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Clay Concretions of the Connecticut River.[1]

By Miss J. M. Arms.

The concretions with which I am most familiar are found between Brattleboro, Vt., and Sunderland, Mass., a distance of about thirty miles. Between the two towns named, few clay beds occur on the right bank, it being either green with vegetation, sandy or rocky, but on the left shore the beds are numerous.

You are first attracted by the deep blue color of the clay, which can be seen a distance from the shore. In some places, as between the two ferries known as Rice's and Whitemore's, this clay occurs interstratified with sand; in others, as at Sunderland bridge, it forms projecting shelves into the stream which are often thickly strewn with concretions washed from the beds above.

Again, as at the mouth of Saw Mill River, a little stream that empties into the Connecticut, the clay forms a high cliff rising perpendicularly from the water's edge. It is one of the finest exposures to be seen. Stratification planes cut it horizontally, and joint planes obliquely, while the peculiar blue color presents a striking contrast to the green vegetation above, and the sparkling waters below. I have

[1] Abstract of a paper on "Concretions of the Connecticut River," now in course of preparation.

never seen concretions exposed from this wall of apparently pure clay excepting close to the water's edge, where there is no possible way of getting them but to stand in the river and dig, a trowel or stout carving-knife being the best implement for the work.

In collecting claystones it is better to row *up* the stream than down, for in the latter case the dislodged clay renders the water so turbid it is impossible to see the claystones which have been washed into it, and which often have a story to tell. The concretions of each clay bed should be kept separate, and when this is done the fact is proved that *each bed has a form of concretion peculiar to itself.* You would never find, for instance, a circular disk and a cylindrical claystone imbedded together, or a botyoidal mass and an animal form; these are four typical concretions of as many separate beds.

While each bed has its characteristic form, this is not attained with an unvarying degree of perfection. There seems to be an ideal and a struggle to attain it; the resulting concretion being more or less perfect as the conditions are favorable or adverse. When the conditions are favorable and constant, the typical form is repeated many times. One of the most striking examples of this fact we found in a bed nearly opposite Whitemore's ferry. Out of twenty-six concretions, twenty-four had the same peculiar markings. One of the two exceptions, I have little doubt, was the incipient form of the others, and would have developed like them had we let it remain. The other was not found imbedded, and therefore, I presume to say, came from some bed up the river. I have seen in a private collection, forty-eight specimens from one bed so similar one could not tell them apart.

Occasionally the typical form is doubled or trebled in the same specimen, as shown in those from Saw Mill River.

Very long concretions are seldom found, although we have one in our collection measuring twenty-two and a half inches. Imitative forms are abundant. We have spectacles, a money bag, boot, arrow-head, geometrical figures, a seal, goose, fish, rooster, elephant, bird and a baby.

Prof. Hitchcock speaks of receiving a concretion from an able English geologist labeled, "Kimmeridge Coal Money (use and age unknown), found abundant in the Kimmeridge clay, Dorset coast—supposed turned in a lathe, and anciently used as money."

Three questions must be asked: How does the composition of a claystone differ from that of the surrounding clay, and is this composition definite?

What first determines the formation of a concretion?

What are the favorable and adverse conditions of which I have spoken?

Chemical analyses answer the first question by the following results:

Deerfield claystone (opposite Whitemore's ferry), contains, beside clay and iron, 42 p.c. carbonate of lime ($Ca\,CO_3$). Clay immediately surrounding claystone, 2–3 p.c. carbonate of lime. Claystone from south of Sunderland bridge, west shore, 43 p.c. $Ca\,CO_3$; surrounding clay, 2 p.c. Brattleboro claystone, 42 p.c. $Ca\,CO_3$. Hartford claystone, 47 p.c. $Ca\,CO_3$.[1]

The essential difference, therefore, between the clay and claystone, is the almost entire absence in the former of calcium carbonate. These figures show that the composition of concretions is not definite, although it does not vary greatly. We may say that nearly half a claystone is carbonate of lime, and as this is the active agent in the process of formation, we can appreciate Le Conte's appellation of "lime balls" in place of the popular name of "claystones."

The second question is much more difficult to answer. It requires the proof of the existence or non-existence of a nucleus. It has been generally believed that these nuclei exist. Prof. Hall, in the *Geological Report of New York*, speaks of concretions having for a nucleus either a gravel

[1] Prof. Hitchcock gives four analyses thus: 42, 48, 49 p.c. $Ca\,CO_3$, and one from Hadley which seems to be the exception to the rule, 56 p.c. $Ca\,CO_3$.

stone, a bit of iron pyrites, a shell or a crystal of carbonate of lime. Negative evidence, however, is strong. I think it safe to say, that many concretions have no nucleus of foreign matter. If one exist, it is in the form of such a minute grain of calcium carbonate, it cannot be detected with the eye.

Under the direction of Prof. W. O. Crosby, a concretion was sawed in two and polished. Lines of stratification were distinctly seen, but with this exception the mass was perfectly homogeneous. There was not the slightest evidence of a nucleus or of concentric structure. One half was sawed in two again, giving a sharp angle, which proved the extreme fineness of the material. A quarter was etched in chlorhydric acid, and while this rendered evident a concentric structure, it did not reveal a nucleus. Little spherical cavities were seen, as if the tendency to concretionary structure was so great that the concreting material was not satisfied with forming one large concretion, and so made smaller ones within the larger. I also dissolved one claystone in acid, and examined the insoluble residue upon a filter. It was impalpably fine clay, and no foreign particle of any appreciable size was visible.

Prof. Hitchcock says: "In no case in Massachusetts have I seen an organic relic as a nucleus." In 1859 Mr. Charles Stodder exhibited, at a meeting of the Boston Society of Natural History, two specimens cut open, one showing a nucleus less than 1-16 of an inch in diameter, the other not. At the same meeting ex-President Bouvé remarked while showing some concretions: "These bodies do not always have a nucleus; on the contrary, those from many localities very seldom have any. These seem by no means necessary for their production." I have looked through the Proceedings of the Society since 1859, but find nothing that throws additional light upon the subject.

The third question involves the history of a claystone. We first have the clay arranged in layers by the mechanical action of water. That the formation of the concretions is subsequent to the deposition of the clay is proved by the lines of stratification running with unbroken continuity through them. The plastic clay is charged with water containing carbonate of lime in solution. We may suppose some slight change in the conditions causes a precipitation of a portion of the lime, or that certain foreign bodies attract it. In either case we should have centres towards which other molecules of calcium carbonate would be drawn. By the law which governs the diffusion of liquids new material would be brought, and so the concretion would grow. The process is one of segregation—a flocking together of the molecules. Except in taking on a crystalline form, there is little difference between the building up of a crystal and concretion. The molecules segregate, and in the case of the crystal crowd back the other material, while in that of the concretion a part of this material enters into the new form.

If the concreting material comes from all directions with equal facility, as in a porous rock, the concretions are in the form of spheres, but in clay, which is more or less impervious, it spreads laterally most freely. The tendency is, therefore, to lengthen the horizontal diameter, and shorten the vertical, giving the circular disk which is the normal form of clay concretions. I have never seen a clay sphere larger than a pea, and never found one larger than a pin's head.

When a concretion passes from one layer into another poorer in carbonate of lime, the form is contracted; thus a variation in the amount of calcium carbonate results in a variation in the form of the concretion.

What the exact conditions are which cause one bed to produce animal forms, another lenticular, and a third cylindrical, it would be interesting to know. Many observations must yet be made upon these concretions *in situ*.

Note on Specimens of Fossil Wood from the Erian (Devonian) of New York and Kentucky.

By Sir Wm. Dawson and Prof. D. P. Penhallow.

(Plate I.)

The specimens referred to in this note were sent by Prof. J. M. Clarke, of Albany, to Sir Wm. Dawson, and additional specimens of one of them were subsequently obtained through Prof. Clarke from Mr. C. E. Beecher, of Yale University Museum. The greater number of the specimens proved on examination to be of species previously described by Sir Wm. Dawson, as will appear by the following notes contributed by him. One of the specimens, however, belonging to the genus *Kalymma* of Unger, a form not previously recognized in America, and imperfectly known, was placed in the hands of Prof. Penhallow for more detailed study, and the report thereon is appended.

Dadoxylon (Cordaioxylon) Clarkii, [1] Dawson.

