concentric structure is observable.

Sections of this specimen were prepared by Dr. J. M. Clarke, of Albany, N.Y., and forwarded to me for study. They represent a fairly well preserved structure, and even a hasty examination served to show that they exhibited several elements of interest.

Transverse Section.

The structure is somewhat altered, in consequence of which the large cells are, to some extent, wanting in a sharply defined outline, but nowhere was there that extreme alteration met with in specimens of the same species as formerly obtained from the Hamilton group of New York. Nevertheless, the alteration has been carried sufficiently far to render the small hyphæ lying between the large cells, to a great extent unrecognizable.

The best material representing this species, heretofore studied, was that originally collected by Dr. Bell from Gaspé, but it was in small fragments and did not permit of extended study. It, nevertheless, showed the large cells of the medulla to be very perfectly preserved, and the hyphæ also, to be unaltered in form.[2] It was upon a study of this material that the diagnosis of the species was first based. Later, a revision of the Celluloxylon primævum of Dawson, as represented by material from the Hamilton group of New York, collected by Dr. J. M.

[1] Ann. Bot. X., 41, 1896.

[2] Trans. R. Soc. VII., iv., 20, 21.

Clarke, showed that this plant was referrable to N. crassum, but that it had been highly altered by crystallization.[1] More recently, material collected by Prof. C. S. Prosser from the Hamilton group of New York, furnished specimens much more perfectly preserved, but yet much altered by crystallization.[2] From this it is to be observed that the excellent state of preservation of the material now at hand, affords excellent opportunities for verification of the previous diagnoses.

The cells of the Medulla are large, ranging from 40 μ.–62 μ. broad, but are chiefly rather uniform in size, and average about 56 μ. in diameter. This, it will be observed, is rather larger than observed in former specimens of this species, which showed a range of 23 μ.–46 μ. in one case[3] and 32 μ.–39 μ. in another.[4]

The entire structure is rather lax—not so much so as in N. laxum and N. Ortoni, but closely comparable with previous specimens of N. crassum. Medullary spots are numerous and irregularly distributed. They are of an irregularly rounded or oblong form, and appear to range from 174 μ. to 261 μ. in diameter. Here and there they seem to have undergone exceptional alteration leading to the formation of spherical cavities about 436 μ. in diameter. They are, however, in most cases, occupied by a somewhat loose plexus of hyphæ having a somewhat variable diameter, ranging upwards from 4.68 μ.—similar in general character and size to the hyphæ lying between the large cells of the medulla.

Even without the aid of a magnifying glass, a certain concentric structure with broad zones is apparent in the transparent section, but this is by no means as clearly defined as in N. Logani. Under a magnifying power of moderate strength, this appearance entirely disappears,

[1] l. c. VII., iv., 25.
[2] Proc. U.S. Nat. Mus., XVI., 116.
[3] Proc. U.S. Nat. Mus., XVI., 116.
[4] Trans. R. Soc. Can., VII., iv., 20—23, 29.

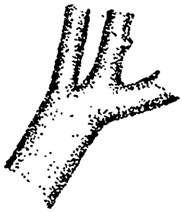
and it is extremely difficult to determine precisely upon what it depends, but it seems probable that it is determined by a peculiar disposition of the cells in relation to the medullary spaces.

Large transverse sections also exhibit radial fissures due to shrinkage, but there appears to be a total absence of those radial bands simulating medullary rays, so conspicuous in N. Logani. On the other hand, the medullary spots, already described, are connected radially and tangentially by more continuous and open tracts as medullary spaces, which thus form a sort of netted system between the various sub-divisions of which the large cells lie in distinct and often more or less rounded groups. This distribution of the elements gives the transverse section a very characteristic appearance. It had already been noted in the previously described specimens of N. crassum, but owing to the very limited area of the Gaspé sections, and the highly altered character of the specimens from the Hamilton group, a proper description was not possible, and this structural feature was, therefore, omitted from the diagnosis. It is, nevertheless, an important diagnostic element, under the present circumstances of limited material, since it seems to definitely differentiate this species from all the others.

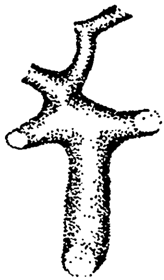
Longitudinal Section.

In longitudinal section the cells of the medulla are somewhat strongly interlacing, while groups of a dozen or more often cross the general direction of growth more or less abruptly, and sometimes turn off nearly at right angles for a short distance. These features also appear in previously described specimens, both from Gaspé and from New York. The intercellular hyphæ are freely interlacing and cross the large cells in all directions, but their structure is so altered by decay as to render it impossible to determine if they are septate or not. Nowhere have trumpet hyphæ been found, thus confirming previous observations in this respect.

The medullary spots are, in most cases, elongated vertically, assuming an oblong or lenticular form, two to several times higher than broad, features also characteristic of the formerly described specimens of this species. The spots are, as in other cases, crowded with interlacing hyphæ, and into them there also project large cells from the surrounding structure, which branch more or less freely. These sections afford numerous instances of branching cells, and in one spot there were found two such cases, (figs. 1 and 2), one of which exhibited five subdivisions, primary and secondary, while the other showed three primary divisions terminal to the parent cell.



1



2

So many are the instances of this kind, and so varied are the dimensions of the branches, that I cannot but consider this specimen as affording very strong evidence in support of the conclusions already reached, that the medullary spaces "are the special areas within which branching is accomplished," and that it is here that the small hyphæ have their origin from the large cells of the medulla.[1]

The present material is thus found to not only extend our knowledge of the geographical range and stratigraphical horizon of this plant, but it affords strong corroborative testimony with respect to previous conclu-

[1] Trans. R. Soc. Can., VI., iv., 42; VII., iv., 22.
[2] Ann. Bot., X., 46, 1896.

sions, and extends its differential characters to an important extent. It thus becomes necessary to revise our original diagnosis in conformity with the facts now at hand.

NEMATOPHYTON CRASSUM (Dn.) Pen.

Transverse.

Concentric structure rather obscure. Radial tracts none. Medullary spots numerous, irregularly round or oval, chiefly 174 μ.–261 μ. broad, and connected by narrow spaces which form a more or less distinct network, enclosing groups of large, thick-walled cells. Cells of the medulla not very compact, rather uniform, ranging from 23 μ.–62 μ. broad, chiefly about 40 μ.

Longitudinal.

Cells of the medulla interlacing, often in groups. Medullary spots vertically lenticular or oblong, crowded with small hyphæ, 2 μ.–10 μ. broad, which arise within these areas from branching cells derived from the surrounding structure.

Highly crystalline forms often show a replacement of the normal structure by a pseudo-cellular structure (Celluloxylon.)

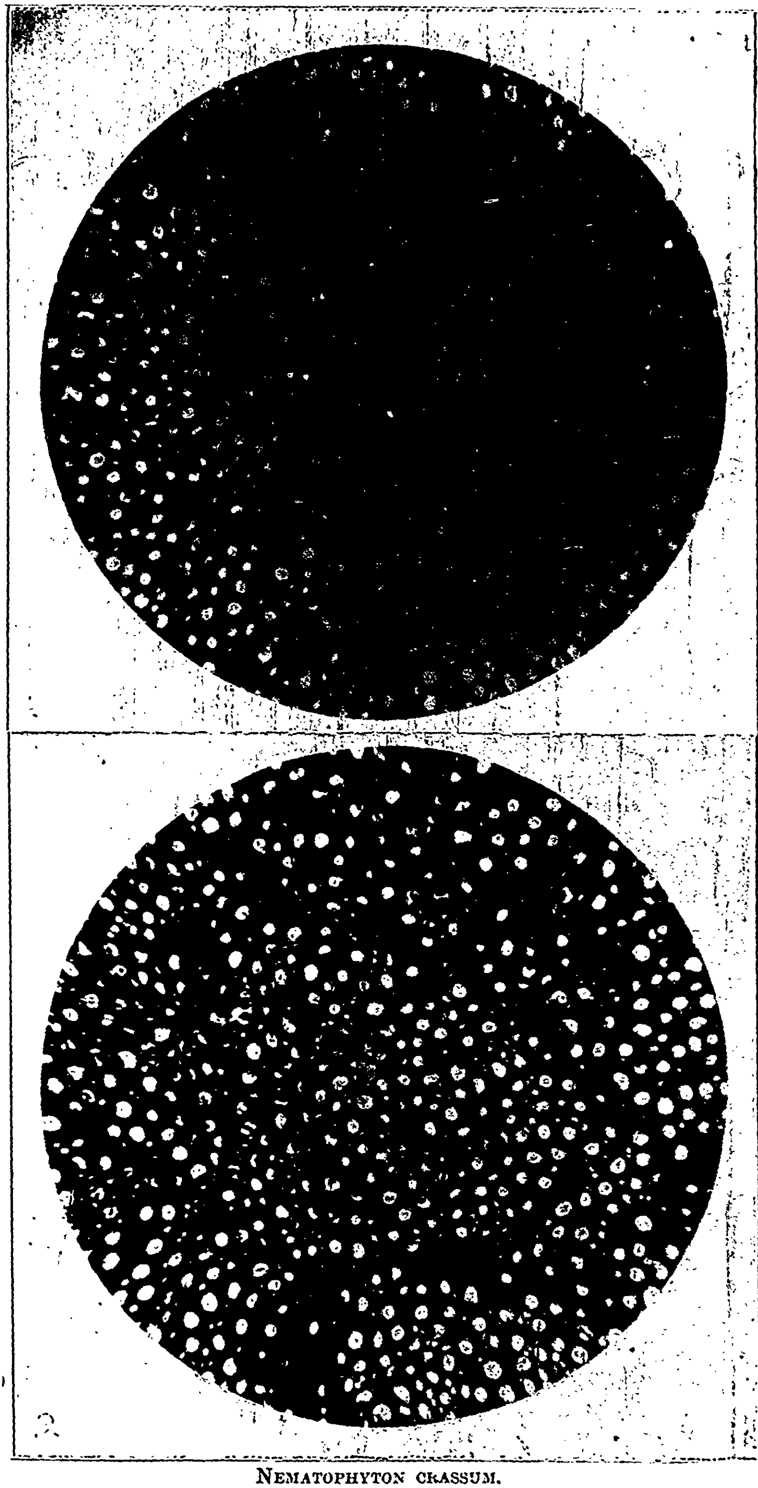
Found as fragments, also the base of the stipe showing root processes.

Middle Erian (Devonian) of Gaspé (*Bell*); Hamilton group (Middle Erian) of New York (*Clarke and Prosser*), and the Upper Silurian (Lower Helderberg) of New York (*Mixer.*)

DESCRIPTION OF FIGURES.

Fig. 1. Transverse section of Nematophyton crassum, showing the distribution of the medullary spots. x 45.

Fig. 2. Transverse section of Nematophyton crassum, showing distribution of the medullary spaces connecting the medullary spots. x 45.



NEMATOPHYTON CRASSUM.

Pre-Cambrian Fossils Especially in Canada.

(Abstract of a paper by Sir W. Dawson, LL.D., F.R.S. Read in the Geological Section of the British Association, Liverpool Meeting, September, 1896.)

The paper was intended to be introductory to the exhibition by the lantern of specimens of *Eozoon Canadense*, for the purpose of showing its structures to geologists who may not have had opportunities of seeing authentic or perfect specimens. Canadian examples of the rocks and fossils were referred to, because that country possesses the greatest areas and the best exposures of Pre-Cambrian rocks, because in that country large portions of them have been well explored and mapped, and because, in Canada, Eozoon was first discovered.

The base of the Cambrian system may, for the present, be fixed at the lower limit of the Olenellus fauna, now recognized in Newfoundland and in the western part of Canada, as well as in the United States. With this the Protolenus horizon of Matthew in Southern New Brunswick should probably be associated; and there, as well as in Newfoundland, the lowest bed of the series is marked by a barren sandstone.[1] The Olenellus Zone affords, according to Walcott, 165 species, representing all the leading types of Marine Invertebrate life.[2]

Beneath this, in New Brunswick and Newfoundland, is a great thickness of red and greenish slates or shales, resting on a base of conglomerate, which lies unconformably on the Huronian system (Coldbrook Series), of whose debris it is, in part, composed. It contains, as far as known, no Trilobites, but has a few fossils referred to Ostrocods, Mollusks, Worms, Brachiopods, Cystideans, and Protozoa. Matthew has named this group in New Brunswick the Etcheminian system. He regards it as Pre-Cambrian, but still Palæozoic. It seems to correspond

1 Matthew, *Protolenus Fauna*, Trans. Acad. Science, N.Y., March, 1895.

2 Memoir on Lower Cambrian, U.S. Geol. Survey.

with the Signal Hill Series and Random Sound Series of Murray and Howley in Newfoundland, with the Kewenian or Kewenawan Series of Lake Superior, which, according to the observations of the Canadian Survey, covers great areas between Lake Superior and the Arctic Sea. It may be correlated with the Chuar and Grand Canyon formations of Walcott in Arizona. In the latter these occur with a few other fossils, including a fragment of a Trilobite, numerous specimens of large laminated forms, which may be regarded as connecting the *Cryptozoon* of the Cambrian, and the *Archæozoon* of the Upper Laurentian with Eozoon.[1]

If, with Matthew, we regard the Etcheminian beds and their equivalents as lowest Palæozoic, then the fossiliferous formations underlying these should be included under the term *Eozoic*, proposed by the author many years ago in connection with the description of Eozoon; and the term Algonkian, used by the United States Geological Survey, will include both Palæozoic and Eozoic formations.[2]

Next below the Etcheminian in New Brunswick, Newfoundland, Lake Superior and Lake Huron, and also, apparently, in Colorado, we have the great thickness of mostly coarse, clastic sediments, associated with contemporaneous volcanic outflows and ash-rocks, originally described by Logan and Murray as the *Huronian* system. These rocks are of a character not likely to yield many fossils. There are, however, slates, limestones, and iron ores associated with them, which have afforded laminated bodies comparable with Eozoon, burrows of worms, spicules of sponges and indeterminate fragments referable to Algae or to Zoophytes. In rocks of similar age in Brittany, Barrois and Cayeux announce the occurrence of Sponges, Foraminifera and Radiolarians.

[1] Hall, Report on Palæontology of N. York, No. 36, Matthew Bulletin, N. Brunswick, Nat. Hist. Society, 1890, Walcott l.c.

[2] This term is, in any case, unhappy in form and sense, and perhaps should be dropped.

Doubt has, however, been cast on these in a recent paper by Dr. Rauff, of Bonn. It is not improbable that the Huronian may admit of sub-division into two members; and, if its deep sea limestones could be found, perhaps into three. It underlies the Etcheminian unconformably, and, so far as known, is itself unconformable to the Laurentian, which must have been subjected to some disturbance and to much intrusion of igneous matter, as well as to great denudation, before and during the Huronian period.

Next in descending order is the Upper Laurentian, or *Grenvillian* system (the upper part of Logan's Lower Laurentian), which is well developed in the St. Lawrence and Ottawa Valley and also in New Brunswick, as well as in the Adirondacks and the eastern slope of the Apalachians. It contains various gneissose and schistoze rocks, which, though crystalline, show, on analysis, the same composition with Palæozoic slates,[1] and it includes also bands of quartzite and of graphite and graphitic schist, as well as large beds of magnetite. Above all, it is remarkable for the occurrence of great zones or belts of limestone, associated with what seem to be altered sedimentary beds, and is in many places rich in graphite and in apatite. It is scarcely possible to doubt that in this great system of several thousands of feet in thickness we have evidence of tranquil oceanic deposition and of abundant animal and vegetable life. It, no doubt, also occupies great areas covered by later deposits, while there is evidence that the portions exposed have undergone enormous denudation.

The graphite of this system has yielded no distinct structures, except imperfectly preserved fibres; but in some places it assumes the form of long ribbon-like bands, suggestive of fronds of algæ, and an American palæontologist, Mr. Britton, has described one of these forms from

[1] Adams—Am. Journal of Science, July, 1895.

the Laurentian limestone of New Jersey, under the name of *Archaeophyton Newberrianum.*[1]

It is in one of the limestones, the highest of the series, rich in nodules and grains of Serpentine, that the forms described as *Eozoon Canadense* occur. It is not the object of this paper to enter into any details as to these, or any discussion of their claims to be regarded as of animal origin, but to allow the specimens exhibited to speak for themselves, referring to previous publications for a more particular account of their structure and modes of occurrence.[2]

Below the Grenville series we find an immense thickness of orthoclase gneiss, associated with igneous dykes and masses, without limestones or other indications of organic remains, but presenting alternations with thick bands of Hornblendic schist. This is the "Ottawa gneiss" of the Geological Survey of Canada, a fundamental rock, perhaps a portion of the primitive crust of the earth, or a product of aqueo-igneous, or crenitic action, before the beginning of regular sedimentation. It is the Lower Laurentian or Archæan complex of some authors, and is quite distinct from the overlying Grenvillian, except in the occurrence of orthoclase gneisses in both.