To this species belong a number of slender stems imbedded in the Styliola limestone of the Genessee shale, and one similar specimen from the Naples series, collected by Prof. Clarke. They present the following characters:—

Stem about 1.5 c.m. in diameter, with pith 3 m.m. in diameter, surrounded with woody tissue, but destitute of bark. Woody cylinder in transverse section showing radiating rows of square fibres, converging into distinct wedges toward the pith, which is composed of parenchyma. The terminations of the wedges are about 8 in number.

The radial section shows woody fibres, with two or three rows of bordered pores and medullary rays of various lengths. There are a few scalariform and reticulated vessels in the points of the wedges next the pith.

[1] Report on Erian Plants of Canada, pt. 2, 1882, p. 124. Palæozoic Gymnosperms, Memoirs of Peter Redpath Museum, 1890.

The tangential section shows numerous medullary rays, simple or with one series of cells superimposed, and very variable in length, from one cell to many in each.

This structure is as near to that of *Dadoxylon Clarkii* as could be expected in the more slender stems or branches represented by these specimens. The cortical tissues are absent. The pith does not show Sternbergia structure, except very faintly in parts.

The specimens from the Naples beds are imperfectly presented, but in so far as can be determined, may belong to the same species.

I have already pointed out, in the publications above referred to, that the characters of this species approximate to those of the stems of *Cordaites,* so that it may be referred to *Cordaioxylon* rather than to *Dadoxylon* proper. I may now add that the species is very near to *Araucarites Ungeri,* of Goeppert, from the Cypridina shales of Thuringia. This species appears to be the same with that originally described by Unger as *Aporoxylon primigenium.* The original description and figures of Unger did not permit an exact comparison, but as now figured by Stenzel[1] in his revision of Goeppert's species, it approaches so near to *D. Clarkii* as to suggest the suspicion that it may be the same, or at least a very closely allied species. The state of preservation, however, is so different that it is scarcely possible to be sure as to this.

With reference to the generic names, there has been great misconception among palæobotanists as to the distinction between stems of *Cordaioxylon* and *Dadoxylon.* This does not at all depend on the occurrence of an Artisia or Sternbergia pith, which may be present in Sigillariæ, Cordaites or Conifers, as it is indeed in young shoots of modern firs, as well as in angiospermous exogens of different genera. The real distinction is in the character of the inner vessels or fibres of the wedges, the peculiar nature of the medullary rays, and the thinness of the woody cylinder in *Cordaites.* I have no hesitation on these grounds in referring *D. Clarkii*

[1] Royal Academy of Berlin, 1888.

and probably *D. Ungeri* to *Cordaioxylon*, while I am equally certain that the other Devonian species, *D. Ouangondianum*, *D. Halli* and *D. Newberryi* should be referred to *Dadoxylon*, a name which is properly applied to the woods of Palaeozoic Conifers, as *Walchia*, *&c.* The name Araucarites, used by Stenzel after Goeppert and Presl, leads to a mistaken view of affinities.

Before leaving this species, it is interesting to observe that the association of this type of gymnospermous wood, with the very different type of plant of the genus *Kalymma* described in Prof. Penhallow's note, applies both to the Cypridina shales of Europe and to the corresponding beds in America.

DADOXYLON NEWBERRYI, Dawson.[1]

With the above specimens of Prof. Clarke's collections from the Styliola beds, are fragments of much larger stems with thicker-walled woody fibres, having three rows of contiguous bordered pores, and long medullary rays, with for the most part, two rows of narrow cells side by side. On comparison with the specimens collected by Dr. Newberry in the Devonian of Ohio, from which my description of 1871 was taken, I find no difference other than what may depend on difference of preservation. I therefore refer Prof. Clarke's specimens to the above species, which is a true *Dadoxylon* and nearly allied to *D. Ouangondianum* of the Devonian of New Brunswick, and to *D. Acadianum* of the Lower coal formation of Nova Scotia. All three species occupy an intermediate position between the species with more composite medullary rays separated by Brongniart to form the genus *Palæoxylon*, and the ordinary species with medullary rays having only one row of cells like *D. materiarium*, of the Upper coal formation.

KALYMMA GRANDIS, Unger.

By D. P. PENHALLOW.

Specimens of a fossil plant from the Genessee or Black Shale (Devonian) of Moreland, Kentucky, collected by Mr.

[1] Report on Erian Plants of Canada, 1871. Page 14. Plate I. *Figures* 7 and 8.

Charles E. Beecher of the Yale University Museum, and placed in my hands by Sir Wm. Dawson, to whom the specimens were sent in the first instance by Prof. J. M. Clarke of Albany, and by Mr. Beecher, embrace a portion of a stem and several mounted sections. To these there were subsequently added other transverse and longitudinal sections. The derivation of the specimen from the formation referred to is vouched for by Mr. Charles E. Beecher, who collected it. (Plate I, fig. 4.)

The principal specimen, apparently a fragment of a stem, has an elliptical transverse section measuring 2.3x3.8 cm. No cortical structure is represented, although it is evident that certain parts corresponding to a cortex were at one time present. The surface shows numerous closely aggregated bundles traversing the stem longitudinally. With a hand lens of very moderate power each of these bundles presents a distinctly fibrous structure. In the transverse section these bundles are found to be so arranged as to constitute a narrow marginal zone. They are separated by parenchyma tissue, which forms radial bands usually much less in width than the bundles lying on either side.

Internal to this is a somewhat broad zone of parenchyma tissue, followed by an inner vascular zone. In this latter the bundles are somewhat widely separated by parenchyma tissue. They are all small, usually measuring 1.5 mm. in diameter. In transverse section they are round, elliptical, triangular or even crescent shaped, this latter being, in one specimen, somewhat uncommon and apparently resulting from the partial fusion of two bundles. It is also to be observed that all the bundles do not lie strictly within a zone of uniform width, as occasionally a bundle will be found isolated and situated more towards the centre of the stem. This is apparently a normal situation, as no evidence of displacement appears. Central of this inner vascular zone is a large pith composed of large and thick walled cells, in all respects the same as the more external parenchyma tissue.

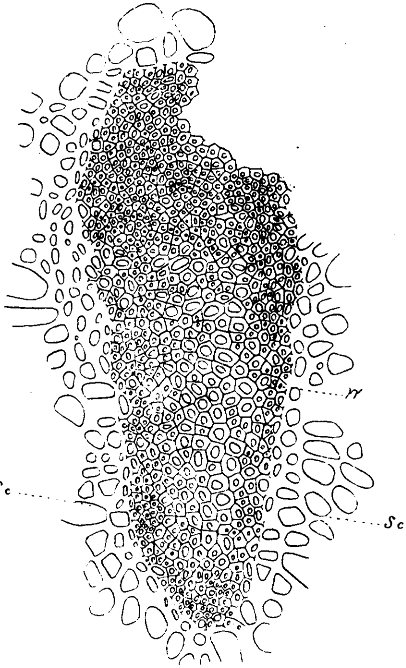
The entire parenchyma structure of the stem is remarkably well preserved. A very marked peculiarity of the specimen is to be found in the extreme lightness and the porous nature of the greater part of the structure. This latter feature is so conspicuous as to render the coarse cellular tissue readily distinguishable without the aid of a glass. As determined by Sir Wm. Dawson, the infiltrated material is wholly calcite, and it is probable that the deposition was limited, being developed first in the cell walls and later extending to some of the cell cavities which in small tracts are completely filled up.

The various sections examined show the entire structure to be in a fine state of preservation. From them we gather the following facts:—

The parenchyma tissue is very coarse and thick walled. It abounds in intercellular spaces which are, for the most part, small. The primary cell is usually well defined, but no structural markings have been observed. (Plate I, fig.3.)

The bundles of the marginal zone are radially elongated, usually two or three times larger than broad and narrower at the inner extremity. Occasionally they are double as shown in fig. 1, from which it will also be seen that the cell walls are very thick, and there is an apparent absence of vessels. The outer face of this figure also shows a portion of the bundle removed. This is a common feature, although in some cases the same space is occupied by cells which appear isolated—separated by somewhat wide structureless areas, a result evidently due to the decay of the primary cell membranes and a wide separation of the liberated parts. We may, therefore, refer the disappearance of the cortical structure and the outer portions of the marginal bundles to the action of decay, rather than to the operation of mechanical action on the stem. Viewed longitudinally these bundles also show a complete absence of vessels, while the cells are found to be very long with tapering extremities, similar in many respects to the cells of bast tissue. No markings have been detected.