The Eozoic group of systems will thus for the present include the Huronian and Grenvillian or Upper Laurentian, the fauna of which is characterized by the prevalence in the former of Annelida, Sponges and Protozoa, and in the latter, so far as known, of Protozoa alone, represented by peculiar and gigantic forms, as Eozoon and Archæozoon, and some smaller types (Archæospherinæ).

As at present known, these systems are of a character unfavorable to the preservation of organic remains—the Huronian because of its coarse and littoral character, the Grenvillian because of its great metamorphism. It may,

[1] Annals N.Y. Academy, Vol. IV., No. 4.

[2] See papers in the Geological Magazine for 1895, also Memoir in Publications of Peter Redpath Museum.

however, be hoped that should deep sea deposits of Huronian age be discovered, or the Grenvillian rocks in a less altered state, additional species may be found; nor is it impossible that there may be additional formations filling the probable gaps in time between the Lower Laurentian and the Grenvillian, or between it and the Huronian, or between the latter and the Etcheminian. In any case there is ample scope for the labor of those who have the necessary skill and patience. It was added that important detailed explorations of the Laurentian and Huronian, supplementary to those of Logan, are now in progress, under Dr. Dawson, Director of the Geological Survey of Canada; more especially by Dr. Ells, Dr. Adams and Mr. Barlow, and may be expected to yield important results.

In concluding, the author insisted on the duty of palæontologists to give more attention to the Pre-Cambrian rocks, in the hope of discovering connecting links with the Cambrian, and of finding the oceanic members of the Huronian, and less metamorphosed equivalents of the Upper Laurentian, and so of reaching backward to the actual beginning of life on our planet, should this prove to be attainable. At the close of the paper a number of micro-photographs, showing the forms and structures of Eozoon and other ancient remains, supposed to be organic, were projected on the screen.

The President said that they were all delighted to have the subject presented in this way. The dawn of life on the globe was, perhaps, the most fascinating of all subjects with which the geologist had to deal. The subject of Eozoon Canadense was intimately associated with the name of Sir William Dawson.

Dr. Hicks said no one else could possibly have given such an exposition of Eozoon.

In the discussion which followed, Mr. Matthew, Dr. Johnston Lavis, Sir James Grant, Professor Rupert Jones, Professor Bonney, and others took part. One speaker remarked that Eozoon had been attacked for many years, but there were some geologists who still had faith in it.

In responding, Sir William Dawson thanked the speakers for the fair and friendly manner in which they had received his old friend of the Laurentian rocks, and hoped it was not merely on the principle that nothing but good was to be said of the dead. His object had been to exhibit to a representative audience a series of characteristic examples of these curious objects, leaving those present to form their own conclusions. In any case, he thought they must admit that the discussion of the subject had been of advantage to science; and he hoped it would eventually lead to a great extension of our knowledge of the earliest forms of life.

It was announced that additional specimens were on exhibition at University College Museum, and that some of these would be demonstrated under the microscope on the following afternoon. (Partly from Report in Liverpool *Post.*)

REMARKS ON THE DISTINCTIVE CHARACTERS OF THE CANADIAN SPRUCES[1]—*Species of Picea.*

By GEORGE LAWSON, Ph.D., LL.D., F.R.S.C., Professor of Chemistry, Dalhousie College, Halifax, Nova Scotia.

Our native spruces (belonging to the genus *Picea*) have received attention at different times from many botanists, but their conclusions in regard to the number of species,

[1] This important paper, originally presented to the Royal Society of Canada in 1887, appears to have been published privately, since it cannot be found in any of the journals of that year. The renewed interest which has of late centred in the possible distinction of *Picea nigra* and *P. rubra* makes it desirable that these observations should be placed in some publication through which they may be brought more prominently under the notice of working botanists, to whom they are known, but not accessible. D. P. PENHALLOW.

Montreal, October, 1896.

and the exact relations of these to each other, have not been concordant. It seemed desirable to invite attention again to the subject, and this was done in a preliminary paper read in Section IV. of the Royal Society of Canada, at the meeting held at Ottawa in May last (1887.) The discussion on that occasion, and subsequent correspondence, have shown that the matter is not without interest, and have suggested the desirability of publishing some of the facts then stated, as well as results subsequently reached, together with some historical details—so as to indicate our present knowledge on the snbject, the information still needed, and the directions in which profitable enquiry may be made. Local observers and collectors throughout the Dominion, and travellers visiting northern points, may do much to aid in determining the geographical range of the several species, varieties and forms, and the continuity or intermittence of their distribution in different regions.

The beautiful evergreen coniferous trees called "spruces" form a marked feature of the wild forest lands of the Canadian Dominion, especially in the Atlantic maritime districts, and in the tracts of country lying around the great lakes. The spruces are valued, not only for their large yields of useful lumber, applicable to so many purposes of life on land and sea, and for the summer shade and winter shelter which, as living trees, they afford our dwellings, but they are likewise regarded with interest, and as having some importance, from scientific points of view. How far the differences in structure and habit presented by the several species, and their aberrant or so-called intermediate forms, are to be regarded as indicative of genetic differences, or may be accounted for by the mere effects of past or present external conditions, is a question of more than incidental interest. It naturally leads to a comparison of these trees with their allies in other parts of the northern hemisphere, far beyond the range of the present Canadian forest, immense as it is, and to the consideration of other facts bearing upon their probable ancestry, in regard to which, however, the results, so far, are insufficient to warrant satisfactory conclusions.

These trees, and their extra-Canadian allies, have been variously described by botanists, at different times, under the several generic names: *Pinus, Abies, Picea.* Linnæus, upon whose system our nomenclature is founded, embraced under *Pinus:* the true pines, the Lebanon cedar, the larch, the silver (or balsam) fir, and the hemlock. In selecting specific names for the silver fir and spruce, he adopted those used by Pliny and other classical writers, who called the spruce *Picea* and the silver fir *Abies.* But he unfortunately transposed these names, calling the spruce *Pinus Abies*, and the silver fir *P. Picea.* This opened the way for much confusion, for when the old aggregate genus *Pinus* came to be successively divided up into segregate genera, and the classical names were adopted as generic ones, choice had to be made between two courses—either to apply these names so as to denote the trees intended by the classical writers, or to use them, at variance with classical usage, in accordance with the Linnæan nomenclature. As has just been indicated, succeeding botanists separated the true pines, and other marked groups of the Linnæan genus *Pinus*, into separate genera; at first the spruces and firs were classed together under the one generic name *Abies.* Link, in 1841, separated the two groups into distinct genera, restoring the classical names, *Picea* for the spruces, and *Abies* for the firs. But in Britain, where Coniferæ have been grown to an enormous extent, both for ornament and use, especially since the middle of the present century, a silver fir continued to be almost universally called a *Picea*, and a spruce an *Abies*—until within the last few years, when English scientific writers have adopted Link's use of the names, and thus adapted their nomenclature to continental custom and classical usage. Among English foresters, gardeners and nurserymen, however, the old way, so long familiar, will be given up slowly, and not without regret.

The Canadian spruces, so far as regards their distinctive specific characters, have been a puzzle to botanists. They were not known to Linnæus. Miller and Aiton recognized two species, *alba* and *nigra*, and Lambert introduced a third (*rubra*) that had been recognized by the younger Michaux as a variety of *nigra*. Accordingly, in most of the works on Coniferæ published since Lambert's (1825) by European and English botanists,[1] we find the three species described without hesitation. But there have not been wanting expressions of doubt as to the permanent distinctness of the third species, and of suspicion even, that all three were connected by intermediate forms so closely as to be doubtfully entitled to rank as more than varieties of one species. A full statement of synonymy would occupy too much space, and, indeed, be out of place in this publication; a brief indication of the views held by a few prominent botanists will suffice for the present.

In Persoon's Synopsis Plantarum, 1807 (the authorship of which is believed to belong to Richard), *rubra* is described with rubicund cones, slightly bilobed scales, and red brown bark, and is curiously enough assigned geographically to Hudson Strait; *alba*, with incurved leaves, lax subcylindrical cones, entire scales, whitish bark; *nigra*, with straight leaves, ovate black-purple cones, scales undulated at the margins, bark blackish.

Endlicher, in the standard work on Coniferæ for the time (1847), "Synopsis Coniferarum," characterized three species as follows: (pp. 112–15); *alba*, cones subcylindrical, lax, pendulous, scales broadly obovate undivided, entire (faces of leaves whitened glaucous, pulvinuli pale brown,

[1] Persoon, Antoine; Don, London, Link, Parlatore, Endlicher, Gordon, etc.

cone long-stalked, cylindrical or ovoid oblong, 2 to 2½ inches long, largest diameter, ½ inch, scales quite entire, at first green, changing to pale brown); *rubra*, cones ovate-oblong, scales split into two lobes, margin otherwise quite entire (doubtfully distinct from the next, leaves more acute, cones larger, green when young, scales constantly and evidently split-lacerate irregularly, margin otherwise entire, the wood becoming reddish); *nigra*, cones ovate-acute, scales obovate, undivided, erose, denticulate, bark blackish, faces of leaves white-dotted; cones shortly peduncled, drooping, an inch and a half long, at first purpurascent, finally reddish brown, scales with thin margins becoming undulate-lacerate.

Professor Beck, in the Botany of the Northern and Middle States (1833), which formed the precursor of Dr. Asa Gray's standard Manual, described three species (p. 340), as: *nigra*, * * * leaves straight, strobile ovate, scales elliptical, undulate on the margin, erosely denticulate at the apex; *rubra*, * * * strobile oblong, scales rounded, somewhat two-lobed, entire on the margin; *alba*, leaves incurved, strobile subcylindrical, loose, scales obovate, very entire.

I have not been able to refer to the first edition of Dr. Gray's Manual of Botany of the Northern United States (published in 1848), but in the second edition (1856) the red spruce of Beck is dropped, and only *nigra* and *alba* described—the former with dark rigid sharp green leaves, cones ovate, or ovate-oblong (one to one and a half inch long), the scales with a thin and wavy or eroded edge—a common variety in New England having lighter colored or glaucous-green leaves rather more slender and loosely spreading, and indistinguishable from *alba* except by the cones. *A. alba* is characterized as having oblong-cylindrical cones (one to two inches long), the scales with firm and entire edges; otherwise as in the lighter-colored variety of the last. The remark is added: Probably these two, with the red spruce, are mere forms of one species.

In subsequent editions of the same work the descriptions are amended, the leaves of *nigra* being characterized as either dark green or glaucous-whitish, and the cones are said to be recurved, persistent while those of *alba* are two inches long, nodding, cylindrical, pale, deciduous, the thinner scales with an entire edge (the latter a handsomer tree than the former, more like a balsam fir.) These descriptions point to the red and black spruces being both included under *nigra*.

Professor Alphonso Wood, in his Class Book and Flora of the United States and Canada, also characterized only two species: *alba,* with incurved leaves, cones lax, subcylindric, with entire two-lobed scales; *nigra,* with straight leaves, ovoid cones, scales erosely dentate at the edge.

Dr. Chapman, in the Flora of the Southern United States (1860) likewise gave two species (pp. 434–5): *nigra,* leaves dark green, cone one and one-half inch long, ovate, or ovate-oblong, the scales with a thin wavy or denticulate margin; *alba,* leaves more slender and less crowded, light green, cones 1 and 2 in. long, oblong cylindrical, with the scales entire.

The late Prof. Brunet, of Laval University, an acute and careful botanist, of whom Dr. Gray had a high opinion, described three forms: *alba, nigra* and a variety *grisea* (Canadian Naturalist, new series, vol. iii., p. 108).

The Abbe Provancher, in Flore Canadienne, characterized *alba* and *nigra* clearly.

The late Andrew Murray, who took so much interest in American Coniferæ, in his later writings ignored *rubra.*

Professor Fowler, in his carefully prepared list of the plants of New Brunswick, gives two species, *alba* and *nigra,* as common throughout that province.

Prof. Parlatore, in the Monograph of Coniferæ in De

Candolle's Prodromus, Vol. xvi., second section, pp. 413–14, published in June, 1868, recognizes our Canadian species as three: *nigra*, the black spruce or double spruce of Anglo-Americans; *rubra*, with leaf-faces albo-glaucescent (indicating that he probably had a form of *nigra* in view); and *alba*, with oval-oblong, or oval-cylindrical cones, pendulous, on longer branchlets than the others (the geographical range extending to the Rocky Mountains, on authority of specimen from Bourgeau).

In Dr. Robert Bell's chart of the northern limits of trees forming the Canadian forests, the two spruces, *alba* and *nigra*, are lined together.

Prof. Macoun, in the Catalogue of Canadian Plants of the Geological Survey of Canada, gives two species, combining *rubra* with *nigra*.

Sir Joseph Hooker, in his tabulation in the Outlines of Distribution of Arctic Plants (Linnæan Transactions, 1864), gives only *alba* and *nigra*, and Sereno Watson, in the Botany of California, also dismisses our spruces in N.E. as "two species."

The following descriptions of the several species are not thrown into systematic form, being merely intended to call attention to points of difference, and to suggest observation and enquiry, so that the necessary information may be obtained for the formation of accurate and permanent diagnostic characters:

1. PICEA ALBA.—Link, in Linnæa, xv., p. 519.

Picea alba, the white spruce of Canada, is recognized at a distance, from the allied species, by the comparative massiveness of the foliage with which its horizontal or pendant boughs are clothed, and by its glaucous or whitish-green tint—the leaves when newly expanded being pale and silvery, as if covered with the most delicate coating of hoar frost. This appearance, however, is caused by the individual leaves not being wholly green, but having longitudinal rows of apparently white or colorless dots or spaces, owing to the non-development of chlorophyll in certain surface cells at regular intervals. The old bark of the stem is grayish, not dark-colored, and the young shoots of the year present a smooth, shining, ivory-white surface, altogether destitute of trichomes or roughness of any kind. The leaves vary in actual size with the vigor of the tree, but are longer in proportion than those of either of the other species; the leaf-bases from which they arise are arranged uniformly around the horizontal branches, but, although, spreading in direction at their bases, are more or less curved upwards in a secund manner, presenting a nearly uniform flattened brush-like surface of foliage. The cones vary in absolute size, according to vigor of tree, etc., but are always of much greater length and usually more slender than those of the other species, being nearly cylindrical, not sensibly thickened in the middle as in *nigra*, nor below the middle as in *rubra*. Dr. Bell well expresses their form as finger-shaped. The scales are also more numerous than in the allied species, and the spiral arrangement is different. The cones are green at first, the individual scales being sometimes clouded with a slight brown band-like patch on the exposed part, but not extending to the edge. In ripening, the green color mellows into a more or less decided straw color, but the cones when mature are never either dark or decidedly reddish. When of a lively straw-color, and profusely produced all over the tree, as we often see them along the shore, hanging down from the drooping tips of the young branchlets, the contrast with the bright silver-frosted needle foliage is very pleasing, so that the white spruce is one of the most ornamental of our native trees, and admirably adapted for sea-side shelter. The edges of the cone scales are always quite entire.

Prof. Bell, M.D., President of the Fourth Section of the Royal Society, has very kindly made careful observations, and communicated them to me, on the several points of difference between the white and black spruces. Through his kindness, also, I have had opportunity of examining specimens from widely separated localities throughout the Dominion. His opportunities of travel, for observation and collection of specimens, during his long connection with the Geological Survey of Canada, have been exceptionally favorable. Dr. Bell points out that the most obvious distinctions between the black and white spruce are (1) that the latter is a larger tree than the black, coarser, lighter in general color, as well as in color of bark, twigs, etc.: (2) that, in the white spruce, the boughs are stiffer, more vigorous, and flatter than in the black; (3) that the cones differ in many ways: in the white, they are scattered all over the tree, although most abundant near the top, and drop off every year, whereas the black spruce cones adhere for two, three, four or five years—the current year's crop being at the top (mostly), the previous year's next below, that of the year before still farther down, etc., the quantity of cones diminishing downwards and their age increasing. (4). The white spruce cone is finger-shaped, and green in color till it dries and opens, whereas the black is deep purple and plum-shaped, bulging in the centre. (5). The white is attached by a straight peduncle, the black by a curved thickening one. (6). The number of scales in each is very different, numerous counts of the scales of cones from many trees in northern regions of the Dominion yielding the following results: the white spruce cone seldom has fewer than 60 scales or more than 90—average about 70; whilst the black seldom has many over 30, the average may be about 33—so that the white spruce cone has more than double the number that the black has. Eleven white spruce cones from a tree at Kingston, Ontarió, gave an average number of 77, and of five cones of the same from a tree at the Emerald Mine, near Buckingham (Co. Ottawa, P.Q.), the average is 61.

The white spruce is observed especially along the shores of the ocean, estuaries and lakes, as in Cape Breton Island, around the Atlantic and Bay of Fundy shores of Nova Scotia and New Brunswick, also around the shores of the St. Lawrence Gulf and up the St. Lawrence River, and along the Ontario lakes. Dr. Bell sends a beautiful photograph of this species, showing its characters well, from Grand Lake House, on the Upper Ottawa. I have a specimen collected at Lake Winnipeg by his Hon. Lieut.-Governor Schultz, M.D., in the summer of 1860.