The bundles of the inner vascular zone exhibit considerable variety of form, and most of them show interior tracts



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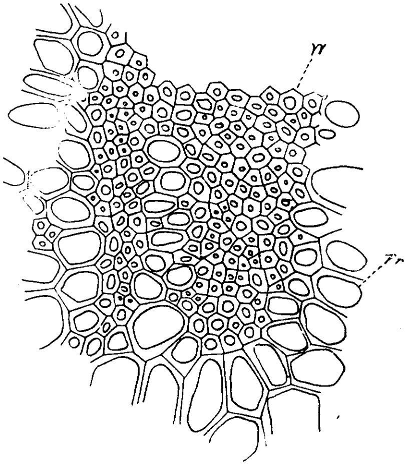

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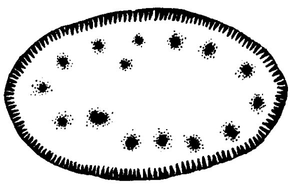

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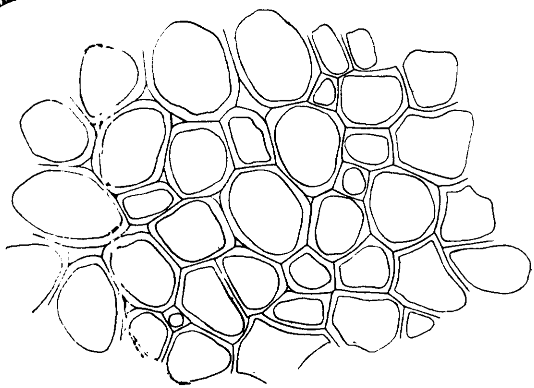

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KALYMMA GRANDIS, UNG.

devoid of structure, as if a more delicate tissue like cambium had been removed. Other and complete bundles, on the other hand, show no such open tracts, nor do they, as appears in figure 2, show more than one kind of tissue, so that we are left somewhat in doubt as to their precise composition. The cross section shows an apparent absence of vessels, and with one exception the same may be said of the longitudinal sections. In one case a single cell shows five transverse bars, possibly the remains of a spiral, annular or scalariform structure. In other respects the cell is the same as the other members of the bundle. Each bundle is surrounded by a layer of sclerenchymatous tissue composed of rather thick walled cells of very unusual dimensions and form.

The specimen is apparently identical with Unger's *Kalymma grandis*,[1] which he considers to be related to the Equisetaceæ—a view correctly based upon the general structure, though the presence of an outer zone of vascular structure must be regarded as exceptional, and, so far as I am aware, it has no parallel in existing types. Uncertainty as to the exact structural characteristics of the vascular bundles renders a more decided opinion as to the affinities of this plant undesirable at the present time.

Additional interest is given to this specimen from the fact that it is the first of the kind from the formation and locality from which it was obtained, and that as already stated by Sir W. Dawson, it aids in connecting the middle Devonian flora of America with that of Europe.

EXPLANATION OF PLATE I.

Kalymma grandis. Ung.

FIG. 1.—Transverse section of a double vascular bundle from the outer portion of the stem. W.—woodcells; Pr.—parenchyma. The large cells forming a line nearly across the figure, show the parenchyma separating the two bundles. x 40.

[1] Richer and Unger, Devonian of Thuringia, p. 71.

Fig. 2.—Transverse section of vascular bundle from the inner vascular zone. W.—woodcells; Sc.—sclerenchyma cells surrounding the wood tissue. x 40.

Fig. 3.—Transverse section of the parenchyma tissue showing thick walls, intercellular spaces and primary cell-walls. x 40.

Fig. 4.—Transverse section of stem. Natural size.

The Composition of the Ore Used and of the Pig Iron Produced at the Radnor Forges.

By J. T. Donald.

The St. Maurice and the Radnor Forges, situated in the vicinity of Three Rivers, are of interest to those interested in the development of the iron industry in Canada, as well as to the student of the history of the early colonists of the Province of Quebec

These forges are at present the property of the Canada Iron Furnace Company, Ld., and the managing director of this company, Mr. Geo. E. Drummond, has kindly furnished the following historical note: "The value of the Three Rivers ores has been known since a very early period in the history of Canada. Official examinations were made by order of the Government of France as far back as 1668; tests of the ore were made before the year 1700, and finally in 1737 a company was formed to erect a furnace and commence the manufacture of pig iron. The Government of France seems later on to have obtained control of the work, for in 1752 the St. Maurice furnace (erected and operated by the Government) was blown in and the old stone stack bearing date 1752 and the Government insignia, the Fleur de Lis, still remains to dispute with that of Principio in Maryland, the right to be considered the oldest in America. At that early period upwards of 300 men were employed under directors who had obtained their skill in Sweden. According to the reports of Colonial Secretary Tranquet, the works were carried on with much success. In addition to pig iron, wrought iron of high quality was manufactured from the product of the bog ore; shot and shell were cast, and pigs and bars were even exported to France. After the conquest the works were leased to private parties, and since then have passed through many hands."

"Many samples of the articles—notably stoves—manufactured from the pig iron made in those early days, still remain to attest the high quality of the iron."

The furnace at Radnor, though similar in construction to that at St. Maurice, from which it is only four miles distant, was erected at a much later date, and in some respects it may be considered the successor of the old St. Maurice furnace. At present the latter is idle, but that at Radnor is in blast. Recently, the ore used and the pig iron produced in this furnace have been analysed. The ore is a mixture of equal parts of the bog ore of the neighborhood and of the curious "*lake ore*" from *Lac la Tortue.* An average sample of each was submitted to analysis, and the results are given below :—No. 1 is the bog ore, No. 2 the lake ore, No. 3 is a lake ore from the same locality, analysed by Mr. W. A. Carlyle, B. A. Sc., some three years ago.[1]

COMPOSITION OF IRON ORE.

	I.	II.	III.
Ferric oxide	60.74	70.04	69.64
Ferrous oxide	....	....	0.72
Manganic oxide	1.18	1.78	2.99
Alumina	2.59	2.20	2.43
Lime	3.47	0.32	....
Magnesia	0.93	0.27	0.60
Phosphoric anhydride	0.69	0.76	0.47
Sulphuric anhydride	0.19	0.23	0.09
Silica	13.94	7.84	8.17
Loss on ignition	16.49	16.84	15.00
	100.22	100.28	100.11
Metallic iron	42.52	49.03	49.31
Phosphorus	0.302	0.331	0.205
Sulphur	0.078	0.093	0.036

[1] Canadian Record of Science, Vol. III., No. I, p. 43.

The close correspondence between Mr. Carlyle's analysis and that of the writer would seem to indicate that this Lac la Tortue ore is of fairly uniform composition over a considerable area.

The Radnor furnace charge consists of 840 lbs. of the mixed ore, 84 lbs. of limestone and 32 bushels of charcoal; the blast used has a pressure of three-fourths of a pound, and ranges in temperature from 300° F. to 450° F. The yield of iron is on an average 42–43 per cent. of the weight of ore used.

The iron sent for analysis consisted of sections of two pigs of different degrees of hardness and produced at different times. Nos. I. and II. are the Radnor irons, No. III. is Dr. T. Sterry Hunt's analysis of a specimen of gray pig made at St. Maurice in 1868.[1]

COMPOSITION OF PIG IRON.

	I.	II.	III.
Iron	94.375	96.302	Undet'd.
Carbon	.378	.336	1.100
Graphite	1.904	1.796	2.820
Silicon	1.379	.485	.860
Sulphur	.062	.049	.025
Phosphorus	.464	.430	.450
Manganese	1.145	.895	1.240
	90.707	100.293	

CANADIAN ARGOL.

BY J. T. DONALD.

Argol, as is well known, is the commercial name for the crude cream of tartar, which, owing to the diminished solubility of the tartrates, in alcohol is deposited on the vessels in which grape juice is fermented. The principal producers of this material are, of course, the grape-growing

[1] Report Geol. Survey, 1873-74.

countries of Europe. The sample before us however, is the produce of Canada.

In the year 1886, while investigating a process for the separation of tartrate of lime from commercial cream of tartar, the writer desired to obtain argol direct from the fermentation vat. With this end in view he wrote to the Ontario Grape Growing and Wine Manufacturing Company of St. Catharines, Ont., asking if they could supply a quantity. They replied they had none, as they removed all incrustation and sediment from their vats each season and threw it away as refuse. Here the matter dropped at the time.