I desire specially to call the attention of observers to one point in regard to the geographical distribution of *Picea alba*. For many years it has appeared to me to be essentially a maritime species, growing around the Atlantic and northern coasts of Canada, and extending by way of the St. Lawrence westward to the great lakes, as far, at least, as shown by Governor Schultz's specimen, as Lake Winnipeg. Its absence in *inland* localities is not noticed, so far as I have ascertained, in published works, yet, even in the narrow peninsula of Nova Scotia, bounded on one side by the Atlantic Ocean, and on the other by the Bay of Fundy and waters connecting with the Gulf of St. Lawrence, the absence or scarcity of this tree in inland localities, or even in such as are only a few miles distant from the shore, is very marked. It appears, therefore, to be especially desirable, in recording localities for its occurrence, to note their distance from seaboard or great lakes. I have already endeavored to impress upon observers the consideration that the only reliable material for tracing geographical distribution must consist of substantial data, actual local observations carefully noted and authenticated by specimens, corrected, reduced and compared, after the manner of H. C. Watson, and left on record in such form as to render elimination of errors possible, and that mere general impressions received by travellers over the country, although often of great practical value, are not to be regarded as absolute scientific results.[1] In the early days, when Douglas and Thomas Drummond were solitary wanderers over the Continent, and Menzies was touching the coast at Chebucto and nameless points on the Northern Pacific shores, every scrap of information, and especially their notes on range of species, was of substantial value, but now we have the means of working out problems by more systematic and scientific methods, and of eliminating the errors of individual observation.[2]

2. PICEA NIGRA, *Link*, in Linnæa xv., p. 520.

The black spruce is a sombre tree, the old bark of dark color, the surface of young shoots of the year of a dark brown, and clothed with a short sparse fur of thick short curved trichomes. The foliage is of a decidedly dark green color, but distinctly glaucous or hoary. The leaves are short, almost straight, radiating from the branch in a bottle brush fashion at a nearly uniform angle except that they are turned away from the lower surface of the branch. The leaves (as in other species) vary in size with vigor of tree, but are always much shorter than in the other species, and blunt at the apex. The cones, when young, are of a deep purple, or purpurascent color, becoming reddish-brown as they ripen, darkening with age, and ultimately changing to a deep dark gray-black when old. The other species drop their cones during the first winter after they are formed; *P. nigra* retains them for several years, the recent crop of the year being near the top of the tree mostly, the previous years next below, that of the year before further

[1] See Trans. Royal Soc. of Canada, Vol. II., Sec. iv., p. 16.

[2] *Abies arctica*, Murray, Seeman's Journal, 1867, p. 273, cum ic., is referred by Parlatore as a variety of *alba*.—DC, Prodromus, XVI., p. 414. On same page there is description of something no doubt quite different, *Abies arctica*, Cunningh.. ex Henk. & Hochst. This is referred to *rubra*.

down, and so on, the cones diminishing in quantity downwardly as their age is increased. The cone is attached to its branchlets by a curved stalk (whereas that of *P. alba* is straight), and the cone itself is conspicuously much wider in the middle than towards base or apex; several of these differences are taken from Dr. Bell's notes, but are entirely in accordance with my own observations.

This species appears to be widely distributed, both in coast and inland districts, extending apparently far north, and in the south ascending the mountains. Black spruce is famed among lumbermen as a tree yielding sound, strong and lasting timber. In Nova Scotia it is found, not on dry ground, but on wet flats, apparently irrespective of atmospheric moisture. In inland districts, groves of it occur in the red spruce forests, on the wet lands around lakes, and along river sides, and on shelving terraces on the hill sides, but it also grows down to the sea-shore intermixed with *P. alba*—the favoring condition apparently being a retentive moist soil. In the north and north-west, the tree appears, from accounts and photographs received, to be more vigorous than along the Atlantic region of Nova Scotia.

3. PICEA RUBRA, *Link*, in Linnæa, xv., p. 521.

Picea rubra, the red spruce, is readily known by its clean, uniform bark (not broken into large scales) of a distinctly reddish color, by its long, slender shoots, giving it the appearance of being a more rapid grower than *nigra*, but not so robust in habit as *alba*, and by its bright green foliage, without any trace of hoariness or glaucescence. The leaves, as compared with those of the allied species, are short, incurved, not so secundly as in *alba*, but bent inwards towards the branchlets, and on the leading shoots they are more or less closely appressed to the leader, giving it a very elongated slender appearance. The year's shoots are of a lively chestnut-red color, and are beset with short, erect, thickish, curved, epidermal processes (trichomes), which arise especially around the edges of the flat basal plates of the leaf-bases, variously called peg-processes, sterigmata, etc. The cones are of a bright chestnut color, regularly ovate in form. The wood is softer than that of the black spruce, it is also less enduring under open air exposure, as we know from experience; every season the red spruce poles have to be replaced more frequently than the black in fences.

The best general description that has hitherto been published of *P. rubra* is that of my late friend, William Gorrie, in the Transactions of the Botanical Society of Edinburgh, Vol. X., p. 353. Mr. Gorrie's description was taken from the tree as observed by him in the plantations and pleasure grounds in Britain, but, so far as it goes, it corresponds entirely with the tree as seen in the Nova Scotian woods:—" The red spruce fir, or Newfoundland red pine, is found in Nova Scotia, some parts of Lower Canada, and northward to Hudson Bay, but is not included in Dr. Asa Gray's Flora of the Northern United States. It is said to be a better and finer tree than either of its allies—the black and white spruces—from which it further differs in being entirely devoid of that glaucous green by which the leaves of these two are distinguished. It is, in fact, exactly like the common Norway spruce in the color both of its foliage and young branches, but differs from it in its thinner and more slender growth, shorter leaves, and much smaller cones. From this close resemblance in color of *rubra* and *excelsa*, Americans call the latter the red spruce of Europe. Like the *alba*, the *rubra* drops its cones in the course of the first winter and succeeding spring, while those of *nigra* are retained on the tree for two or more years. Like its two American associates, *alba* and *nigra*, *rubra* seems to delight in moist soils containing a proportion of peat and moist upland climates. Those now growing at Tynehead were reared from seeds gathered in Newfoundland, and a portion of the plants which were planted on good, dry, heavy soil, within from two to three miles, and at half the altitude, dwindled away after the first few years, till they entirely perished. The trees at Dunmore are, no doubt, growing at a low altitude, but they are sheltered by a high-wooded bank on the south, and are on a damp bottom. Mr. Andrew Murray, a distinguished member of the Botanical Society, and recognized authority on Coniferæ, has ignored the existence of *rubra*, but he has probably never seen it growing, as, although long introduced, it is still scarce in Britain." In illustration of these remarks, Mr. Gorrie exhibited and presented to the Botanical Society branches and cones of (1) *P. rubra* taken from a group of trees growing on the railway banks, near Tynehead Station, in Midlothian, at an altitude of about 800 feet. The trees had then (13th January, 1870), been about fifteen years planted, and were from 12 to 18 feet in height; (2). *P. rubra*, from a group of trees growing in drained and improved ground, which must once have been marshy, in Dunmore Park, near Stirling, Scotland, not 50 feet above high-water mark, seemingly about the same age as the last, and from 15 to 20 feet in height; (3). *P. alba*, from near Tynehead Station; (4). *P. nigra*, from Dunmore Park.

In addition to acknowledgments for specimens already made in this paper, my best thanks are due to Mr. John MacAloney, of Halifax, who collected for me the several forms growing on the shores of the Bay of Fundy; to Mr. W. S. Calkin, B.A., now of Cornell University, who, while an undergraduate of Dalhousie College, obtained those of the district around Truro; and to Mr. S. J. McLennan, B.A., who made similar collections around Sydney Harbor, Cape Breton.

Segregation in Ores and Mattes.

By David H. Browne, Sudbury, Ontario.

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During the last few years, the origin of the Sudbury nickel-ore deposits has been the subject of much discussion. The igneous and the aqueous theories have been both strongly championed, and at the present date, while the balance of opinion leans to the igneous side, the lack of any decisive testimony on which arguments *pro* and *con* could be based, has tended to make a decision necessarily difficult and unsatisfactory.

Bell, in his report on the Sudbury ores,[1] says: "The general character of the deposits seems to indicate that they have originated primarily from a state of fusion." H. B. Von Fullon[2] states that "Die Erze sind nicht wâsserigen, soudern feuer flüssigen Ursprunges," *i.e.*, "not of aqueous but of igneous origin." Vogt[3] assigns these and other similar sulphide ores to "segregation from a molten basic magma," and Kemp[4] gives it as his opinion that the appearance of the ores "leaves no reasonable alternative but to conclude that they are as much an original crystallization from the igneous magma as any other mineral in the rock."

On the other hand, Posepny refers to the igneous theory as something extraordinary; Emmens[5] thinks that nickel is an essential constituent of the gangue, and Argall[6] "submits that it is to the leaching of basic eruptives at or near the surface our principal deposits of nickel are due."

All these latter opinions, based as they are on resemblance to other ore-deposits, may be considered as

1 Report on the Sudbury Mining District, p. 49.
2 Ueber Einige Nickelerzvorkommen, p. 281.
3 Zeitschrift fur praktische Geologie, Nos. 1, 4, 7, 1893.
4 Ore-Deposits of the United States, p. 319.
5 Canadian Mining and Mech., Rev., August, 1893.
6 Nickel, etc., Colorado Scientific Society, December, 1893.

obiter dicta. To one familiar with the unique appearance of the Sudbury ores, their immense size, their geological and commercial importance would seem to warrant close study, long-continued observation and experimental research before a sound judgment as to their origin could be reached. In order to furnish some material or basis on which a judgment can be made, the following data concerning the similarity of segregation in mattes and ores are submitted.

Copper nickel matte, made in water-jacketed blast-furnaces from roasted copper-nickel ore, consists of a mixture of sulphides of copper, nickel and iron. An average matte will contain, approximately,

Cu,	24	per cent.
Ni,	20	" "
Fe,	28	" "
S,	28	" "

This matte is tapped into hemispherical or conical cast-iron matte pots or moulds, in which it is allowed to set, after which it is turned out on the dump to cool. These moulds or matte pots are about 24 inches diameter by 14 inches deep. After the matte has set, and while cooling on the ground, it cracks by contraction, the cracks extending either radially from the centre, splitting the matte into pyramidal or cuneiform fragments, or else vertically through the centre, dividing the matte into quarter sections. On a pot of matte broken in the latter shape, concentric iridescent bands of color show the rate at which the matte has cooled from outside to centre. The specific gravity of matte does not vary appreciably throughout a pot, it being, as a rule, from 5 to 5.2.

After matte has been broken, two separate forms of incrustations may be observed on its surface. The first consists of small hairs or wiry crystals of copper, often occurring in small geodes or bubbles near the top or outside of the matte pot. The second consists of ferro-nickel crystals,[1] generally found near the centre or bottom, and having the form of squares or rectangular triangles about $\frac{1}{8}$ to $\frac{1}{16}$ inch in diameter. These are tin white, very thin, flexible and highly magnetic, and have the formula Fe_3Ni_9. While comparatively rare, yet close examination will discover the presence of ferro-nickel in every pot of matte.

It has been known for several years that matte is not homogeneous throughout each casting, nor is it surprising that in such a fluid mixture of different sulphides the elements should, during the time of cooling, attempt to arrange themselves with regard to their respective affinities. A long series of experiments to determine what these tendencies were may be thus briefly summarized.

Numerous analyses showed that in one and the same matte casting a sample broken from the top will be, as a rule, higher in copper and lower in nickel than a sample from the bottom. Eleven pots thus examined gave an average as follows:—

	Cu.	Ni.
11 top samples................	23.26	20.15
11 bottom samples...........	21.14	20.32
	2.12	0.17

Gain Cu at top, 2.12 per cent.
" " bottom, .17 per cent.

The copper seems to vary more rapidly than the nickel from top to bottom.

Further analyses showed that nickel was higher at the centre than at the bottom of the casting. A few examples will illustrate this tendency. A pot casting broken into quarters was sampled at the points shown in the sketch, and analyzed as follows :

[1] Jour. Anal. Chem., March, 1892.

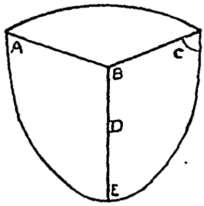


FIG. 1.

	A.	B.	C.	D.	E.
Copper	25.00	25.62	25.02	20.80	24.46
Nickel	20.2	20.9	20.5	21.60	20.20
Iron	29.4	27.3	28.8	35.5	31.5

These analyses show that copper tends toward the top and outside of the casting, while nickel and iron tend to concentrate toward the centre.

A half pot was now selected in which radial cracks seemed to show the centre of segregation. Small portions were broken off at the points indicated and analyzed as follows:

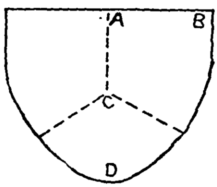


FIG. 2.

	A.	B.	C.	D.
Copper	24.46	23.68	22.46	22.80
Nickle	18.02	19.06	19.16	18.74
Iron	31.0	31.5	31.5	32.00

These samples showed as before the upward and outward tendency of copper, but did not so clearly show the inward tendency of nickel. The reason was found to lie in the manner of sampling, as it was found almost impossible to break with a hammer the sample desired, at the exact point in question. In order to get a correct sample, and to map out, if possible the variations of copper and nickel, a quarter pot was placed under a drill and sampled as indicated in the following sketch by drilling with an inch drill holes one half inch deep at the points marked. These samples were then carefully analyzed, and as they were entirely free from slag, the sulphur was in each case taken as the difference between the sum of copper nickel and iron and 100 per cent. which has been found to be very nearly the correct amount.

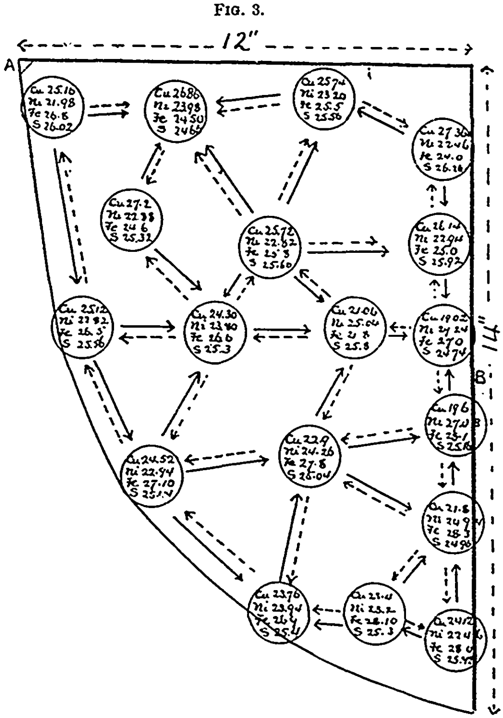
The entire quarter pot was now crushed, quartered, sampled and analyzed.

It contained Cu, 24.64
Ni, 22.86
Fe, 26.70
S, 25.82

The analyses are for convenience written in their respective locations.

The specific gravity of matte at the point A was 5.26 and at B was 5.2. The solid arrows in the sketch indicate the movement of nickel, while the dotted arrows show the movement of copper. Examining these lines carefully, it will be seen that the segregation of nickel to the centre and the dispersion of copper to the outside is very pronounced, variations in the percentage of these two ingredients to the amount of 7 per cent. occurring over a space of three or four inches. It will also be noticed that copper and nickel seem to be mutually antagonistic, an inward flow of nickel being almost always accompanied by an outflow of copper.

FIG. 3.



Section of quarter pot a little over one-third natural size.

Taking the vertical central line and the horizontal central line, as showing the tendencies of the metals at their greatest fluidity, we may now map the variations in a curve.

From the vertical central lines it will be seen that the curves of copper and nickel are nearly reciprocal. The horizontal central line shows a similar tendency. From these examples, which are given merely as an illustration of what has been proved true by numerous other analyses, the following statements may be inferred:

1. In a mass of molten copper-nickel iron matte, the sulphides of copper and nickel are mutually antagonistic.

2. The tendency of nickel and, though in less degree, that of iron is also to concentrate toward the centre, with a slight downward inclination.

3. The tendency of copper is to disperse toward the outside and to rise toward the top of the casting.

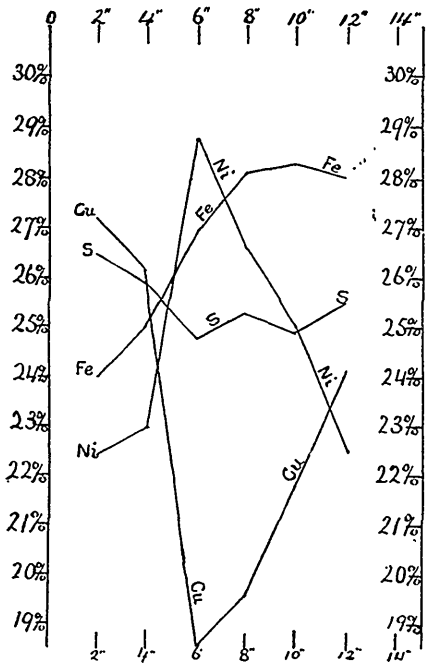
These statements are verified in a striking manner by furnace practice. The matte as it flows from the blast furnace passes first to a forehearth in which it accumulates and the slag rising to the surface is separated. In this forehearth, where the matte is subjected to a prolonged heat, nickel tends to sink to the bottom, and as after every tapping there remains a layer of matte perhaps two or three inches thick in the forehearth below the tapping ring, this matte becomes gradually enriched in nickel and impoverished in copper. On changing the forehearth after several weeks running the bottom is found coated with a tough magnetic matte which averages about 46 per cent. nickel and 12 per cent. copper. The matte made in this forehearth has during the run averaged perhaps 22 per cent. copper and 18 to 20 per cent. nickel. This shows that under prolonged heating the copper nickel sulphides are more perfectly separated the copper going upward and the nickel downward.

Again, the Orford process[1] of separating copper from nickel consists in smelting matte with sodium sulphide

[1] Mineral Industry, 1892, vol. i., p. 357.

produced by reduction of salt-cake with coal. The sodium sulphide forms with the matte an exceedingly fluid magma, from which, on cooling nickel separates as a "bottom" or cake of nickel sulphide occupying the lower part of the matte pot, while copper floats upward with the soda sulphide. After cooling a sharp demarcation line is found between the two sulphides, and separating the "bottoms' or crude sulphide of nickel and repeatedly resmelting with sodium sulphide the copper can be almost entirely removed and pure sulphide of nickel can be produced. We are thus justified in drawing the following inference.

FIG. 4.



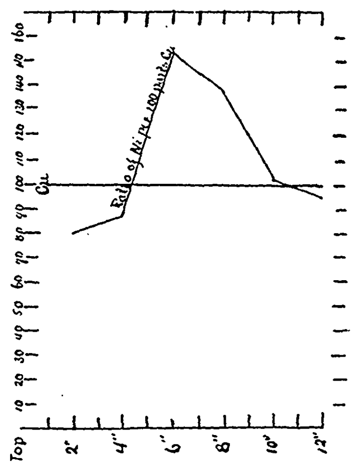
Central vertical line of matte.

Vertical column — per cent. Horizontal column distance from top of pot.

If copper-nickel-iron sulphides can be held in a molten condition either by using prolonged heat or by imparting fluidity by the addition of fluxes for a sufficient period of time to allow the mutual repulsion of the metals to act, the copper and nickel will separate as individual minerals, the sharpness of separation being dependent on the fluidity of the mass and the time occupied in cooling.

If we now examine the Sudbury ore-deposits, a general resemblance in their formation to the formation of mineral in mattes may be readily seen. The tendency of copper pyrites to separate from the nickeliferous pyrrhotite is very noticeable. However closely the two minerals may be intermingled, each is entirely free from traces of the other. The chalcopyrite is free from nickel, while the pyrrhotite beside it is equally free from copper. Beside this chemical separation, there is an equally noticeable physical separation. Bell[1] Kemp[2] and others have remarked the tendency of copper pyrites to separate in veins or stringers of ore surrounding masses of included diorite. It may be stated, as a rule, that copper tends toward the rock, whether forming the vein-walls or forming included masses. The miners often remark the way in which copper follows the rock, and look on the presence of massive copper ore as indicating an approach to the rock. In driving a drift from the shaft which is sunk in the clean diorite to and through the ore, the first symptoms of the presence of the vein are small shots or pockets of copper pyrites impregnating the rock. Coming nearer to the ore-body, the amount of copper increases,[3] large masses being met with before any nickel is found. On reaching the ore-vein proper, the copper pyrites is found

FIG. 4A.

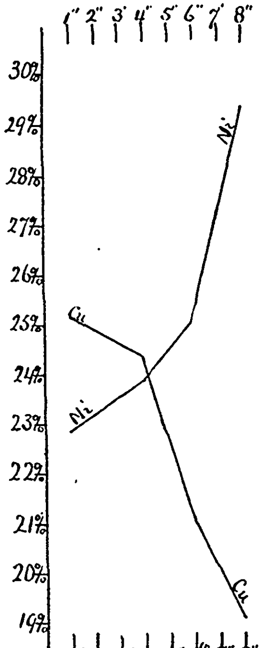


Central vertical line of matte.
The per cent. copper taken as 100.
Vertical lines distance from top. Horizontal — variation of nickel.

1 Report on Sudbury Mining District, 1888–90, p. 49.
2 Ore-Deposits of the United States, p. 319.
3 Peters: Modern Copper Smelting, p. 291.

mixed with pyrrhotite and rock, while in the heart of the vein a large quantity of nearly pure pyrrhotite almost free from copper is found. The cross-section of the ore-body then shows as follows: rock, copper-ore and rock, copper-nickel ore, nickel ore, copper-nickel ore, copper ore and rock, and, finally, rock again. This can be mapped in the form of a curve across the ore-body in a horizontal line, the height of the curves showing the ratio of copper and nickel.

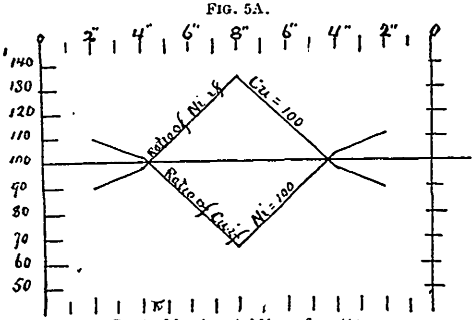
FIG. 5.



Central horizontal line of matte. Vertical column = percent. Horizontal column = distance from outside.

The figure does not, of course, represent a cross-section of any particular mine, but shows, as well as can be done without figures, the manner in which copper and nickel are found on cross-cutting a large vein such as at the Copper Cliff mine. As there is much ore intermixed with the rocky walls, and many included fragments of rock in the ore-body itself, and as each mass of rock tends to attract copper-ore, it follows that the ore as mined shows about equal amounts of copper and nickel. Fig. 6 must then be taken merely as a general indication of the way in which the minerals occur at the Copper Cliff mine.

FIG. 5A.

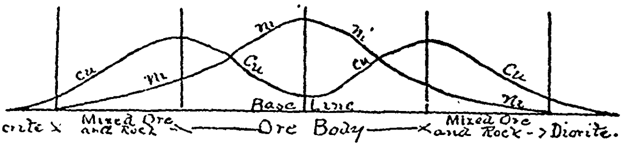


Central horizontal line of matte.
Horizontal distance = distance from outside to centre of pot.
Vertical height = per cent of metals.

A general tendency of copper to disperse to the rock and to the vein walls, and of nickel to concentrate towards the centre of the deposit, is thus shown to exist in the ore-body. Comparing Fig. 6 with Fig. 5, it will be seen that in matte, as well as in ore, the travel of the metals is the same, copper moving outward along a horizontal line toward the cool outer surface, and nickel moving inward to the centre.

That copper-ore is attracted by the rock is readily seen on examining the rock heaps at the various mines. This

Fig. 6.



Horizontal Central Line of Ore-Body.

rock occurs not only at the edges of the deposit, but also in masses of every shape and size in the ore-body. If the ratio of copper and nickel in the ore be taken as 1 to 1, *i.e.*, 100 pounds copper to every 100 pounds nickel, the ratio in the sorted rock will be from 150 to 200 pounds copper to every 100 pounds nickel. These metals are not an essential constituent of the rock, but occur as shots and veinlets of ore scattered through a dioritic matrix.

We are justified, then, in stating that in the ore-body the tendency of copper is outward along a horizontal line toward the rock, while the motion of nickel is inward toward the centre of the vein.

It has been often said that the Sudbury ore-deposits were originally worked for their copper contents, and that the presence of nickel was noticed only after deeper excavations had been made. This is in a certain sense true. The surface workings of the Copper Cliff mine, for example, yielded nearly pure copper pyrites, while the lower levels give nearly equal proportions of copper and nickel. The change is regular and gradual.[1] Business considerations forbid the use of comparative figures, but in general terms it may be said that a deposit which shows large amounts of copper and small amounts of nickel at the surface, changes regularly with the depth to a nearly equal ratio at the present time. The tendency of copper and nickel to separate—the copper outward and the nickel inward—seems also to increase with the depth. Taking the copper as unity, and plotting the percentage of nickel at each level as a factor thereof, the ratio of the two metals will be shown to approach each other as the depth increases.

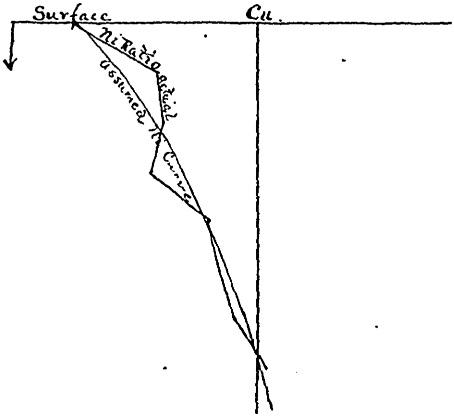
Comparing this Fig. 7 with Fig. 4A, it will be seen that in the mattes the tendency is to change from a high copper matte at the surface to matte carrying nearly equal amounts of copper and nickel at about one-third the depth of the pot, then a rapid decrease of copper and increase of nickel near the centre, and a recovery to nearly equal parts of copper and nickel at the bottom. In the ore we cannot tell what proportion of the depth of the deposit has been opened out, but there is, nevertheless, a parallelism between the ratio of copper and nickel in the ore as far as opened and the ratio of copper and nickel in the upper half of the matte pot.

From the behavior of copper-nickel mattes kept for a long time in a molten condition, we have drawn the inference that in proportion as the time of cooling is prolonged, the more perfect is the separation of copper and nickel into their respective sulphides. If the theory of igneous origin be the correct explanation of the Sudbury ore-bodies, it is evident that the upper and outer portions of the deposit were the first to cool, while in the centre and lower part of the deposit the sulphides have longer remained fluid. If, then, a parallelism exists between the ore and the matte, we would expect to find the separation

[1] Levat: Progres de la Metallurgie du Nickel, p. 27.

of nickel more perfect on the lower levels than on the upper. This is in reality the case. The nickel-bearing portion of the Sudbury ores consists of magnetic pyrrhotite containing more or less intermixed pentlandite. Nickel may be considered to exist in the pyrrhotite as a foreign element, replacing a certain portion of the iron. Pentlandite, on the other hand, is a true nickel mineral (Fe+Ni), S, containing, approximately, Ni, 35 per cent.; Fe, 30.25; S, 34.75. While it is true that the percentage of nickel in the picked nickel ore does not vary much with the depth, yet the deeper the mine the more perfect will be the separation of nickel as a true nickel mineral. This nickel mineral does not occur in separate massive form, but as small crystals or patches, varying in size from that of a pin's head to a hazel nut, intimately associated with the pyrrhotite. By crushing to a rather coarse powder and sorting with a magnet, the minerals can be separated for analysis.

FIG. 7.



Vertical central line of ores.

Ratio of nickel to copper in ores. Vertical line = copper taken as unity. Heavy line = ratio of nickel. Light line shows average variation of nickel ratio. Vertical distance shows depth from surface.

In ore from near the surface the crystals of pyrrhotite are small-grained, bright and sharply lustrous, containing more than one-half of the total nickel as an element replacing iron; while in ore from a depth of several hundred feet the pyrrhotite is largely in soft, dull crystals containing very little nickel as an element replacing iron. The following analyses will show this tendency:

Copper Cliff Mine.	Depth in feet.	Per cent. of Total Ni in Pyrrhotite.	Per cent. of Total Ni in Pentlandite.
Picked Ni ore.............	Surface.	51.7	48.3
" "	600	34.	66.
" "	700	29.	71.
" "	800	18.	82.

In samples of ore of the same percentage in nickel, taken from different depths in the deposit, the nickel separates as an individual mineral more perfectly as the depth increases, or, in other words, at those points in the deposit where, if the igneous theory be true, the ore has remained longest in the molten condition, and better opportunity has been offered for physical and chemical separation.

We have now seen that an agreement in the method of arrangement of the elements exists between the ores and mattes along the following lines:—

1. The tendency of copper in both ores and mattes is to rise vertically upward and accumulate at the surface, and also,

2. To travel horizontally outward from the centre and accumulate on the outer cooling surfaces.

3. The tendency of nickel in both ores and mattes is to sink vertically toward the centre, and also,

4. To leave the outer cooling surfaces and to travel horizontally inward toward the centre.

5. In both ores and mattes the separation of nickel in the lower part of the deposits as an individual mineral sulphide is in direct proportion to the fluidity of the mass and the length of time occupied in cooling.

It does not seem possible to explain this parallelism by any other theory than this; that the nickel deposits of Sudbury existed primarily as eruptions of molten sulphides mixed with the constituents of the dioritic enclosures, and that by gradual cooling the diorite was first separated, then the copper as copper pyrites, and the iron as pyrrhotite containing some nickel, and, finally, in those portions remaining longest molten the nickel separated as a true nickel mineral. While this view may be at variance with the theories of many authorities, yet it seems to be the only conclusion feasible in view of the similarity in the manner of segregation of the elements in copper-nickel ores and mattes.

Appended Note to the Paper[1] of Mr. Browne.

By J. F. Kemp.

That the reactions of metallurgical processes have served to throw much light on the problems of igneous rocks has long been recognized, and from the observations of J. H. L. Vogt, and others, on slags and the artificial minerals yielded by them, important inferences have been drawn regarding rocks. This source of evidence is a fruitful and suggestive one, for, although on a small scale when compared with volcanic phenomena, the parallelism, so far as it goes, is close—the principal difference being that slags cool quickly, under slight pressure and without the presence of mineralizers. The advantages are that the reactions are under observation, and all the factors can be noted.

Late developments in the mining of associated nickel and copper ores, and attempts both recent and early to utilize titaniferous magnetites have exposed such geological relations that many observers have felt compelled to regard the ores themselves as of igneous origin. They occur in rocks of this original character, and ores that show small evidence of any geological disturbance. In the case of the associated sulphides of nickel and copper, the occurrence of the ores in the outer portions of the intrusions has been the chief argument

[1] This note is added with the full sanction of Mr. Browne.

against their igneous origin, for they have been regarded as contact deposits, and have been referred by the writers cited above by Mr. Browne, to aqueous solutions.

But as our knowledge increases of the changes that take place in those molten magmas that have remained in this condition some time before crystallizing, we have come to recognize that very important differentiations take place, and always with the relative increase of the basic minerals toward the outer portions. Alfred Harker has shown this for gabbros in England; Pirsson has done the same for syenitic rocks in Central Montana, and G. P. Merrill for others in the south-western portion of the same State. Many other observers have noted equally significant, though less extensive manifestations of similar phenomena. Instead of magmas being fairly homogeneous and stable, we must regard them as quite the reverse, and as subject to changes and differentiation, whose causes we perhaps do not yet fully understand.

It is not every magma that holds enough metallic elements to yield an ore-body; but where such are present with sulphur, it is reasonable to infer that the resulting sulphides would follow the course of the basic minerals. If the latter tend to segregate toward the contacts, so would the former. This is the line of argument that has been previously followed. Mr. Browne's paper now adds the further important point that even in small amounts of fused matter, and above all in those made still more fluid in the Orford process by the addition of sodium sulphide, the two metals, nickel and copper, tend to separate according to the relations that are observed on a large scale in ore-bodies.

While we do not fail to appreciate that it is a long step from a pot of fused matte to a great ore-body some hundreds of feet in extent, yet the parellelism is very significant, and it is fair to infer that what holds good for the small amount would be even more marked in the large.

NOTE.

The *British Medical Journal* states that a new and unexpected agency is having a most beneficial effect in contributing to the abatement of the smoke nuisance in London. The relative clearness of the London atmosphere within the last twelve months has been plainly apparent, and the smoke cloud which obscures the London atmosphere appears to be progressively lightening. Mr. Ernest Hart, Chairman of the Smoke Abatement Exhibition in London, frequently pointed out that the greatest contributors to the smoke cloud of London were the small grates of the enormous number of houses of the poor, and a great deal of ingenuity had been exhausted with relatively little success in endeavoring to abate this nuisance. The use of gas fires was urgently recommended, but had hitherto been difficult, owing to its cost and the want of suitable apparatus. The rapid and very extensive growth of the use of gas for cooking as well as lighting purposes by the working classes, due to the introduction of the "penny-in-the-slot" system, is working a great revolution in the London atmosphere. During the last four years the South London Gas Company alone has fixed 50,000 slot metres and nearly 38,000 small cooking stoves in the houses of the workingmen.

BOOK NOTICES.

APPLETON'S SCHOOL PHYSICS. (American Book Company.)

This handsome volume of 544 pp. is the joint production of Professors Mayer, Nipher, Holman and Crocker, under the literary superintendence of Professor Quackenbos. It is beautifully printed, various kinds of type being most judiciously employed, and profusely adorned with admirable illustrations specially prepared for this book. One looks in vain for the familiar cuts that have done duty in so many of its predecessors. Altogether it is most attractive to the student and pleasant to work in.