In June, 1890, the same company wrote informing the writer they had taken a hint from his letter of 1886, had allowed the argol to accumulate, and now had about one ton, represented by a sample sent with the letter. On examination this sample was found to be a good one, containing 79.75 per cent of bitartrate of potash. Later on it was found that whilst a large portion of the quantity mentioned was of this high grade the value of the whole had been lowered considerably by an ignorant workman mixing with it a quantity of muddy sediment which contained only a small portion of tartar.

A fair sample of the whole was submitted to an American refiner of cream of tartar, and he purchased the lot at a price which was satisfactory to the producers. This sample is of interest, not because of any peculiarity of composition, but because it represents, so far as can be learned, the first parcel of Canadian argol that has found its way into commerce.

Aids to the Study of Canadian Coleoptera.

By J. F. Hausen, Montreal.

(Plate II.)

A New Variety of *Elaphrus pallipes*, Horn (Fig. I.)

In looking over some unnamed material in the collection of the Natural History Society of Montreal, my attention was drawn to a small *Elaphrus* I had not seen before, and which I thought at first might possibly be new. On investigation, however, I find it has been described by Dr. Horn[1] and I cannot do better than extract here his excellent description of the typical form :—

"Form rather slender, surface dark bronze as in *ruscarius.* Head densely punctured, eyes large and prominent. Thorax narrower than the head, slightly longer than wide, base narrower than apex, sides moderately arcuate, posteriorly sinuate, hind angles rectangular; disc convex, with apical impression moderately deep, median impression moderate and with a short smooth line more deeply impressed at its middle, within the hind angles a broad impression; surface densely punctured, and with a vague impression on each side of middle; beneath sparsely, but not deeply, punctured. Elytra oboval truncate at base, widest behind the middle, sides slightly sinuate behind the humeri, disc densely and finely punctured with usual three discal and a marginal series of ocellate foveæ and with polished, more elevated spaces between the foveæ of each series, those of the sutural row larger and the outer two quite small. Body beneath bronzed, shining, sparsely punctured at the sides. Legs testaceous, with æneous surface lustre, tips of tibiæ and femora darker. Length, ·24 inch; 6 mm. *Male.*—Anterior tarsi, with three joints dilated.

This species takes its place with *riparius* and *ruscarius,* from which it differs in its generally longer form, narrower and less accurate thorax and its entirely pale legs. The sculpture of the underside of the thorax is somewhat more dense and less deeply impressed, and the interval less shining than in *ruscarius,* and more sparse than in *riparius,* and with intervals distinct, occurs in Oregon and British Columbia."

While of the two individuals before me one is quite of the normal color, the other differs from the typical form by being suffused with beautiful purplish bronze, and by having

[1] Trans. Am. Ent. Soc., vol. VII (1878), p. 51.

the front part of the femora of a dark greenish color. The form is also somewhat more elongate and less compact. If deserving of a distinct name it might appropriately be called *purpurans*.

Both specimens were collected by Mr. Selwyn, of the Geological Survey, in British Columbia.

PTEROSTICHUS (DYSIDIUS) STENOPUS, SP. NOV. (Fig. 2.)

Ater nitidus, angustius elongatus; prochorax latitudine longior, tenuiter marginatus, lateribus modice rotundatus, postice angustatus et punctulatus, dorso canaliculatus, impressionibus basalibus simplicibus et rugose punctatis, elytra vix latiora, striata, tripunctata, interstiis convexis evidenter punctulatis, apice sinuata, stria scutellari longa, marginali simplici, parapleuræ latitudine longiores, punctulatæ; subtus piceo-niger nitidus; trophi, antennæ (articulis tribus basalibus exceptis) pedibusque piceis; abdominis segmenta lateribus subimpressa, basi crebro subtiliter punctulata, tibiæ maris posteriores introrsus villosa, articulis tribus extus sullcatis. Long. ·46 poll. =11·7 mm.

Simillius P. luctuoso *forma, at notis aliis exceptis prothoracis foveis simplicitus facile distinguendus, ab affinibus forma augustivri sat distinctus.*

In shape not unlike *P. luctuosus*, Dej., but may be at once separated by its single thoracic impressions, which are punctured almost to the dorsal line. The abdominal segments are very shining, with a slight pitchy tint posteriorly, and the femora are darker than the tibiæ.

This species would seem to take its place more properly in the *Dysidius* group than in any other. I have but a single example, a male, collected at St. Rose, P.Q.

The group of which *P. mutus*, Say, may be taken as a sample, and which corresponds, in part, to the sub-genus *Dysidius* of Chaudoir may be defined by the following characters :—

The thorax is finely margined, but little narrower behind, scarcely sinuate on the sides, with the posterior angles generally obtuse, rarely slightly prominent, and the anterior transverse angular impression more or less obliterated; the basilar impressions are single, deep and more or less punctured. The grooves on the outer edge of the hind tarsi are usually well marked; metathoracic espisterna longer than broad, elongate, and the palpi cylindrical truncate, elytra with three dorsal impressions, sinuate at tip and with the scutellar stria long. The species may be separated as follows:—

Male, with inner side of hind tibiæ clothed with hair; three points of the tarsi grooved.
  Color purplish.
    Basal prothoracic impressions not punctured; hind angles rather obtuse. 1. *purpuratus.*
  Color black.
    Form stouter, basal impressions more or less punctured.
      Black, with piceous lustre, angles of prothorax small, subrectangular. 2. *mutus.*
      Black, without piceous tint, hind angles slightly more prominent, abdominal segments at base more freely punctured. 3. *pulvinatus*, n. sp.
    Form more slender.
      Prothorax longer and strongly punctured at base. 4. *stenopus*, n. sp.

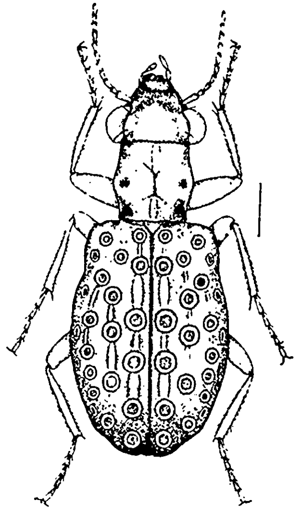
Male, with hind tibiæ not villose on the inner side; tarsal grooves less deep, not reaching to third joint; prothorax feebly sinuate on sides behind, hind angles rectangular, basal impressions feebly punctured. 5. *lustrans.*

For more detailed descriptions the student may be referred to the following papers and memoirs:—

1. *P. purpuratus*, Lec. Jour. Acad. Nat. Sc. Phila., 1853, vol. II, p. 242. Ohio, Ills. Pa. Length 14·3 mm.; ·55 in.

2. *P. mutus*, Say (*Feronia*) Trans. Am. Philos. Soc., v. II, p. 44. *Fer. morosa*, Dej. spec. III, p. 283 (*Omaseus*) *picicornis*, Kirby Faun. Bor. Am. IV, p. 33. Atlantic States and Can. 10–13 mm.; ·47–50 in.

3. *P. pulvinatus*, n. sp. In Naturaliste Canadien, v. XX (1891) No. 2.



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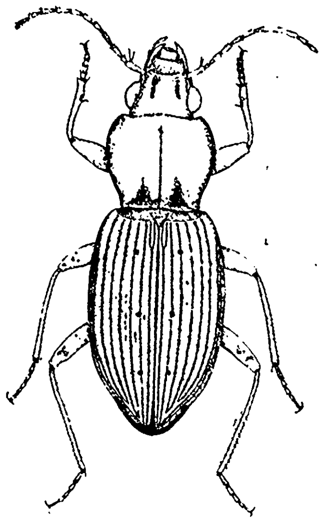

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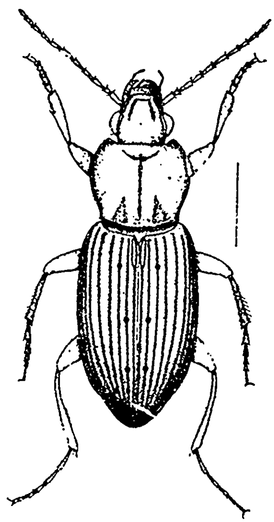

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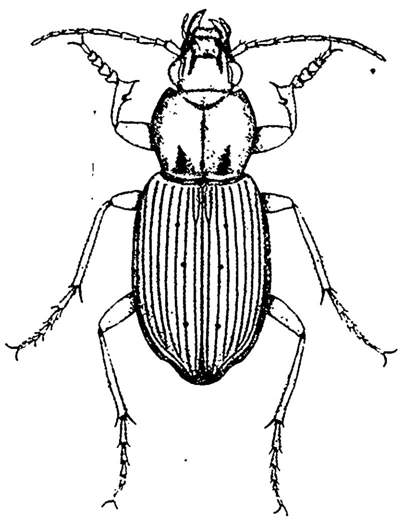

4

HAUSEN ON CANADIAN COLEOPTERA.