Nor is the matter unworthy of its presentment. It is written throughout with direct reference to practical things on the one hand, and to scientific principles and the method of establishing them by experiment on the other. Very properly a thorough account of the mechanics of visible bodies, and the properties of matter is made the basis of the other branches of Physics, and occupies no less than 228 pp. out of the whole 544 pp. The whole subject, including the introductory mechanics, is treated in a very fresh and interesting manner. Much information not usually found in Text-books of Physics (*e.g.*, the capital account of meteorology) is given. The numerous examples interspersed between the sections are mostly new, and drawn from practical life. It is justly remarked in the preface that "the reputation of the several contributors, and the standing of the great scientific schools which they represent, must secure for this work a consideration accorded to few American school-texts." We think that the general merits of the book will assure the fulfilment of this prophecy, and as it is important that a book which is to be widely used should be as perfect as possible, we shall without further description of the general features of a work which every teacher of physics should see for himself, employ the rest of our space in pointing out certain blemishes which could hardly fail to arise in an attempt to re-write freshly such familiar subjects as Mechanics and Physics.

The attention of teachers is called in the preface to the "thorough and original treatment of motion, energy, force, and work. . . . . These subjects are treated with the greatest simplicity, precision, and thoroughness, for it is believed that a proper understanding of them lies at the base of all scientific knowledge, however far it may be pursued." It is as difficult as it is important to write with simplicity and precision on elementary mechanics, especially when any attempt is made at originality of treatment; and on this account most of the criticisms we have to make will be directed against the earlier part of the book.

We will note first some faults of precision. In the preliminary statements and definitions (which seem to us rather advanced in character compared with succeeding chapters) occurs the statement (p. 8) that "all our knowledge of time and space is, therefore, essentially *relative*," by which is meant that we can only define one point of time or space by reference to some other. This is not the usual meaning of the word *relative*, as applied to knowledge in philosophy. Nor is it correct to define (p. 12) any body as *homogeneous*, when it is of the same *density* in all its parts. Velocity is stated (p. 18) to be the *ratio* of the distance travelled to the time occupied. But ratios are only between like things. On p. 16 a distinction is formally drawn between *uniform* and *constant*. But on pp. 18, 20, 24, 26, 28, and generally this distinction is ignored. On p. 19 for continu*al* read continu*ous*. The appeal to "experience" on p. 22, while discussing the purely kinematical motion of a point, is confusing. The value of g is stated on p. 20 for all parts of the earth without limitation. On p. 25 the figure is not drawn to the scale described in the text. A much more serious error (p. 90) is the use of the meaningless phrases "the unit of acceleration is one centimetre per second," "an acceleration of a centimetres per second" several times over. An incline of 5 in 100 surely means in 100 along the incline, not along the horizontal, as on p. 153. In the section on Heat (p. 290) "in proportion to" is used in the popular and, in this case, inaccurate sense. On p. 330 the figure of the vibrating string is misleading, and at the foot of the page the omission of "inversely" makes the statement of the number of vibrations give the opposite of the fact. c, at the foot of p. 417, is a misprint for C, and there are misprints of numbers in lines 6 and 7 of p. 418. On p. 436 we read "an electrified body brought near to any other body of different potential will *attract* it." P. 474 should read "The *Grove and* Bunsen cells also give off." We note on p. 481 "If wires twice as *thick* are used, the resistance is one half as great," and on p. 503, "Why is dry air a good insulator? *Because it is a non-conductor*." Further data are required to solve Questions 2 and 6 on p. 369; and C.D. (p. 431) is not drawn a horizontal through the centre of the needle, as described. The sine of an angle should not be defined as a line on p. 310, while the ordinary meaning of the tangent is assumed on p. 493.

Passing to more important matters, we think that a strict logical order is too often departed from. Conservation of energy is doubtless the principle by which the branches of Physics should be connected. But surely it should be reached as a generalization after the meaning and methods of measuring energy have been carefully studied. Instead of this we first have (p. 33) with no better definition than that "energy, or the capacity of doing work, is possessed by matter in virtue of its mass and velocity" (Capitals), a general statement of the conservation, transformations, and availability of energy. It is not till p. 95 that the student learns how energy depends on velocity, and then only from a *definition* of the energy as $\frac{1}{2}MV^2$. Work having been independently defined as measured by the product of the force into the distance, a numerical example is then taken of the energy acquired by a falling body. Its velocity is calculated (p. 96) from the formula $V^2 = 2gs$. The energy and work done having been deduced from the formulæ $E = \frac{1}{2}MV^2$ and $W = FS$, it is remarked that these results must necessarily be the same, for the two formulæ must, *of course*, be equivalent.

Again (on p. 362) in an explanation of polarization, we find, "According to the accepted *undulatory theory* of light," though no account of this has been given, beyond a few remarks in the beginning of the chapter (70 pages before), in which it is stated that "the ether vibrations pass off in all directions by a species of wave-motion." The properties of wave-motion are not described at all till in the following chapter on Sound, where, after some examples of vibration, we find the statement that "To represent a sound-wave a curve is used, called the sinusoidal curve," and the curve is figured. But no proof is given that this *does* represent a sound-wave, nor is simple harmonic vibration anywhere investigated.

On p. 456 the explanation of the condenser is given thus: "The reason for the greater capacity of one of the plates when near the other is due to the attraction between the two charges." But Capacity is not explained till p. 458, where the definition is reached that "The capacity of a body for electricity is measured by the amount of electricity required to raise its potential by unity." This itself will puzzle a student who has only been told (twenty pages before) that "when neighboring bodies differ in such a way that electrical phenomena are observed in the region between them, the bodies are said to be *at different potentials*." He may wonder not only what kind of a difference this is, but also what is a *unity* of it. The excellent hydraulic illustrations given later (p. 478) will help to relieve his perplexity.

After the parallelogram of forces has been established, it seems a fault of method to recur to experiment for the proof of the principle of moments (p. 111) and of central forces (p. 113.) The fewer the experimental principles from which a science can be deduced, the better. Other experimental results then come in as verifications of theory.

Of actual mistakes we have observed few. But on p. 29 occurs the following: "It is found also to be true that the amount of work done to produce a given acceleration in a given object is the same at what ever velocity the particle is already moving; for instance, to accelerate its motion by 10 feet a second would require no more work if the object is moving a mile a second than if its velocity is only a foot a second, or if at the outset it was zero." The student who relies on formulae will wonder how $\frac{5290^2-5280^2}{2}$ can be the same as $\frac{11^2-1^2}{2}$; or if he is in the habit of thinking out his dynamics, he will see that to produce a given acceleration requires a given force to act for a given *time*; and that if the body is travelling at a greater rate during that time it will cover a greater space, and the force will consequently have to do more work. The source of the confusion is made clear by the question on p. 33; "If a ball is at rest upon the floor, and you set it in motion so that its velocity is one foot a second, is the work done by you any greater or any less than if the ball had been moving with a velocity of 5 feet a second and you had increased it to 6 feet?

How would you explain this from the statements *concerning rest* as given under kinematics ?" The reference is, of course, to the fact that we can have no knowledge except of relative motion, and the confusion arises from neglect of the warning given by Clerk Maxwell, in his little treatise on Matter and Motion, that in every mechanical problem we must *begin* by defining the system which we mean to consider. A similar oversight led Professor Newcomb into the discovery of an elaborate mare's nest about the relativity of energy, described in his paper in Vol. XXVII. of the Phil. Mag. Those who wish to see the whole matter placed in the clearest light, together with another reason why the absolute energy of a system can never be known to us, and the considerations which render this of no importance, should consult Maxwell's Matter and Motion. (§§ II, III to XXX—I, CX).

A confusion arising from the opposite error of neglecting to remember that all force is of the nature of stress and that all energy must be conceived as relative, or between parts of some system, leads the writer to a somewhat severe handling of Potential Energy. Thus (p. 36), a raised stone " before it starts has no velocity and, therefore, no energy" ; and (p. 39) "At the extreme end of the swing does the pendulum possess energy ?", to which the answer, No, is expected. On p. 42, we have—" In such instances the body does not possess actual energy, but only the possibility of acquiring it. It is said to possess *potential* or *possible* energy" ; again (p. 97), " the amount of Potential Energy relatively to a given *point*" ; and finally (p. 98) Potential Energy receives its quietus from the scathing epithet " so-called."

It is, no doubt, probable that all forms of Potential Energy may be reduced ultimately to cases of relative motion ; but it seems less confusing, meanwhile, to keep the felicitous term Potential Energy to denote those forms of the capacity to do work which depend on the relative position or condition of bodies relatively at rest, without implying that the energy is in these cases less real ; while *kinetic* covers the cases of energy due to relative motion. This is a better distinction than that between *possible* and *actual* energy (p. 42).

It is unfortunate, too, to exclude the idea of direction from the terms *velocity* and *acceleration*, as is done in such phrases as "accelerated as well as curved" (p. 56) " the motion (with uniform velocity) may be over any path, either straight or curved." This is certainly not a modern practice.

It is more in accordance with modern fashion to discard as far as possible the idea of force as a cause historically so important and fruitful, and so harmless if properly safeguarded. How necessary this conception is appears from the fact that after defining (p. 44) force as " any tendency to acceleration," and rejecting the usual definition not only in the text, but in the questions (p. 48. "Is force ever the real cause of any effect? Why not? What is the cause?") the writer finds himself compelled to announce in a footnote (p. 76) that for convenience he will in future employ the word in its usual sense, not before he has done so many times unconsciously in the interval.

We have only to add that the diagram of the Astronomical Telescope (p. 355) would be clearer if the whole pencil from one end of the arrow had been traced, instead of one ray from each end. Nothing can be learned from it as it stands, while it may easily encourage a familiar misapprehension. On p. 364 no hint is given that the length of the rhomb of calcite must bear a certain proportion to its breadth if it is to be cut as directed in constructing a Nicol Prism.

Some very recent additions to our knowledge are included in the book (*e.g.*, Mr. Woodward's ingenious way of representing a sound-wave), but we should have been glad to see some notice of Dr. Lodge's work on Lightning Conductors, since they are spoken of. Gleams of humor are not wanting, especially in the questions: *e.g.*, "Wild pigeons have been shot in the latitude of Albany, N.Y., with Carolina rice in their crops. About what must have been the velocity of their flight? (Apply scale to your map of the United States)" (p. 27). The height of the Washington Monument is assumed known (p. 101.) Other traces of nationality will be observed by the foreign reader.

JOHN COX.

THE BIRDS OF MONTREAL.—By Ernest D. Wintle, Montreal. W. Drysdale & Co. Price, $1.50.

This book is a welcome and valuable addition to the literature of the Natural History of Montreal and the surrounding district. We must congratulate Mr. Wintle on the completion of his task which, he tells us in his preface, has occupied him for fifteen years. This volume supplies a long felt want, and its issue will, there can be little doubt, give an immediate impulse to the study of Ornithology, especially among young men. It will be a guide to the sportsman, as well as a hand-book for the scientist. There is no more fascinating recreation than gunning for game; and it is as health-giving as it is delightful. The author and his collaborateurs have had many a tramp through forests and by streams before possessing themselves of such a mass of facts as is packed into this attractive little volume. In reading it, one can fancy he hears the bracing October winds whistling through the reeds, and the whirring of the wings of the partridge startled in the thicket. The middle-aged citizen, who was accustomed to cricket and football in his youth, at least once a year, finds the old longing for out-door activity come upon him with irresistible force, and so he forsakes his desk and goes off, with rod and gun, into the northern wilds and is a boy again, for a week or two. Thus he renews his energies and keeps up the steadiness of nerve and firmness of muscle that ought to belong to the hardy race born and bred in this northern clime. And when the taste for science is added to the keenness of the sportsman for game, the delights of such outings are immensely enhanced. The variety and rarity of the birds his gun brings down will be a matter of greater consequence than the number he bags. Three great ends are gained by the scientific sportsman. He can compete with others in obtaining game and in securing an invigorating supply of oxygen and ozone for his blood, but he has the further advantage of adding to his stock of knowledge at the same time. Mr. Wintle and the friends who have sympathized with him and helped him in making his collection of birds had evidently many enjoyable trips to the country during the last fifteen years; and they used their opportunities well. The result has been that the author can speak confidently as to the fulness and accuracy of the list of the *Avifauna* of the Montreal district, which he supplies in this volume. To add to the list, even the spoils of the pot hunters have been carefully enquired into, the stalls of the Bonsecours and other markets having been often visited with a view to noting the species offered for sale and the localities whence they were procured.

It is fitting that the knowledge of the Natural History of the city and district of Montreal, with so famous a school of science in its centre, should be as complete as possible. This book of Mr. Wintle's will at least establish for our city a claim to precedence over every other place in the Dominion, so far as the Department of Ornithology is concerned. The geology of the district has long been known; and there is also a fair approximation to an acquaintance with its botany. This publication cannot but stimulate amateurs working in other departments not yet wholly overtaken to continue to prosecute their researches, in the hope that they too may soon be able to present to the public lists as complete as Mr. Wintle can claim this one of his of the Birds of the District is.

Not since 1839 has there been any attempt to catalogue the *Avifauna* of Montreal. A list was compiled in that year by the late Prof. A. Hall, M.D., which was published in the "Canadian Naturalist and Geologist" in 1861-2, and for which he was awarded a medal by the Natural History Society of Montreal. Although Prof. Hall's was regarded at the time as a fairly complete list, it was in comparatively few hands, and so, for practical purposes, the lovers of birds in the district had to be content with such knowledge of the subject as they themselves could pick up, with the help of those larger general works to which they could get access. There is, perhaps, no department of Natural History in which so many persons are interested as Ornithology. Birds are most attractive creatures; and those who may long have wished to know more about those beautiful, agile, gentle visitants which build nests in their orchards yearly, or flit from limb to limb of the trees on the Mountain Park, can now gratify their desire.

It is interesting to contrast Mr. Wintle's list with Dr. Hall's. Making allowance for the change of nomenclature, the whole 208 species embraced in the latter, with the exception of 13, are included by our author as having been lately seen in the district of Montreal. Mr. Wintle's volume embraces 65 additional species, in all 254 kinds of birds that are either permanently resident here, or visit us every year for a longer or shorter period. Of this number, only 11 are permanent residents, 16 are winter visitants, 77 are summer visitants, 132 are transient visitants, while as many as 17 are accounted accidental visitants.

The first 135 pages are occupied with notes on the 254 species described, giving place and date of their capture; while the next 89 pages are taken up with a detailed description of them, to help in their determination by amateur scientists. The closing pages contain some breezy sporting sketches by well known devotees of the gun in the city; and these give a completeness to the volume which adds to its attractiveness. The publishers have also done their part well; the general make-up of the book being a credit to Canadian enterprise.

R. C

Annual Report of the Geological Survey of Canada. New Series. Vol. VII., 1894.

This large volume of over 1,200 pages contains, in addition to the Summary Report of the Operations of the Survey for 1894, seven detailed reports on certain portions of the Dominion, and is accompanied by eleven geological maps. The Summary Report shows that geological work is being carried on by the large staff of the Survey in every part of the Dominion. Especial mention is made of the trial borings now being put down at Athabasca Landing in the North-West Territories, where there is good reason to believe large supplies of oil will be obtained from the Devonian rocks at a depth of about 1,500 feet. An account is also given of the recent advances in the development of the mining industry of British Columbia, where, of late years, such extensive mineral deposits have been discovered, as well as of the explorations in the Labrador peninsula, carried out by Mr. Low, who has discovered in this inhospitable region deposits of iron ore which are believed to surpass in size any that have hitherto been discovered in North America.

Of the special reports, two deal with British Columbia, one by Dr. G. M. Dawson, containing a description of a portion of the Interior Plateau of that province in the Kamloops district, and the other by Mr. R. G. McConnell, giving an account of the exploration of the Finlay and Omineca Rivers. These are followed by a report on the country about Red Lake in Keewatin, by Mr. Dowling. The fourth report is by Dr. R. W. Ells and Dr. F. D. Adams on a portion of the

Province of Quebec, comprising the Island of Montreal and a part of the "Eastern Townships" to the south and east. Mr. Chambers then describes the superficial geology of the Provinces of New Brunswick, Nova Scotia and Prince Edward Island, while in the concluding reports Dr. Hoffmann and Mr. Ingall treat of the chemical work of the Survey on the mineral statistics of the Dominion respectively. Dr. Dawson's report contains an excellent description of the Interior Plateau of British Columbia from both a geographical and geological standpoint. The very extensive development of the Cambrian in this part of the Dominion is noted, as well as the continued volcanic activity from Cambrian to recent times, the volcanic materials, at a very moderate computation, having a thickness of 20,000 feet.

The map accompanying the report of Dr. Ells and Dr. Adams will be of the greatest value to all naturalists working in the vicinity of Montreal, combining, as it does, a presentation of the topography of the district with all roads, etc., on a scale of four miles to one inch, with that of the geological structure of this portion of the province which is well brought out by the colors in which the map is printed. The map comprises an area of about 7,500 square miles, extending from about Ste. Agathe on the north-west to Lake Memphremagog on the south-east. A more extended notice of it will be given in the next number of THE RECORD OF SCIENCE. In an appendix to the report, Dr. Ami gives a most welcome list of all the fossils hitherto recognized in the various geological formations occurring in the area, a list which will be of much service to the Society in future geological excursions.

The Geological Survey is doing excellent work for the Dominion of Canada in many ways, and it is to be especially regretted that the priceless collections illustrating the natural history of the Dominion and its economic resources, which have been gradually accumulated through a long series of years, are so miserably housed, being stored in a building which is not only not fireproof, but is in continual danger of collapse through the weight of the specimens which it contains. It might be destroyed in an hour, and the Dominion would thus be deprived of treasures, many of which could never be replaced. The offices, also, are inadequate and inconvenient, and the space available in the museum has become too restricted. The advantage to Canada of an adequate display of its mineral resources can scarcely be exaggerated, and that the museum, even in its present state, possesses much interest to the general public is evidenced by the fact that more than 26,000 visitors have registered during the past year. The Government should see that a suitable building is provided for this important department of the public service, as the present one is nothing short of a disgrace.

PROCEEDINGS OF THE AUSTRALIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1895.

Very few countries should be of more interest to Canadians than the large island continent of Australia. Like Canada of some forty years ago, it is a collection of some five or six different colonies professing allegiance to Britain. It is at the present time considering the question of federation, studying our political system, and endeavoring to avoid what they consider its faults. Then its natural history differs in many respects from that of Canada; its fauna as peculiar as are its aborigines; the country itself, with its large arid plains, scarcely any large rivers or lakes and a climate quite the opposite to our own. All this excites an interest, which is increased by hearing of the labors of so many earnest and talented workers in the different branches of natural science. The record of these labors in the volume mentioned above is, therefore, a most welcome addition to our scientific literature.

The meeting held at Brisbane in January, 1895, was presided over by the Hon. A. C. Gregory, who, for many years, held the position of Surveyor-General. His address was upon "The Geographical History of the Australian Continent during its Successive Phases of Geological Development."

The President, at the close of his address, gives the following summary: "Australia, after its first appearance in the form of a group of small islands on the east, and a larger island on the west, was raised at the close of the Paleozoic period into a continent of at least double its present area, including Papua, and with a mountain range of great altitude. In the Mesozoic times, after a grand growth of vegetation which formed its coal beds, it was destined to be almost entirely submerged in the cretaceous sea, but was again resuscitated in the Tertiary period with the geographical form it now presents. Thus its climate, at the time of this last elevation, maintained a magnificent system of rivers which drained the interior into Spencer's Gulf, but the gradual decrease in rainfall has dried up these water courses, and their channels have been nearly obliterated, and the country changed from one of great fertility to a comparatively desert interior, which can only be partially reclaimed by the deep boring of artesian wells."

The introductory address by J. H. Maiden, President of Section B, was upon the "Chemistry of the Australian Indigenous Vegetation."

Professor David's address to Section C deals with the two glaciations observable in Australia. The first in the Permo-Carboniferous, the second in the Pleoscene or Pleistocene time. Baron von Mueller, in Section E, considers the commerce of Australia with neighboring countries in relation to geography. In Section F is an interesting address on the Prehistoric Arts of the Aborigines of Australia. In Section I, the teaching of science in matters of health. Many other interesting papers are also to be found among the proceedings of the different sections.

Speaking of the disruption and elevation of strata in the Permo-Carboniferous age (Gympic beds) when the more important Auriferous deposits of both the eastern and western parts of the continent were formed, Mr. Gregory says in his inaugural address :— There was not only great disruption of the strata, but igneous rocks forced themselves into the fissures of the sedimentary beds, and the resulting metamorphism of the adjacent rocks increased the confusion, as beds of slate may be traced through the transformation of their sedimentary character by the recrystallisation of their component elements into diorites, having that peculiar structure of radiating crystals which usually characterises rocks of volcanic origin. As regards the Auriferous deposits in these lodes, it appears that the simple fissures were filled with water from the ocean or deep-seated sources; but in either case the powerful electric currents which continually traverse the earth's surface east and west met resistance at the lines of disruption, and electric action being developed the mineral and metallic salts in the water in the fissure and the adjacent rocks would be decomposed, and the constituents deposited as bases, such as gold and silver, or as compounds, such as quartz, calcspar, and sulphide of iron, all which were in course of deposit at the same time, as the angles of the crystals cut into each other. The theory of thermal springs is contra-indicated as the lime appears as calcspar, a form occurring in cold solutions and not in the form of Aragonite as in hot solutions. There have been many speculations as to the sources from which the gold was derived, but that which best accords with the actual conditions is that the metal exists in very minute quantities in the mass of the adjacent rocks, from which it has been transferred through the agency of electric currents and the solvent action of Alkaline Chlorides, which dissolve small quantities of the precious metals, and would be subject to decomposition at the places where fissures caused greater resistance to the electric current. One remarkable circumstance is that the character of the rocks forming the sides of the fissures has an evident influence on the richness of the ores in metal, where lime, magnesia, or other alkaline compounds or graphite enter into their composition, the gold especially is more abundant than where the rocks contain silica and alumina only.

In Queensland, Gympic affords some instructive examples of fissure lodes. In some large masses of rock have fallen into the fissure before the ore was deposited, and have formed what miners term "horses," where the lode splits into two thin sheets to again unite below the fallen mass. . . . The ore was originally an auriferous pyrites, but the sulphide of iron was largely decomposed, leaving the gold disseminated through the oxide of iron.

The auriferous deposits, which occur in the intrusive granites, appear under conditions differing from the true lodes in sedimentary rocks, as the intrusive granitoid rock forms dykes, which fill fissures in the older true granites, and also cut through the sedimentary slates. It bears evidence of intrusion in a state of fusion, or at least in plastic condition, and has subsequently crystallised, after which there has been shrinkage, causing cavities, as the sides of the dyke were held in position by the enclosing rock. The vertical shrinkage being greater than the horizontal, the cavities were nearer the horizontal than the vertical, and, being afterwards filled with ore, formed what are called floors, one characteristic of which is the tendency to lenticular form, or a central maximum thickness with thinner edges.

E. T. Chambers.

ABSTRACT FOR THE MONTH OF JUNE, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	Thermometer. Mean.	Thermometer. Max.	Thermometer. Min.	Thermometer. Range.	Barometer. Mean.	Barometer. Max.	Barometer. Min.	Barometer. Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	Wind. General direction.	Wind. Mean velocity in miles per hour	Sky Clouded in Tenths. Mean.	Sky Clouded in Tenths. Max.	Sky Clouded in Tenths. Min.	Percent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY
1	58.00	66.3	52.2	14.1	29.8930	30.010	29.798	.212	.3270	67.8	47.2	N.W.	13.54	4.7	9	0	70	0.01	....	0.01	1
2	57.20	65.0	48.0	17.0	30.0870	30.122	30.037	.085	.2777	59.7	43.2	N. W.	11.75	1.8	8	0	94	....	....	....	2
3	65.42	77.1	51.9	25.2	30.0887	30.152	30.037	.115	.3558	56.3	49.2	S.W.	16.37	0.0	1	0	96	....	....	....	3
4	69.43	80.9	58.6	22.3	30.0178	30.075	29.964	.111	.3342	48.2	47.7	S. W.	12.25	0.2	1	0	99	....	....	....	4
5	73.28	86.4	56.9	29.5	30.0245	30.097	29.976	.121	.4248	53.2	54.5	W.	5 00	0.0	0	0	74	....	....	....	5
6	69.25	80.3	58 3	22.0	30.0175	30.090	29.971	.119	.5233	73.3	60.2	N.E.	7.75	5.2	10	0	51	....	....	....	6
SUNDAY......7	.....	69.9	60 2	9.7	......	......	......	....	....	....	....	S. E.	5.37	....	....	..	00	1.05	....	1.05	7..........SUNDAY
8	59.08	62.2	57.6	4.6	29.7432	29.838	29.646	.192	.4805	95.7	57.8	S E.	7.96	10.0	10	10	00	0.24	....	0.24	8
9	59.95	64.9	55.6	9.3	29.6265	29.675	29.587	.088	.4575	89 0	56.5	N.E.	13.46	8.3	10	0	00	1.38	....	1.38	9
10	59.97	65.9	56.0	9.9	29.6378	29.672	29.559	.113	.2445	47.5	39.8	N.W.	13.50	2.8	10	0	82	....	....	....	10
11	58 75	65.2	50.6	14.6	29 5478	29 593	29.478	.115	.2963	60.5	44.7	W.	20.66	6.7	10	0	59	Inap.	....	Inap.	11
12	56.02	61.1	50.7	10.4	29.6593	29.790	29.594	.196	.2935	66.0	44.3	N.E.	8.42	5.8	10	0	37	Inap.	....	Inap.	12
13	59.38	67.8	48.0	19.8	29.9013	29.993	29.819	.174	.3025	59.5	45.3	N.E.	6.21	0.2	1	0	91	....	....	....	13
SUNDAY......14	.....	72 4	50.2	22 2	......	....	......	....	.....	...	....	N.E.	9.38	....	......	..	69	....	....	....	14..........SUNDAY
15	61.80	70.2	52 2	18.0	30.1802	30.219	30.105	.114	.3777	69.2	51.2	S W.	5.54	6.5	10	0	7	....	....	....	15
16	68 43	79.8	59.0	20.8	30.1190	30.188	30.061	.127	.4515	65.5	56.0	S.W.	12 33	1.2	4	0	81	....	....	....	16
17	68 95	79.4	58.1	21.3	29.9752	30.069	29.902	.167	.4562	65.8	56.3	S. W.	11.15	3.7	10	0	90	....	....	....	17
18	72.50	84.5	60.9	23.6	29.8980	29.935	29.845	.090	5571	70.8	61.8	S. W.	14 88	0.6	4	0	86	....	....	....	18
19	73.75	82.1	63.6	18.5	29.8866	29.955	29.813	.142	5256	63.3	62.5	S.W.	13.42	3.8	9	0	91	....	....	....	19
20	75.92	84.8	65.6	19.2	29.8635	29.875	29.837	.038	.5633	63.2	62.2	S. W.	14.03	4.0	10	0	88	....	....	....	20
SUNDAY......21	.....	76.3	63.4	12.9	......	......	.....	....	....	....	....	S. W.	12.00	....	...	..	10	1.26	....	1.26	21..........SUNDAY
22	67.13	71.2	55.5	15.7	29.7360	29.937	29.612	.325	.4562	66.8	54.8	N W.	16.46	2.8	8	0	91	....	....	....	22
23	61.56	69.9	52.6	17.3	30.0492	30.096	30.006	.090	.3542	63.5	49.2	N.W.	10.56	1.8	10	0	91	...	....	....	23
24	63.25	71.0	54.0	17.0	30.2103	30.252	30.104	.148	.3488	60.3	48.6	E.	10.92	2.2	5	0	85	....	....	....	24
25	65.18	75.4	55.0	20.4	30.1826	30.276	30.067	.209	.4306	70 5	55.0	S. E.	13.88	4.5	10	0	60	....	...	....	25
26	69.15	79.8	61.0	18.8	29.9015	29.967	29.838	.129	5012	70.3	58.7	S. W.	14.71	5.0	10	0	50	0.05	...	0.05	26
27	66.85	74 6	59.0	15.6	29.9262	30.045	29 794	.251	.4565	69.3	55.6	S. W.	11.38	1.5	4	0	89	....	....	....	27
SUNDAY........28	.....	81.3	59.9	21.4	......	......	......	....	.....	..	....	S. W.	14.12	...	...	..	39	0.04	....	0.04	28..........SUNDAY
29	59.55	68.2	51.2	17.0	29.7090	29.929	29.562	.367	.3673	71.0	49 8	S.W.	18.79	4.5	10	0	69	0.03	....	0.03	29
30	59 50	68.1	44.2	23.9	30 0587	30.161	29.992	.169	.3155	62.5	49.5	S.W.	16.25	3 7	10	0	63	Inap.	....	Inap.	30
31	.....	....	....	....	......	......	......	....	.....	....	....	......	.....	....	...	..	..	....	....	....	31
Means	64.59	73.40	55 66	17.73	29.9208	30.0005	29.8463	.1542	.4031	65.72	52.29	S. 63½° W.	12.04	3.17	7.46	0.4	64.6	4.06	....	4.06	... . Sums
22 Years means for and including this month	65.01	73.79	56.44	17.35	29.8937	.....	......	.151	.4363	69.73	....	.....	⁎13.12	5.6	..	..	¶53.8	3.51	....	3.51	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	....	1094	213	829	203	3905	577	1873	
Duration in hrs..	....	122	32	66	27	291	45	130	7
Mean velocity....	....	8.96	6.66	12.56	7.52	13.42	12.82	14.41	

Greatest mileage in one hour was 35 on the 29th.
Greatest velocity in gusts, 48 miles per hour on the 29th.

Resultant mileage, 3706.
Resultant direction, S. 63½° W.
Total mileage, 8c94.
Average velocity, 12.04 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ⁎ Ten years only.

The greatest heat was 86.4° on the 5th; the greatest cold was 44.2° on the 30th, giving a range of temperature of 42.2 degrees.

Warmest day was the 20th. Coldest day was the 12th. Highest barometer reading was 30.276 on the 25th. Lowest barometer was 29.478 on the 11th, giving a range of .798 inches. Maximum relative humidity was 99.0 on the 9th. Minimum relative humidity was 29.0 on the 4th.

Rain fell on 11 days.

Auroras were observed on 1 night on the 16th.

Thunder storms on 2 days, on the 7th and 21st.

ABSTRACT FOR THE MONTH OF JULY, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER.				BAROMETER.				†Mean pressure of vapor.	‡ Mean relative humidity.	Dew point.	WIND.		SKY CLOUDED IN TENTHS.			Percent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
	Mean.	Max.	Min.	Range.	Mean.	Max.	Min.	Range.				General direction.	Mean velocity in miles per hour	Mean.	Max.	Min.					
1	70.68	78.4	62.1	16.3	30.0913	30.131	30.011	.120	.4862	65.0	57.8	S.W.	13.00	1.2	3	0	88	0.00	....	0.00	1
2	74.50	89.3	59.2	30.1	30.0237	30.200	29.890	.310	.5173	62.3	59.7	S.W.	19.88	0.0	0	0	87	....	....	....	2
3	59.90	67.3	55.6	11.7	30.1542	30.224	30.082	.142	.3590	70 0	49.8	E.	18.58	8.3	10	5	32	0.09	....	0.09	3
4	58.66	62.3	53.7	8.6	29.9395	30.122	29.755	.367	.4835	97.9	58.2	N.E.	11.08	10.0	10	10	00	2.04	....	2.04	4
SUNDAY.........5	.....	63.6	56.0	7.6	......	.....	......	....	....	....	....	N.W.	12.25	....	....	..	1	0.23	....	0.23	5.........SUNDAY
6	62.62	71.0	55.0	16.0	29.9133	29.980	29.850	.130	.5138	89 8	59.5	N.E.	7.21	8.2	10	4	26	0.00	....	0.00	6
7	65.11	73.4	58.4	15.0	29.8665	20.893	29.849	.044	.5235	84.3	60.2	S. W.	12.83	6.3	10	0	47	0.07	....	0.07	7
8	69.23	78.3	56.4	21.9	30.0160	30.121	29.891	.230	.5143	72.8	60.0	S. W.	18.38	3.2	6	0	79	....	....	....	8
9	72.05	79.1	63.3	15.8	30.1468	30.215	30.080	.135	.5883	73.8	63.0	S.	10.25	6.8	10	0	26	0.12	....	0.12	9
10	74.25	80.2	68.8	11.4	29.0533	30.133	29.982	.151	5570	66.6	62.0	S. W.	15.79	4.5	10	0	81	0.00	....	0.00	10
11	73.33	79.4	66 0	13.4	29.9447	29.997	29.887	.110	.6155	74.5	64.8	S. W.	15.33	4.2	9	0	64	....	....	....	11
SUNDAY........12	.....	86.7	68.0	18.7	......	......	......	....	.....	...	....	S. W.	19.30	....	......	..	86	0.00	....	0.00	12..........SUNDAY
13	70.63	82.0	65.0	17.0	29.7968	29.832	29.708	.124	.6193	83.3	65.0	N.W.	8.00	5.2	10	2	46	0.36	....	0.36	13
14	68.02	75.8	60.1	15.7	29.8885	29.949	29.819	.130	.4272	62.7	54.5	N.	6.67	5.8	10	3	69	....	....	....	14
15	65.57	77.6	56 3	21.3	29.5808	29.730	29.438	.272	.4873	76.3	57.5	S.	14.58	4.5	10	0	50	0.21	....	0.21	15
16	60.33	66.9	51.3	15.6	29.7807	29.901	29.695	.206	.3913	73.0	52.0	W.	17.08	6 7	10	3	57	0.00	....	0.00	16
17	66.53	75.3	58.6	16.7	30.0903	30.205	29.971	.234	.4117	63.2	53.0	W.	5.50	4 5	10	0	44	0.00	....	0.00	17
18	70.03	79.8	56.0	23.8	30.2827	30.338	30.243	.095	.4423	60.5	55.2	S.W.	6.29	3.7	10	0	84	....	....	....	18
SUNDAY 19	.....	81.6	64.1	17.5	....	......	.....	....	....	....	....	S.	12.63	....	...	..	31	....	....	....	19..........SUNDAY
20	67 47	70.0	64.8	5.2	29.9725	30.072	29.803	.269	.6280	93.3	65.5	S.	12.29	9.2	10	5	00	0.57	....	0.57	20
21	74.30	82.1	68.1	14.0	29.9095	29 984	29.842	.142	.6402	76.5	66 0	W.	12.92	4.5	10	0	76	0.00	....	0.00	21
22	73.87	83.7	64.3	19.4	29.8293	30.001	29 591	.410	.7348	85.3	69.3	S.	9 29	5.8	10	0	54	0.00	....	0.00	22
23	65.65	71.5	59.8	11.7	29.7905	29.917	29.638	.279	4412	69.7	55.3	S. W.	19.54	2.2	5	0	96	0.02	....	0.02	23
24	65.25	72.1	57.5	14.6	29.8543	29.933	29.780	.153	.4480	72.5	56.0	S.W.	12.50	4.2	9	0	47	....	....	....	24
25	68.90	78 6	61.0	17 6	29.8425	29.935	29.779	.126	.4815	68.3	57.8	S.W.	17.17	3.2	10	0	82	....	...	....	25
SUNDAY........26	.....	81.2	61.5	19.7	......	......	......	....	.....	.	....	S. W.	19.88	..	...	..	82	....	...	....	26 ....SUNDAY
27	70.87	77.8	63.6	14.2	29.8025	29.863	29.756	.112	.5853	76.8	63.3	S.W.	11.08	8.0	10	4	10	0.00	....	0.00	27
28	72.42	80.5	60.5	14.0	29.9372	29.965	29.877	.088	.5782	73.3	63.2	N.W.	4 88	4.2	7	0	75	....	....	....	28
29	74.98	84.3	64.4	19.9	29.9243	30.016	29.811	.205	.5950	69.2	63.7	S. W.	7.79	2.5	10	0	82	0.00	....	0.00	29
30	73.53	83.1	63.5	19.6	29.7362	29.805	29.637	.169	.6418	75.7	65.8	S. W.	14.04	6.2	10	0	73	1.12	....	1.12	30
31	62.02	68.6	55.6	13.0	30.0052	30.103	29 912	.191	.2802	50.0	47.2	N.W.	14.54	0	0	0	98	0.01	....	0.01	31
Means	68.57	76.82	60 79	16.03	29.9323	30.0200	29.8369	.1831	.5182	73.58	59.46	S. 55¼° W.	13.01	4.93	8.44	1.32	57.2	4.84	....	4.84	... . Sums
22 Years means for and including this month	68.74	77.22	60 63	16.59	29.8943	....	.....	.142	.4984	71.1	....	.....	ꜱ13.15	5.4	..	..	¶58.8	4.05	....	4.05	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	238	608	400	25	1077	5073	1172	1087	
Duration in hrs..	28	61	25	6	101	335	95	86	7
Mean velocity....	8.50	9.97	16.00	40.17	10.66	15.14	12.34	12.64	