5. *P. lustrans*, Lec. Ann. Lyc., v. V, p. 181, Cal. ·12 mm. ·468 in.

EXPLANATION OF PLATE II.

Fig. 1. Elaphrus pallipes, Horn, var. purpurans, n. var. ?
" 2. Pterostichus stenopus, n. sp. ♂
" 3. " pulvinatus, n. sp. "
" 4. " mutus, Say "

ON SOME CAUSES WHICH MAY HAVE INFLUENCED THE SPREAD OF THE CAMBRIAN FAUNAS.

BY G. F. MATTHEW, M.A., F.R.S.C.

The attention given of late years to the succession and the regional variation of the Cambrian faunas, and the discovery of these faunas in different parts of the earth where they were previously unknown, has enabled us to form a judgment, imperfect though it may be, of the causes which have effected the development of these faunas.[1]

Prof. Jules Marcou has given much attention to this subject, and has stated his opinions in a series of articles published in the American Geologist.[2] In these articles he attributes the peculiarities of the Cambrian faunas in various regions of what is now Europe and North America to the peculiar distribution of the land and sea in those early times. He supposes a land connection between the north of Europe and North America as giving the means of transit, along shore lines, for the resembling faunas of Scandinavia and Acadia, and conceives of a land-barrier along the line of the Appalachian ranges as an obstacle to the migration of the Olenellus fauna eastward. A land-barrier such as Barrande has described in his great work on the Silurian system in Bohemia, is supposed by Marcou

[1]The remarks which I make in the following pages are rather suggestions than positive opinions, as to the causes which have produced changes in the Cambrian faunas, or have led to their annihilation.

[2] The lower and middle Taconic of Europe and North America.

to have separated the Welsh-Scandinavian fauna from the Cambrian faunas of the south of Europe.

Such land bridges and barriers, no doubt, had an important influence in assisting or retarding the diffusion of littoral species in former times, as they have at the present day, but in connection with their influence, it may be well to consider what effect ocean currents of different temperatures may have had on the dispersion of marine forms in the Cambrian age.

Marcou is one of the geologists who still upholds the comparatively recent origin of the Olenellus fauna, making it more recent than the Paradoxides fauna; but then he separates from Olenellus the Olenelloid forms found in Sweden and Russia, considering them to be of a more ancient type, and anterior to the Paradoxides genus.

On the other hand, we find Mr. C. D. Walcott, since his visit to Newfoundland, expressing the opinion that the Olenellus fauna is anterior to the Paradoxides fauna. This is on the assumption that all the Olenelloid forms are of nearly the same age, and anterior to the Paradoxidean forms. In this view he has the support of many European palæontologists, and especially of specialists in the Cambrian and Ordovician faunas.

Between these two extremes are several palæontologists, chiefly in America, who are not prepared yet to accept the view that the Olenelloid forms are always and everywhere older than the Paradoxidean. The actual infra-position has been shown, so far as America is concerned, only in Newfoundland.

In Acadia, though the remains of Olenellus and its allies have not been found, those of other species of animals occur, analogous to forms of the Holmia beds in the north of Europe, and so it may be inferred that genera of the Olenellus group will in time be found here. But the entire priority of all the Olenelloid trilobites to the Paradoxides in every part of the globe, may be considered an open question, or, to say the least, not fully established.

A review of the Cambrian faunas of Europe and North

America appears to the writer to show that the cotemporary existence of species of Olenelloid and of Paradoxidean trilobites in contiguous areas is possible, although this is not necessarily an inference from the peculiar distribution of these trilobites.

As a basis for the comparison of faunas, no better standard is available than the indisputable succession of zones in the Paradoxides beds of Scandinavia, where the following succession of Cambrian beds has been shown to exist:—

1. The Holmia (Olenellus Kjerulfi) beds.
2. The Paradoxides beds (proper).
   P. Œlandicus zone.
   P. Tessini zone.
   P. Davidis zone.
   P. Forchammeri zone.
   Agnostus lavigatus zone.
3. Olenus beds.
4. Peltura beds (including the Dictyonema slates.)
5. Ceratopyge (Dicellocephalus) beds.

The last division is considered by the Swedish palæontologists not to be Cambrian but to belong to the next system (Ordovician or Lower Silurian.)

In dealing with the subject from a more general point of view it is necessary to insert another zone of Paradoxides beds which is only imperfectly represented in Scandinavia in the "Exsulens Kalk" at the base of the Tessini zone; this is the group of strata with *P. rugulosus*, which species is well represented in all the Southern faunas, and in the Acadian regions comes between the Œlandicus and Tessini zones.

The complete series of Paradoxides beds proper, would thus stand as follows:—

a. P. Œlandicus (=lamellatus) zone.
b. P. rugulosus (=Eteminicus) zone.
c. P. Tessini (=Abenacus) zone.
d. P. Davidis zone.

e. P. Forchammeri zone.
f. P. Agnostus lævigatus zone.

For comparison I would first refer to the interesting fauna of Cambrian age, described by M. Jules Bergeron, and occurring at the Montaigne Noire, Dept. Herault, in the south of France.

Until of late years the fauna of Sabero in Spain, studied by De Verneuil and Barrande many years ago[1] has been the only one in the south of Europe giving an exact horizon in the Cambrian system. Now, however, that we have Cambrian faunas from other districts in that part of the continent, there is a broader basis on which to build our comparisons. In two of these districts we find varietal forms of species known elsewhere, and in one of them a peculiar combination of types, which it is difficult to parallel in other Cambrian areas, and especially in Scandinavia. To the fauna from the south of France one can easily find a parallel; but that of Sardinia, though in a country so near at hand, is perplexing, and difficult to place, owing to the novel forms which it contains.

M. Jules Bergeron has given a full account of the fauna observed by him in the shales of Montaigne Noire, and illustrated the forms with excellent plates representing the species which occur there. This fauna consists of about ten forms, (seven described species) nine trilobites and one cystidian. It is referred by M. Bergeron to the Menevian, but it is rather to be compared to that part of the Menevian which has been set off by Dr. Hicks as the Solva group. It agrees very closely with the sub-section 1 *c.* 2 of the St. John group, and has species equivalent to those of the "Exsulens Kalk" of Scandinavia.[2]

The talented author of the publication describing this fauna, found it to extend through twelve metres in thick-

[1] Faune primordeale dans la chaine cantabrique.

[2] Etude geologique du Massif ancien situé au sud du plateau central. J. Bergeron, Paris.

ness of slates, and to contain only one species of Paradoxides (*P. rugulosus*, Corda. var.) The species here attains an unusually great size, and, as M. Bergeron remarks, compares for size (being about a foot in length) with the great Paradoxides of other countries. Being so large and occupying the field for so long a period, we may believe that the conditions which surrounded it were highly favourable to its growth and development, and that the south of Europe may have been one of its principal centres of dispersion.[1]

The variety of *P. rugulosus*, found at Montaigne Noire, is remarkable for the prolonged points of the side lobes of the pygidium. In this respect it departs from the type of the species found in Bohemia, and from. *P. Eteminicus* found in Acadia.[2]

That this fauna is parallel to that of Division 1 *c.* 2 of the St. John group is clear from the following comparison of species:—

[1] Although the writer has stated in a previous publication that *P. rugulosus* in Scandinavia was preceded by *P. tessini*, an examination of the characters of one of the forms which Dr. Brogger has referred to this species (as a variety) seems to show that it is a distinct species. Dr. Brogger speaks of two varieties occurring at Krekling, Norway; a large form with smooth shield: and a smaller one with finely granulated shield; neither variety of surface is that of *P. rugulosus*, and the large form differs also from the type of this species in the shape of the glabella, as well as in the form of the hypostome (to which the doubleur is attached): and in these respects also from *P. Eteminicus*, the Acadian representative of this species. The small form approaches much closer to the type *P. rugulosus*, and may be of that species.