Greatest mileage in one hour was 32 on the 26th.

Greatest velocity in gusts, 36 miles per hour on the 16th.

Resultant mileage, 5690.
Resultant direction, S. 55¼° W.
Total mileage, 9080.
Average velocity, 13.01 miles per hour.

*Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ꜱ Eleven years only.

The greatest heat was 89.3° on the 2nd; the greatest cold was 51.3° on the 16th, giving a range of temperature of 38.0 degrees.

Warmest day was the 29th. Coldest day was the 4th. Highest barometer reading was 30.338 on the 18th. Lowest barometer was 29.458 on the 15th, giving a range of .880 inches. Maximum relative humidity was 99.0 on the 4th. Minimum relative humidity was 33.0 on the 31st.

Rain fell on 21 days.

Auroras were observed on 1 night on the 11th.

Thunder storms on 4 days, on the 13th, 15th, 22nd and 30th.

Errata for May and June, 1896:—22 years monthly mean of Barometer for May, 29.9845; for June, 29.9058.

ABSTRACT FOR THE MONTH OF AUGUST, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range.	BAROMETER. Mean.	Max.	Min.	Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	66.27	73 2	52.5	20.7	29 9960	30.141	29.822	.319	.3427	56.8	48.5	S.W.	10.46	3.2	7	0	81	....	....	....	1
SUNDAY........2	....	76.1	61.1	15.0	....	.....	......	....	....	....	....	S.W.	10.92	....	...	....	68	....	....	....	2..........SUNDAY
3	71.68	81.4	58.4	23.0	29 8865	29.937	29.832	.105	.5283	69.3	60.3	S.W.	12.25	1.5	4	0	94	....	....	....	3
4	74.92	82.5	67.8	14.7	29.8443	29.936	29.768	.168	.6132	70.2	64.8	S.W.	17.25	4.5	10	0	09	....	....	....	4
5	61.95	69 0	58.0	11.0	29.9693	29.989	29 944	.045	.4993	90.3	58.8	N.	12.88	10.0	10	10	00	0.54	....	0.54	5
6	62.98	66.4	58.4	8.0	29.9593	29.997	29.939	.058	.5547	96 2	61.8	N.	3.63	10.0	10	10	00	0.04	....	0.04	6
7	74.08	83.6	62.3	21.3	29.9095	29.935	29.861	.074	.6927	82.3	67.8	W.	9.50	5.3	10	1	58	Inap.	....	Inap.	7
8	76.68	85.1	66.0	19.1	29.9243	29.997	29.843	.154	.6175	68.0	65.5	S.W.	5.79	2.7	10	0	83	....	....	....	8
SUNDAY....... 9	.....	85.7	70.7	15.0	......	......	......	....	...	....	....	S.W.	14.58	....	.....	...	63	0.02	....	0.02	9..........SUNDAY
10	77 92	87.7	68.0	19.7	29.8458	29.890	29.803	.087	.7208	76.2	69.5	S.W.	10.25	3.7	10	0	68	....	....	....	10
11	81.15	89.7	74.1	15.6	29.8837	29.914	29.852	.062	.7698	73.0	71.7	S W.	16.96	2.5	7	0	86	....	....	....	11
12	77.47	86 1	70.1	16.0	29.9805	30.061	29.932	.129	.6340	67.2	65.3	S.W.	13.88	1.8	8	0	85	....	....	....	12
13	67.67	76.7	58.5	18.2	30.0643	30.135	29.999	.136	.4717	69.8	57.3	N.	9.21	2.5	8	0	64	....	....	....	13
14	71.45	80.2	61.8	18.4	30.0613	30.107	30.033	.074	.4097	54.3	53.3	S.W.	8.38	0.7	4	0	95	....	...	....	14
15	71 78	83.1	58 8	24.3	30.0545	30.142	29.969	.173	.4623	59.2	56.3	S.W.	7.13	1.0	3	0	92	....	....	....	15
SUNDAY.. 16	.....	75.1	62.8	12.3	....	......	.....	....	... .	....	....	S.W.	14.83	...	..	...	11	1.54	....	1.54	16..........SUNDAY
17	62 57	69.6	56.1	13.5	29.9112	29.946	29.889	.057	.3460	61.2	48.8	W.	15.00	2 2	7	0	96	....	....	....	17
18	56.57	63.2	52.5	10.7	29.9435	29.985	29 891	.094	.3443	75.8	48.7	N.W.	7.13	7.3	10	0	32	0.52	....	0.52	18
19	57.28	65.0	51.1	13.9	30.1272	30.178	30.039	.139	.3155	68.2	46.3	N.W.	13.25	7.0	10	2	85	Inap.	....	Inap.	19
20	63.12	71.9	56.4	15 5	30.1338	30.212	30.066	.146	.3675	63.8	50.3	S.W.	15.66	3 7	10	0	79	....	....	....	20
21	62 73	74.4	53.1	21.3	29.9643	30.060	29.900	.160	.4355	77.2	55 0	S.	8.90	7.7	10	0	48	0.64	....	0.64	21
22	65.77	74.1	56.8	17.3	29 9190	29 941	29 880	.161	.5266	83.8	60.3	S.	7.33	5.7	10	1	64	0.08	...	0.08	22
SUNDAY.......23	.....	74.0	66.2	7.8	......	......	......	....	.....		....	S.	19.55	....	...	..	3	1.07	....	1.07	23..........SUNDAY
24	64.68	72.9	56 0	17.9	2,.9290	30.054	29.881	.173	4267	69.7	54.5	S.W.	16.42	1.7	5	0	97	....	....	....	24
25	59.45	67.5	50.0	17 5	30.0867	30.146	30.020	.126	.3537	70.8	49.3	S.W.	5.04	0.0	0	0	92	....	...	....	25
26	67.37	77.4	53.3	24.1	29.9443	30.035	29.844	.191	.4438	66.5	55.5	S.	16.95	4.7	10	0	55	....	...	....	26
27	61.97	66.8	57.3	9.5	30.0422	30.147	29.886	.261	.4022	73.0	52 7	W.	10.50	6.7	10	3	76	0.81	....	0.81	27
28	60.20	67.5	54.3	13.2	30.2510	30.300	30.198	.102	.3408	64.5	48.0	W.	10.08	5.3	10	0	82	Inap.	....	Inap.	28
29	59.58	65.5	47.8	20.7	30.1808	30.300	30.035	.265	.3705	73.3	50.8	W.	8.96	1.0	4	0	85	.....	....	....	29
SUNDAY.......30	.....	75.7	54.2	21.5	....	....	......	..	.....	....	....	S.	13.54	....	....	....	65	0.02	....	0.02	30..........SUNDAY
31	58.08	62.7	53.5	9.2	29.7745	29.898	29 646	.252	.3848	78.9	51.3	W.	9.75	9.7	10	3	26	0.07	....	0.07	31
Means	66.75	75.28	58 96	16.32	29.9841	30.053	29.914	.139	.4759	71.52	56.63	......	11.48	4.3	7 9	1.2	64.6	5.35	....	5.35	... . Sums
22 Years means for and including this month	66.71	75.04	58 71	16.37	29.9405	......	......	.134	.4808	73.0	....	S. 56¾° W.	s12.7	5.3	...	..	¶55.3	3.67	....	3.67	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	741	8	11	202	1353	4023	1583	621	
Duration in hrs .	82	2	2	13	111	313	147	67	7
Mean velocity....	9.04	4.00	5.50	15.54	12.19	12.85	10.79	9.27	

Greatest mileage in one hour was 27 on the 4th.

Greatest velocity in gusts, 36 miles per hour on the 23rd.

Resultant mileage, 5672.
Resultant direction, S. 56¾° W.
Total mileage, 8542.
Average velocity, 11.48 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. : Eleven years only.

The greatest heat was 89.7° on the 11th; the greatest cold was 47.8° on the 29th, giving a range of temperature of 41.9 degrees.

Warmest day was the 11th. Coldest day was the 18th. Highest barometer reading was 30.300 on the 28th. Lowest barometer was 29.646 on the 31st, giving a range of .654 inches. Maximum relative humidity was 99.0 on the 5th, 6th, and 22nd. Minimum relative humidity was 39.0 on the 14th.

Rain fell on 14 days.

Auroras were observed on 2 nights, on the 9th and 17th.

Thunder storm on the 9th.

ABSTRACT FOR THE MONTH OF SEPTEMBER, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range.	* BAROMETER. Mean.	Max.	Min.	Range.	† Mean pressure of vapor.	‡ Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Percent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	53.93	61.3	48.2	13.1	30.1075	30.238	29.977	.261	.2960	71.5	44.7	W.	13.30	3.0	9	0	72	....	....	....	1
2	56.57	63.8	46.5	17.3	30.1520	30.301	29.945	.356	.3215	70.3	46.8	S.W.	8.25	7.5	10	0	30	0.00	....	0.00	2
3	58.47	64.2	50.7	13.5	29.2922	29.975	29.704	.271	.4412	88.3	55 0	N.W.	16.20	7.3	10	0	00	0.39	....	0.39	3
4	50.53	56.8	45.5	11.3	30.1380	30.206	30 049	.157	.2582	70.5	41.3	N.W.	10.58	2.8	8	0	78	....	....	....	4
5	53.78	62.5	41.1	21.4	30.0895	30.209	29.958	.251	.3150	76 7	46.0	S.E.	10.38	6.7	10	0	39	0.09	....	0.09	5
SUNDAY........6	.....	65.4	51.4	14.0	....	.....	......	....	.....	....	....	S.E.	14.59	....	....	....	09	0.55	....	0.55	6 ....SUNDAY
7	59.32	64.5	55.1	9.4	29.9680	30.119	29.791	.328	.3843	76.3	51.7	S.W.	15.67	4.7	10	0	81	....	....	....	7
8	59.45	69.6	49.7	19.9	30.1978	30.241	30.169	.072	.4155	82.8	53.8	S.W.	3.75	0.3	1	0	80	....	....	....	8
9	62.40	71.6	52.4	19.2	30.0800	30.188	29.962	.226	.4452	79.8	55.5	N.E.	6.13	0.0	0	0	83	....	....	....	9
10	66.23	75.6	55.1	20.5	29.8463	29.918	29.803	.115	5048	78.0	59.0	S.W.	7.63	0 0	1	0	96	....	....	....	10
11	74.18	83.8	61.5	22.3	29.8916	29.963	29.827	.136	.6008	72.0	63.5	S.W.	16.13	0.0	0	0	87	....	....	....	11
12	66.33	71.9	61.4	10.5	30.1918	30.312	30.050	.262	.4903	75.5	58.3	N.E.	15.80	4.8	10	0	61	....	....	....	12
SUNDAY........13	.....	65.9	56.5	9.4	....	......	......	....	....	...	....	N.E.	20.82	....	......	...	69	....	....	....	13 ....SUNDAY
14	61.15	68.0	51.6	16.4	30.0333	30.175	29 908	.267	.4455	81.6	55.2	S.W.	8.80	9.2	10	5	27	0.06	...	0.06	14
15	58.28	65.7	48 5	17.2	29.9822	30.058	29.926	.132	.3612	72.6	49.2	N.W.	12.62	5.7	10	0	47	0.01	....	0.01	15
16	52.30	60.2	45.2	15.0	29.9452	30.051	29.824	.227	.2933	74.8	44 3	W.	6.96	2.8	10	0	84	....	....	....	16
17	55.75	61.8	50.9	10.9	29.6425	29.746	29 521	.225	.4067	91.0	53.2	S.	7.50	8.2	10	0	00	0.35	...	0.35	17
18	56.35	63.7	49.8	13.9	29.8373	30.895	29.748	.147	.3597	80.2	50.0	W.	13.79	5.3	10	0	67	0.00	....	0.00	18
19	55.18	57.1	52.4	4.7	29.6155	29.786	29.489	.297	.4088	93.8	53.5	S.W.	10.92	10 0	10	10	00	0.41	....	0.41	19
SUNDAY........20	.....	54.0	41.4	12 6	....	......	....	....	... .	....	....	W.	20.33	...	...	...	97	0.02	....	0.02	20 ....SUNDAY
21	55.47	62.8	47.8	15.0	29.8397	29.927	29.816	.111	.3370	76.7	48.0	S W.	16.00	6.0	10	0	64	....	....	....	21
22	44.45	49.0	39.0	10.0	29.9357	30.073	29 824	.249	.2252	73.8	37.2	N.W.	16.79	8.2	10	0	05	0.11	...	0.11	22
23	42.62	47.8	34.3	13.5	30.1495	30.236	30.073	.163	1693	61.7	30.0	N.W.	13.83	3.7	10	0	97	....	....	....	23
24	51.17	59.5	43.6	15.9	30.1065	30.210	30.013	.197	.3047	81.2	45.3	S.W.	11.30	8.0	10	3	34	0.22	....	0.22	24
25	58.32	66.1	49.0	17 1	30.1395	30.230	30.066	.164	.3810	78.7	51.7	S.	13.17	9.5	10	7	48	0.00	...	0.00	25
26	61.70	67.5	54.4	13.1	30.1067	30.136	30.081	.055	.4747	86.2	57.3	S.W.	13.67	7.2	10	0	30	0.28	...	0.28	26
SUNDAY........27	.....	62.5	54.3	8.2	......	......	......	....	.....		....	W.	12.21	...	...	.	00	0.18	....	0.18	27..........SUNDAY
28	48.75	54.3	44.0	10.3	30.2487	30.306	30.200	.106	.2285	66 8	38.0	S.W.	6.83	0.5	3	0	92	....	....	....	28
29	53.72	64.3	38.2	26.1	30.1033	30.230	29.918	.312	.3533	83.8	48.7	S.E.	12.21	6.3	10	0	48	0 01	....	0.01	29
30	60.70	69.2	54.3	14.9	29.6187	29.780	29 527	.253	.4453	84.0	55.7	W.	15.04	7.3	10	3	49	0.43	....	0.43	30
31	.....	.....	.....	.....	....	....	......	..	.....	....	....	....	....	....	....	....	....	....	....	....	31
Means	56.81	63.68	49.13	14.55	29.9930	30.965	29.8911	2.054	.3718	78.10	49.72	......	12.37	5.19	3.15	1 06	52.46	3.11	....	3.11	... . Sums
22 Years means for and including this month......	58.52	66.58	50.76	15.69	30.0139	......	.....	.180	.3829	75.59	....	S. 73¾° W.	ꜱ12.69	5.5	...	..	¶53.9	3.14	....	3.14	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	412	950	194	656	837	2719	1540	1648	
Duration in hrs..	43	65	18	51	67	200	135	138	3
Mean velocity....	9.58	14.62	10.78	12.86	12.50	13.59	11.41	11.94	

Greatest mileage in one hour was 34 on the 20th.