[2] It approaches in this respect, as well as in its long eyelobe, the genus *Centropleura* of Angelin, of which genus Angelin made *P. Loveni*, found at a higher horizon, the type, and in which he included *C. decr:curus* (Ang.) and *C. serratus* (S. & B.) of a still higher horizon; but *Centropleura Loveni* has four points to the pygidium, and belongs to the same group of Paradoxidean forms as the Welsh Anopoleni. The two other species of *Centropleura* named above are referred by the latter Swedish geologists to Dicellocephalus.

Paradoxides rugulosus, var.	c. f.	P. Eteminicus.
Conocoryphe coronata, var.	c. f.	Ctenocephalus Matthewi.
" Levyi	c. f.	Conocoryphe Baileyi.
" Heberti	c. f.	Conocoryphe Walcotti.
" Rouayrouxi	c. f.	Solenopleura Robbii.
Agnostus Sallesi	c. f.	Agnostus vir.
Trochocystites Barrandei	c. f.	Eocystites primævus.

Of *Conocoryphe Heberti* it is said that the dorsal suture is not visible, but it probably has a suture similar to the other Conocoryphes, and not to Ctenocephalus as the figures would lead one to suppose.

Conocoryphe Rouayrouxi is a Solenopleura by its dorsal suture, inflated fixed cheek and punctate surface; the eye-lobe is more posterior than in *S. Robbii*, but otherwise it resembles this species.

Agnostus Sallesi is a species of the section "Limbati" of Tullberg. In the Acadian region this section predominates very decidedly over the section "Longifrontes" at this horizon (Div. 1 *c*, 2) there being of this latter section in the St. John group, only the rare *A. partitus*. This seems also to be the case in Sweden, for although Dr. Brogger and others have referred *A. gibbus* to the "Exsulens Kalk" and *A. atavus*[1] (both Longifrontes) to the Holmia beds; they are apparently scarce in these lower beds. *A. Sallesi* differs from all the Scandinavian and Acadian "Limbati" in its pecular first lobe of the pygidium ; but it is Limbatus, and therefore of the section most common at this horizon.

In the preceding table I have compared a Trochocystites found by M. Bergeron with *Eocystites primaevus* of Acadia ; for although we have not yet found examples of the latter species sufficiently complete to determine its genus, the plates which have so far been recovered are of such a form as to make it probable that it will prove to be a Trochocystites.

The shales of Montaigne Noire containing this Paradoxides fauna, are succeeded by a group of sandstones and shales of no great thickness, at the top of which the Arenig

[1] In Lindström's catalogue of the fossil faunas of Sweden the infra position of this species is recorded as doubtful. (See page 2.)

fauna appears. Thus the only Cambrian fauna which this region shows is that of the Acadian sub-section, Div. 1 c. 2.

This also is the case in the north of Spain, whence Barrande and DeVerneuil described a primordeal fauna in 1860 of the following genera: Parodoxides, Conocephalites [including the genera Ptychoparia, Conocoryphe and Ctenouphalus] Arionellus [Agraulos], Orthisini [Protorthis, Hall], Orthis, Capulus [Parmophorella], Discina and Trochocystites; an assemblage referable to the Acadian Division 1c.

An older fauna than those of France and Spain described above, or, at least, one having types that are more archaic, is that described by Professor G. Meneghini, from the Cambrian beds of Sardinia.[1]

This writer has published a memoir on the Cambrian trilobites of Iglesiente in that island which shows that there are there some novel and peculiar types of trilobites.

The writer of the memoir on these trilobites recognizes two horizons or zones in the Cambrian rocks of this island, each containing its special types. The lower of these he compared to the Menevian group and the Lingula Flags of Britain, and the upper to the Tremadoc slates.

The fauna of the lower horizon is of great interest, partly as combining two faunal facies which are distinct elsewhere, and partly on account of two peculiar types of trilobites which existed there. The most notable of these types is that of the Oleni figured and described in this work. These are remarkable for their stout rachides and for their general olenelloid aspect. They differ from the Oleni of the north of Europe in the fact that their eyes are placed opposite the glabella instead of being nearly in front of that part, as is the case with all the northern forms; and the eyelobes also are unusually long. In one species (*O. Zoppii*) the eyelobes are decidedly drawn in at the posterior end, especially in the young individuals.[2] Now, if we follow the

[1] Palæontologia dell' Iglesiente in Sardegna, Fauna cambriana trilobiti, memoria del Prof. Guiseppe Meneghini, Firenze 1888.

[2] See Tav. I., fig. 10, and for a more mature individual Tav. III., fig. 13.

development of the trilobites of the genera Olenellus and Paradoxides (related genera) it will be observed that a long or continuous eyelobe, and one drawn in at the posterior angle of the dorsal suturè, is a character of the early forms, both as larval individuals and as these genera exhibit themselves in successive strata. So well does *O. Zoppii* represent an Olenellus or a Paradoxides that if the glabella were concealed the rest of the body would meet the requirements of a form combining these two genera.[1] Prof. Meneghini also compares his species to *O. micrurus*, one of the oldest species of Olenus of the north of Europe, and the one which there best preserves the Paradoidean type.

In *Olenus armatus*, the second species of this genus described by Meneghini, other primordeal features of the Paradoxides family appear, but chiefly as they show themselves in the genus Olenellus[2]—the glabella strongly lobed and nearly reaching the front of the head shield, and the prominent and large rachis, armed with spines, bring it into relation with Holmia; but the pygidium is more distinctly, than in *O. Zoppii*, that of an Olenus.

The remains of species of Paradoxides which have been recovered in Sardinia are too defective for comparison, but so far as can be judged they are those of the Lower Paradoxides beds, rather than those of the Upper. It is somewhat strange that no hypostomes of Paradoxides are figured or described by Meneghini.

A remarkable group of trilobites in this fauna is the Conocephalites with a tubercle in front of the glabella. Of these there are three species, or perhaps one might say four, if *C. Bornemanni* be included, in which the tubercle is confluent with the front of the glabella. Prof. Meneghini compares one of these species with *C. typus*, Dames, of the Cam-

[1] In *Holmia* (*Olenellus*) *Kjerulfi* the front of the glabella is small compared with the Paradoxides. See de Undre Paradoxideslagren, Linnarsson, Stockholm, Tafl. III., figs. 12 and 14; also Om Skuringsmærker, Kjerulf, Christiania, p. 83, figs. 1, 2, 3.

[2] Compare Tav. II., figs. 6 and 7, with figures referred to in the last foot note.

brian beds of China, but the resemblance is a distant one; the Chinese species is much nearer *C. tucer* of Billings, from the Olenellus beds in Vermont.

The four species of Concephalites found in Sardinia, appear rather to form a special group, distinguished from others by the possession of a frontal tubercle. A parallel case among the Conocoryphinæ is Ctenocephalus which is distinguished from Conocoryphe proper by a tubercle similar to that of these Conocephalites. No Conocoryphes are known in this fauna, though they are so common in the Cambrian rocks of the opposite coast region of France.

A still more remarkable deficiency in this fauna is the absence of the genus Agnostus.[1] We know of no paradoxides fauna and scarcely any Cambrian fauna of trilobites in which this genus does not make its appearance. The tests of this genus are usually found in the greatest abundance in fine dark shales, and especially in the Tessini, Davidis and Forchammeri sub-zones of the North of Europe. The Sardinian deposits are described as of a coarse texture. this would account for the scarcity, but not for the entire absence of the genus.

A fifth species of Conocephalites is described by Prof. Meneghini, (*C. inops*) which is of a different type from those with pre-glabellar tubercle. It is a *Euloma* rather than a Conocephalites, and it is rightly compared to *C. Geinitzi* of the fauna of Hof in Bavaria. But this fauna by its facies is as modern as the Tremadoc slate. Some imperfect examples of *Anomocare* also are figured, a genus which in the North of Europe, appears first in the Upper Paradoxides beds.

This fauna of the lower zone in Sardinia appears to be composed of forms descended from ancestral types of the Parodoxidean family, mingled with precursors of the numerous forms of Conocephalites[2] which showed them-

[1] In these remarks I have assumed that the memoir describes all the trilobites found; and also that the fossils of the lower zone are all of one faunal group, as I see no intimation to the contrary.

[2] The name Conocephalites is here used for such forms as *C. Bavaricus* and *C. Wirthi* of the fauna of Hof.

selves elsewhere mostly in the Upper Cambrian. The Oleni are of a more primitive type than those of the North of Europe, and notwithstanding the presence of so many Upper Cambrian forms the whole assemblage appears to be Lower Cambrian.

It is to be noticed that nowhere in the South of Europe have we recovered the representatives of the later Paradoxides of the north of Europe, or even of *P. Tessini*, except in Bohemia, the Bohemian representative species being *P. Bohemicus.* A similar gradation can be traced on the western side of the Atlantic where the equivalent of the Tessini fauna appears in Acadia, but is not known in Massachusetts; while in Newfoundland the later Davidis subfauna is present in addition to the earlier Paradoxides. Can this deficiency of the later species of Paradoxides in the more southerly district be due to conditions of temperature of the sea, and would a sufficiently high temperature exclude the genus entirely? If so the Paradoxides of the northern seas may have been cotemporary with the Olenelli, Conocephalites and Anomocara of the warmer oceans, and it would be necessary with this landmark gone to reconstruct for the southern areas, the succession of Cambrian faunas from the earliest Olenelloid types to Dicellocephalus and its cotemporaries.

The Utica slate of a later age contains a fauna in many respects analogous to that of the Paradoxides beds of the Atlantic coast of America, but spread over an area on that continent further to the west, and extending to more southern latitudes. It is spread from Labrador to Virginia and as far west as Michigan and Ohio. The *Triarthri* of the Utica slate represented the Paradoxides of the earlier time, and the black bituminous slates of the Utica, the similar alum bearing slates of the Cambrian. The Arctic current which now flows southward along the Atlantic coast has a course corresponding to that of the belt of country along which at the present day the outcrops of the Paradoxides beds and the Utica shale are found.

A diagrammatic view of the distribution and succession of the various phases of the Paradoxides fauna, as at present known, will bring more clearly before the reader the apparent thinning out of the types of this genus in going south from the higher latitudes.

Adopting the symbols for the different phases of this fauna used on a preceding page it may be presented as follows :—

	a	b	c	d	e	f
	P. Œlandicus.	P. rugulosus.	P. Tessini.	P. Davidis.	P. Forchammeri.	P. Lævigatus.
Sardinia (Italy).........	* ?	* ?				
Montagne Noire (France)..		*				
Bohemia................		*	*			
Wales..................	* ?	*	*	*		
Sweden and Norway......	*	*	*	*	*	*
Newfoundland...........		*	*	*		
Acadia (N. Brunswick)..	*	*	*			
Massachusetts		*				

The genera of the upper horizon or zone in the Cambrian rocks of Sardinia, the trilobites of which are described by Prof. Meneghini, are of no less interest than those of the lower, as they show a mingling of the genera of the Paradoxides Zone with those of the summit of the Cambrian system. Thus we find *Anomocare* which in Sweden is a characteristic genus of the Upper Paradoxides beds, in association in these beds with two Asaphus-like forms which Meneghini compares to *Platypeltis* and *Psilocepalus*, genera which in the North of Europe belong to the upper part of the Upper Cambrian.

If we give Anomocare the full range accorded to it by Angelin, Dames and Meneghini, it will include, beside the forms of the Upper Parodoxides, many species found in different countries in the lower part of the Upper Cambrian. It is in this way that Dr. Dames has treated the genus in describing the fauna of Liau-tung in China, and Prof. Meneghini has followed his example. Anomocare is a genus full of interest in connection with the question of the point at which the limit of the Cambrian system shall be drawn. It is a genus which foreshadows the swarm of Asaphoid trilobites which appeared in the Ordovician seas. This is apparent when (taking *A. nomocare limbatum* as the type) we observe in the head shield the narrow cylindrical glabella, the sinuous suture, and the sharp posterior angles of the cheeks; in the thorax the few compact segments; in the pygidium the prominent narrow many-jointed rachis and the flattened border.[1] Many trilobites of the Upper Cambrian beds have been referred to Anomocare, mostly from the head shields, so that it is at present difficult to draw the line between it and Ptychoparia when only these imperfect remains are to be had. Still the presence of these numerous species with flattened borders is a distinctive mark of the Upper Cambrian.

Neither of the two asaphoid forms of Sardinia, described by Meneghini, agree altogether with the definition of the genera (*Platypeltis* and *Psilocephalus*) to which they are provisionally referred. In the possession of extended genal points to the movable cheeks they differ from the types of the genera above named and approach more closely to Asaphus, proper.[2] *Asaphus* (*Platypeltis?*) *Meneghinii* also has a pygidium with several distinct lateral costa and with three marginal points, thus differing from the type. These

[1] It may be thought by some that the presence in Anomocare of a long eyelobe, is an objection to a comparison of this genus with Asaphus-like trilobites, all of which have short eyelobes; but there is as great variety between the species of Paradoxides in this respect as between the two genera named above. In Paradoxides the shortening of the eyelobe is progressive with age both as regards the individuals of a species, and as the species appeared successively in time, and the same may hold good for Anomocare and Asaphus.

[2] Meneghini refers these cheeks doubtfully to the heads of the species described, but the reference to *Platypeltis Meneghinii* is probably correct.

differences if they mean anything, are more primitive features than those of the types of Platypeltis and Psylocephalus.

Prof. Meneghini compares the species of these two Asaphus-like genera described by him, to species of the fauna of Hof in Bavaria, of the Lower Tremadoc (Dolgelly) beds in Wales and of the Upper Cambrian (Dictyonema) shales of Shropshire.

A type of Cambrian trilobites which one might expect to find in Sardinia in association with genera of Dolgelly and Tremadoc age, and which is represented in Wales and Sweden, as well as in the western part of America, is *Dicellocephalus*. This genus, which by the large size of some of its species, by its general form, and its mobile pleura, represented at the close of the Cambrian age the genus Paradoxides of its earlier time, is apparently unknown in the Sardinian rocks.

But Dicellocephalus had its precursor in a species of the Paradoxides beds (Tessini sub-zone) in *Conocephalites ornatus* described by Dr. Brogger from Krekling in Norway.

So many of the Tremadoc genera have their roots far down in the Cambrian zones, that it seems impossible to separate them from their relatives in the older beds. Whether we look to the north of Europe, to Sardinia or to the western United States of America, these links in the chain of life seem too strong to be severed, and the Tremadoc group should therefore be included in the Cambrian system.

If we desire a well defined line to separate the Cambrian system from its successor this is afforded by the beds in which the typical Arenig or Levis graptolites make their appearance.

One phase of the upper Cambrian fauna which we find notably absent from the more southerly regions where Cambrian rocks are found, is the *Peltura* fauna. In Sweden and Norway this presents quite a variety of small and smooth or spinose forms related to Olenus, as it does also in Wales, and to a lesser degree in Acadia, but from other regions it seems to be absent. Its geographical distribution is in fact to a great extent parallel with that of the middle and upper Paradoxides zone; and if these latter owe their presence to cold arctic waters, we may attribute to the same cause the distribution of the Peltura fauna along the coast of America in Cambrian times. The Cambrian fauna of the Liau-tung has not a sufficiently wide range to make it certain that Peltura sub-fauna may not overlay it. But if the succession of Cambrian trilobites, as established in Europe, is to be relied upon for other countries, this fauna is absent from Minnesota, and probably from the Rocky Mountain region of the United States. Neither in Bohemia, nor at any point in the south of Europe has this phase of the Upper Cambrian fauna been met with.

In the absence of the Peltura fauna the lines dividing the different parts of the Upper Cambrian are but obscurely defined, and for the southern countries we have not yet discerned the land marks by which this division may be effected. Only in the western United States is there known a full representation of the southern types of the Upper Cambrian faunas, and here we may hope that these dividing lines will soon be drawn. Prof. Jas. Hall many years ago, described the Cambrian trilobites of the Mississippi Valley. He divided them into three faunal groups of which the upper by its facies, appears to be equivalent to the Tremadoc fauna. Various considerations render it probable that the middle fauna, which Prof. Hall intimates might hereafter be subdivided, includes all the lower part of the Upper Cambrian, so that the Peltura fauna would be excluded. In the middle fauna of the Mississippi Valley a peculiar type of Agnostus which in Sweden is represented by *A. cyclopyge* of the Olenus beds, is here present in *A. Josepha*, and in China by *A. Chinensis.* These Agnosti are associated with species of other genera which are particularly prevalent at the horizons of the Olenus and Dolgelly beds, and thus carry the series of forms down to the Lower Cambrian division without the presence of Peltura.