Greatest velocity in gusts, 60 miles per hour on the 17th.

Resultant mileage, 3435.
Resultant direction, S. 74¾° W.
Total mileage, 8956.
Average velocity, 12.44 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ꜱ Eleven years only.

The greatest heat was 83.8° on the 11th; the greatest cold was 34.3° on the 23rd, giving a range of temperature of 49.5 degrees.

Warmest day was the 11th. Coldest day was the 23rd. Highest barometer reading was 30.312 on the 12th. Lowest barometer was 29.489 on the 19th, giving a range of .823 inches. Maximum relative humidity was 97.0 on the 8th, 19th, 26th and 29th. Minimum relative humidity was 50.0 on the 23rd.

Rain fell on 17 days.

Lunar halo on one night. Lunar corona on one night. Hour frost on one day.

Thunder and lightning on two days, the 6th and 17th.

ABSTRACT FOR THE MONTH OF OCTOBER, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	THERMOMETER. Mean.	Max.	Min.	Range.	BAROMETER. Mean.	Max.	Min.	Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	WIND. General direction.	Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent. of possible Sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
1	52.85	58.3	51.0	7.3	29.8337	29.989	29.690	.299	.3560	88.5	49.5	W.	16.33	8.5	10	2	03	0.34	....	0.34	1
2	44.10	52.1	41.8	10.3	30.1124	30.145	30.090	.055	.2478	85.4	40.0	N.	20.79	10.0	10	10	00	0.02	....	0.02	2
3	44.77	49.2	40.9	8.3	30.1703	30.229	30.112	.117	.2657	89.3	41.7	N.	8.21	9.7	10	9	07	0.03	....	0.33	3
SUNDAY.......4	.....	50.9	44.7	6.2	....	.....	......	....	.....	....	....	N.	2.54	....	....	....	06	Inap.	....	Inap.	4.........SUNDAY
5	46.65	51.8	43.4	8.4	30.2178	30.283	30.150	.133	.2550	80.3	40 8	N.	6.75	6.7	10	0	33	Inap.	....	Inap.	5
6	43.85	47.6	39.8	7.8	30.0928	30.156	29.985	.171	.2487	86 7	40.3	N.	9.92	10.0	10	10	00	....	....	....	6
7	43.73	46.6	41.5	5.1	29.8452	29.932	29.793	.139	.2668	93.3	42.2	N.	9.58	9.7	10	8	00	0.62	....	0.62	7
8	40.42	45.8	37.3	8.5	30.1002	30.296	29.901	.395	.2100	84.2	35.8	W.	18.00	9.7	10	8	26	0.22	....	0.22	8
9	39.33	44.9	33.3	11.6	30.4717	30.549	30.378	.171	.1572	64.8	28.7	W.	9.00	0.5	2	0	98	....	....	....	9
10	39.70	46.5	32.0	14.5	30.5727	30.638	30.485	.153	.1615	68.8	29.8	N.	9.08	0.0	0	0	92	....	....	....	10
SUNDAY.......11	.....	52.5	33.0	19.5	......	......	......	....	.....	....	....	N.	11.17	....	......	....	93	....	....	....	11..........SUNDAY
12	44.43	54 5	35.5	19.0	30.3233	30.308	30.213	.185	.2122	73.2	35.8	N.	20.50	1.7	9	0	84	....	....	....	12
13	44.88	53.6	37.4	16.2	30.0075	30.179	29.816	.363	.2030	69.2	34.8	N.	20.62	4.7	9	0	55	....	....	....	13
14	48.00	55.6	41.0	14.6	29.8188	29.856	29.795	.061	.2240	67.5	37.5	N.	11.25	5.2	8	2	35	....	...	....	14
15	49.37	57.8	41.0	16.8	29.7008	29.795	29.586	.209	.2325	66.5	38.2	W.	8.42	2.8	6	0	85	....	....	....	15
16	39.40	43.0	35.5	7.5	29.6085	29.739	29.539	.200	.2203	90.3	37.0	W.	13.96	7 5	10	2	00	0.19	....	0.19	16
17	35.15	39.0	29.6	9.4	29.9440	30.019	29.820	.199	.1448	71.0	26.5	W.	6.79	7.3	10	4	48	....	....	....	17
SUNDAY.......18	.....	44.8	33.3	11.5	....	......	......	....	.....	....	....	N.E.	7.50	...	..	..	30	0.11	....	0.11	18.........SUNDAY
19	36.27	42.2	31.8	10.4	29.9767	30.071	29.857	.214	.1512	70.8	27.3	N.W.	17.17	5.0	10	0	56	Inap.	Inap.	Inap.	19
20	40.38	48.2	31.5	16 7	29.8923	30.016	29.776	.240	.1953	75.5	33.2	S.W.	17.75	8.7	10	3	16	0.10	Inap.	0.10	20
21	44.20	54.1	35.2	18.9	29.7807	29 868	29.677	.191	.2430	80.7	38.8	S.W.	18.50	6.7	10	0	04	0.22	...	0.22	21
22	37.88	44.8	32.4	12.4	29.9263	29.957	29 867	.090	.1667	74.2	30.0	S.W.	18.00	6.8	10	4	73	....	....	....	22
23	40.68	48.2	36.4	11.8	29.7685	29.924	29.579	.345	.1822	72.2	32.2	S.W.	8.63	8.7	10	2	28	....	....	....	23
24	39.42	47.7	36.0	11.7	29.5877	29.739	29.523	.216	.1947	81.0	33.8	S.W.	15.50	5.5	10	0	53	0.03	....	0.03	24
SUNDAY.......25	.....	35.3	29.9	5 4	......	......	......	....	.....	..	....	N.W.	17.04	....	...	....	19	..	Inap.	Inap.	25..........SUNDAY
26	42.97	50.6	31.4	19.2	29.9793	30.071	29.906	.165	.2023	71.7	34.3	S.W.	15.12	5.7	10	0	33	....	...	....	26
27	44.43	51.7	35.8	15.9	30.2132	30.358	30.096	.262	.2057	70.2	35.0	N.W.	8.50	4.8	10	0	58	Inap.	....	Inap.	27
28	38.32	47.5	30.2	17.3	30.3328	30.421	30.210	.211	.1753	75.8	31.5	N.E.	11.92	3.3	10	0	88	....	....	....	28
29	47.15	54.0	38.1	15.9	30.1127	30.177	30.077	.100	.2995	95.5	44.2	N.W.	11.37	10.0	10	10	00	0.38	....	0.38	29
30	45.80	49.8	43.6	6.2	29.9073	30.078	29 737	.341	.2993	97.0	45.2	N.E.	9.42	10.0	10	10	00	0.08	....	0.08	30
31	48.70	57.1	41.8	15.3	29.7912	29.828	29.751	.077	.2698	96.5	42.3	S.W.	11.63	4.8	10	0	50	0.14	....	14.0	31
Means	43.07	49.21	36.97	12.24	30.0033	30.1004	29.9040	.1964	.2219	79.26	36.53	N. 50° W.	12.61	6.44	9.04	3.11	37.8	2.48	Inap.	2.48	.... Sums
22 Years means for and including this month.. ...	45.25	52.26	38.46	13.71	29.9956	......	......	.213	.2426	76.62	....	......	ƨ13.71	6.44	....	....	¶40.27	3.06	1.25	3.19	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	3016	943	34	426	106	2307	1509	1042	
Duration in hrs..	241	103	13	31	10	151	111	76	8
Mean velocity....	12.51	9.16	2.62	13.74	10.60	15.28	13.52	13.71	

Greatest mileage in one hour was 30 on the 21st.

Greatest velocity in gusts, 48 miles per hour on the 21st.

Resultant mileage, 3740.
Resultant direction, N. 50° W.
Total mileage, 9383.
Average velocity, 12.61 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. ƨ Eleven years only.

The greatest heat was 58.3° on the 1st; the greatest cold was 29.6° on the 17th, giving a range of temperature of 28.7 degrees.

Warmest day was the 1st. Coldest day was the 17th. Highest barometer reading was 30.638 on the 10th. Lowest barometer was 29.523 on the 24th, giving a range of 1.115 inches. Maximum relative humidity was 99.0 on the 30th. Minimum relative humidity was 51.0 on the 10th, 19th and 23rd.

Rain fell on 17 days. Snow fell on 3 days.

Rain or snow fell on 18 days.

Hoar frost on 6 days.

Solar corona on the 13th.

Fog on 3 days.

ABSTRACT FOR THE MONTH OF NOVEMBER, 1896.

Meteorological Observations, McGill College Observatory, Montreal, Canada. Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

DAY.	Thermometer Mean.	Thermometer Max.	Thermometer Min.	Thermometer Range	*Barometer Mean.	Barometer Max.	Barometer Min.	Barometer Range.	†Mean pressure of vapor.	‡Mean relative humidity.	Dew point.	Wind General direction.	Wind Mean velocity in miles per hour	Sky Clouded in Tenths Mean.	Sky Clouded Max.	Sky Clouded Min.	Percent. of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
SUNDAY........1	....	54.7	39.9	14.8	......	....	......	....	....	....	....	S.W.	13.37	....	....	....	72	0.00	....	0.00	1 .... SUNDAY
2	45.62	48.9	42.5	6.4	30.1188	30.277	30.001	.276	.2258	73.7	37.7	W.	15.58	5.2	10	0	16	....	....	....	2
3	40.77	46.0	36.3	9.7	30.3598	30.398	30.323	.075	.2098	82.7	35.8	N.E.	9.46	3.0	8	0	42	....	....	....	3
4	44.63	53.0	31.6	21.4	30.1333	30.301	29.958	.343	.2468	81.7	39.2	S.E.	20.46	6.0	10	0	43	0.00	....	0.00	4
5	52.07	55.4	49.9	5.5	29.6452	29.929	29.398	.531	.3657	93.2	50.3	S.E.	26.70	10.0	10	10	00	0.93	....	0.93	5
6	42.85	52.1	40.5	11.6	29.6050	29.749	29.547	.202	.2172	78.3	36.3	S.W.	32.68	10.0	10	10	00	0.09	....	0.09	6
7	40.45	43.6	36.7	6.9	29.8627	29.919	29.780	.139	.1927	76.3	33.7	S.W.	16.58	8.3	10	5	55	0.00	....	0.00	7
SUNDAY........8	.....	44.8	32.0	12.8	......	......	......	....	.....	...	....	S.W.	15.33	....	....	....	00	0.15	0.00	0.15	8..........SUNDAY
9	35.95	41.8	31.0	10.8	29.9372	30.060	29.868	.192	.1663	79.5	30.2	S.W.	13.21	5.3	10	0	93	....	....	....	9
10	36.12	39.4	32.8	6.6	30.2727	30.329	30.200	.129	.1572	73.8	28.7	S.W.	10.88	7.5	10	0	18	0.00	....	0.00	10
11	42.10	50.3	34.8	15.5	29.8547	30.130	29.661	.469	.2178	79.8	36.2	S.	21.21	7.2	10	0	00	0.26	....	0.26	11
12	41.45	45.7	35.5	10.2	29.9607	30.008	29.935	.073	.1870	71.3	32.8	S.W.	18.29	8.8	10	8	20	0.00	....	0.00	12
13	30.43	33.5	25.8	7.7	29.9890	30.014	29.933	.081	.1370	80.5	25.2	N	10.47	8.0	10	2	12	....	0.00	0.00	13
14	27.43	30.8	25.0	5.8	30.1147	30.183	30.016	.167	.1112	72.8	20.5	N.W.	10.79	9.8	10	9	00	....	0.00	0.00	14
SUNDAY........15	.....	41.2	25 5	15.7	......	......	.....	....	.....	...	....	S.W.	19.54	....	...	...	00	0.40	1.70	0.57	15 ....SUNDAY
16	28.12	30.9	25.5	5.4	30.0620	30.158	29.887	.271	.1440	93.5	26.3	N.E.	10.33	10.0	10	10	00	....	1.20	0.12	16
17	44.67	57.6	30.9	26.7	30.0722	30.350	29.837	.513	.2353	72.2	36.3	S.W.	23.96	7.8	10	2	35	0.02	....	0.02	17
18	38.33	57.3	28.1	29.2	29.9347	30.340	29.569	.771	.2172	82.0	33.5	E.	19.37	10.0	10	10	00	0.54	....	0.54	18
19	28.37	57.6	18.0	39.6	30.1930	30.454	29.834	.620	.1127	63.3	19.7	N.W.	22.04	2.3	7	0	90	0.01	....	0.01	19
20	16.63	19.4	11.4	8.0	30.5957	30.652	30.541	.111	.0643	69.0	8.5	N.W.	8.58	3.5	10	0	46	....	0.00	0.00	20
21	24.05	27.7	17.0	10.7	30.2233	30.504	30.007	.497	.1117	85.8	20.3	S.E.	11.33	8.3	10	0	00	....	0.70	0.07	21
SUNDAY........22	.....	25.5	12.5	13.0	......	.....	......	....	.....	....	....	N.W.	11.25	....	...	...	95	....	0.40	0.04	22..........SUNDAY
23	23.07	36.3	8.8	27.5	30.5310	30.774	30.182	.592	.1132	80.8	18.2	S.E.	12.64	6.5	10	0	04	0.00	....	0.00	23
24	37.30	44.5	29.4	15.1	30.3010	30.683	30.080	.603	.1980	87.5	33.7	N.W.	15.33	5.2	10	0	13	0.22	....	0.22	24
25	22.62	26.0	20.8	5.2	30.5857	30.667	30.433	.234	.0985	81.3	18.2	N.E.	11.37	8.3	10	0	00	....	1.10	0.23	25
26	25.40	29.5	23.1	6 4	30.1388	30.258	29 983	.275	.1295	93.7	23.8	N.E.	8.96	10.0	10	10	00	0.48	0.30	0.51	26
27	38.73	51.8	23.0	28.8	29.8332	29 859	29.781	.078	.2432	96.5	37.7	S.W.	19.25	10.0	10	10	00	0.14	....	0.14	27
28	38.45	55.0	31.8	23.2	30.0812	30.221	29.798	.423	.1905	77.3	32.0	S.W.	18.33	10.0	10	10	00	0.24	....	0.24	28
SUNDAY........29	.....	30.5	22.6	7.9	....	......	.....	....	.....	..	....	W.	11.29	..	......	...	08	....	0.00	0.00	29.......... SUNDAY
30	24.28	28.7	21.3	7.4	30.2867	30.375	30.215	.160	.1078	82.3	19 7	S.W.	10.00	8.3	10	0	03	....	0.50	0.05	30
Means	34.79	41.98	28.13	13.85	30.1077	30.2637	29.9507	.3130	.1760	80.55	29.38	S. 45° W.	15.55	7.57	9.8	3.8	22.2	3.48	5.90	4.19	.... Sums
22 Years means for and including this month	32.56	38.99	26.57	12.98	30.0171	......	......	.2664	.1604	79.72	....	......	s16.40	7.38	...	...	¶28.63	2.39	12.47	3.65	22 Years means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Miles	289	1184	253	1830	498	4804	746	1594	
Duration in hrs..	26	108	29	97	38	244	56	122	
Mean velocity....	11.12	10.96	8.76	18.86	13.11	19.68	13.32	13.07	

Greatest mileage in one hour was 40 on the 17th.
Greatest velocity in gusts, 48 miles per hour on the 17th.

Resultant mileage, 4115.
Resultant direction, S. 45° W.
Total mileage, 11198.
Average velocity, 15.55 miles per hour.

* Barometer readings reduced to sea-level and temperature of 32° Fahrenheit.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ 15 years only. s Eleven years only.

The greatest heat was 57.6° on the 17th and 19th, the greatest cold was 8.8° on the 23rd, giving a range of temperature of 48.8 degrees.

Warmest day was the 5th. Coldest day was the 20th. Highest barometer reading was 30.774 on the 23rd. Lowest barometer was 29.398 on the 5th, giving a range of 1.376 inches. Maximum relative humidity was 100 on the 15th. Minimum relative humidity was 57.0 on the 1st and 20th.

Rain fell on 18 days. Snow fell on 12 days.
Rain or snow fell on 27 days.
Lunar halo on 1 night on the 17th.
Lunar coronas on 2 nights on the 19th and 20th.
Fog on 5 days on 1st, 3rd, 24th, 26th and 27th.