As a result of the comparisons attempted in this paper it may be said that the hypothesis of the circulation of ocean currents between the poles and the equator will explain some of the peculiar features, which may be observed in the distribution and succession of the faunas of the Cambrian age. There are three Northern faunas of Cambrian and Ordovician times, which successively extended themselves to the southward—these are the *Paradoxides fauna*, the *Peltura fauna*, of which the Olenus fauna was an earlier phase, and the fauna of the *Utica Slate*. To these as intermediate between the two latter, might be added the Arenig fauna; but this I have not attempted to discuss.

The Australasian Association for the Advancement of Science.

The Australasian Association for the Advancement of Science held its annual meeting at Christchurch, New Zealand, on January 15, 1891. It will be remembered that this Association was organized only a few years since, taking the British Association as its model. Like this and the American Association, it has no permanent place of meeting, but moves from place to place each year. The last session was held at Canterbury College, Christchurch, New Zealand, with the retiring president Baron Ferd. von Mueller, the distinguished Australian naturalist, in the chair.

The holding of this session of the Association in New Zealand, originated in an invitation given by Sir James Hector in 1888, when in Melbourne representing New Zealand at the Exhibition. The request to hold the meeting in New Zealand was agreed to, and subsequently Christchurch was selected as the *locale* of the session. Immediately upon this being settled, Professor Hutton, the local Secretary, took steps to get together a local committee, and at once proceeded to work out the programme for the session. How successfully this was achieved may be gathered from the high expressions of approval which have proceeded from several of the professors, and the President, Baron von Mueller, and Christchurch is to be congratulated on having been selected as the city in which the meeting of *the Association was held.*

The various sections were organized under their respective vice-presidents, who addressed them on the subjects given below:

Section A.—Professor Lyle.

Section B.—Professor O. Masson.

Section C.—Mr. R. A. Murray, "The Past and Future of Mining in Victoria."

Section D.—Professor Haswell, "Recent Biological Theories."

Section E.—Mr. G. S. Griffiths, "Antarctic Exploration."

Section F.—Hon. G. W. Cotten, "A State Bank of Issue."

Section G.—Mr. A. W. Hewitt, "Ceremonies of Initiation in the Australian Tribes."

Section H.—Hon. Dr. Campbell, "The Advancement of Sanitation among the People."

Section I.—Mr. R. H. Roe, "Literature in Education."

Section J.—Mr. John Sulman, "The Architecture of Towns."

A presidential reception in the afternoon of the second day, by Sir James and Lady Hector, was very largely attended. In the evening the president-elect, Sir James Hector, was installed. The retiring president, Baron von Mueller, in addressing the meeting said that:

"We owe to the British Association that great advance of science, and especially of applied knowledge, which has been made throughout the world.

* * * * * * * * * * *

In introducing the president to you, let me say that he is one who took part in the expedition to the Rocky Mountains. Some thirty years ago he was selected for the position he now holds under the Government, which he has so worthily filled to this time, and during this period he has exercised a great, an enormous influence upon the development of his adopted country. Sir James Hector stands high in the scientific world by the universality of his knowledge. It is remarkable in how many directions he has been useful, and of the application of his knowledge there are many testimonies existing. If any testimony were wanting, it is to be found in the series of volumes of the Institute of New Zealand. They show in a remarkable manner the power of his administrative abilities and the great amount of his own research, which resulted in this long series of volumes, for although in all the colonies there has been an honorable and noble competition in science, New Zealand carries the palm by ths long series of publications through the Institute. I beg with pleasure to induct Sir James Hector into the presidential chair, and I trust, Sir, that your term will be, as I feel sure it will be, a glorious success."

Upon the President-elect taking the chair, His Excellency the Governor of New Zealand addressed the Association at some length, congratulating the members upon the occasion of their meeting, and passing in review the important work which lay before them in Australasia.

Among the guests of the meeting was Dr. G. L. Goodale, of Harvard University, who was on a tour of the world in search of botanical specimens and information. The President called upon him as representing the American Association for the Advancement of Science, of which he is the President. As his remarks are of some interest as showing the common bonds between the three kindred Associations, we reproduce them in full. He said :—"My first duty this this evening is to thank you very heartily Sir James, and you, my dear Baron, for the very warm welcome you have extended to me. Be assured that these cordial expressions are most sincerely appreciated. My second duty is to bring to you greetings from the American Association for the Advancement of Science. When, a few years ago, we learned that one of youi most energetic professors had taken in hand the formation of an Australasian Association, somewhat on the lines of the British Association and our own, we took the deepest interest in the plans, for we hoped that you would realize what we have secured. In these days of extreme specialism there is need of a broad general association, so that specialists might confer together; that they can widen the outlook and that those who are cultivating small portions of the field can see that the ground near to the fence is not neglected. Now, under a general association like this, specialists can meet and confer together, and they can preserve that which they certainly hope to preserve. Then again we have found, and I have no doubt you will find, that general meetings of associations like this diminish, if they do not fully prevent or remove, personal misunderstandings. Sometimes these misunderstandings are allowed to grow until at last they become intensified. In associations like the British Association and our own we find the tendency to anything like personal differences to diminish and disappear, and I hope you will find the same. We have found that the British Association and our own have always done good, by their visits, to the community where the meetings were held. A good many have criticised unfavorably this migratory tendency, holding that it is better to have the meetings in some central place. But it seems that in this the old fable comes back, that 'strength seems to be restored every time we touch new ground.' This migratory tendency is the survival of the migratory tendency inherited from our ancestors. I feel very sure if you were to put it to the vote in the British Association you would not receive a single positive vote in favor of subtituting for these missions, as we may call them, one resident place. Now, when we heard that an Australasian Association was to be formed in this manner, our hopes and best wishes went out to you, and when the opportunity came to present felicitations on your success it was most eagerly accepted; so that I have now great pleasure in presenting, on behalf of the Association I represent, our congratulations upon the pronounced success of the Association. The American Association is not limited to the United States.

As his Excellency the Governor has told you, the British Association met on Canadian soil. Some of our meetings are also held in the large centres of the Dominion of Canada, and the meeting of the British Association was really a joint meeting of the two Associations. We sometimes read disturbing cablegrams, but I love to think that blood is thicker than water. Now, my honored colleagues, through me, extend to you an invitation to visit our Association. Do not regard it as one of those general invitations which means just drop in as you pass by; but if you find you can be present at any of our meetings just inform our General Secretary, and when you did meet, then the general invitation, you would find, would be converted into a most specific one. I again thank you for your cordial welcome, and congratulating the Association upon its past and present success, I have only now to express on behalf of our Association, and on my own behalf, our best wishes for Australasia and the Australasian Association."

The address of the President, Sir James Hector, presented a valuable review of the advance of Scientific knowledge and research in New Zealand. It possesses so much of general interest that we venture to reproduce the greater part of it.

PRESIDENTIAL ADDRESS.

"* * * * Presidents of similar Associations in the Old World, who are in constant contact with actual progress in scientific thought, feel that a mere recital of the achievements during their previous term is sufficient to command interest; but in the colonies most of us are cut off from personal converse with the leading minds by whom the scientific afflatus is communicated; and in our suspense for tardy arrival of the official publications of the societies, we have to feed our minds with science from periodical literature. But even in this respect my own current education is very defective, as I reside in the capital city of New Zealand, which has no college with professional staff, whose duty, pleasure and interest it is to maintain themselves on a level with the different branches of knowledge they represent. I therefore decided that instead of endeavouring to review what had been done in the way of scientific progress, even in Australasia, it would be better to confine my remarks to New Zealand—the more so that this is the first occasion that there has been a gathering of what must, to some extent, be considered to be an outside audience for the colony.

To endeavour to describe, even briefly, the progress made in the science of a new country is, however, almost like writing its minute history. Every step in its reclamation from a wild state of nature has depended on the application of scientific knowledge, and the reason for the rapid advance made in these colonies is chiefly to be attributed to their having had the advantage of all modern resources ready at hand. As in most other matters in New Zealand there is a sharp line dividing the progress into two distinct periods, the first before and the second after the formation of the colony in 1840. With reference to the former period it is not requisite that much should be said on this occasion. From the time of Captain Cook's voyages, owing to his attractive narrative, New Zealand acquired intense interest for naturalists. His descriptions of the country and its productions, seeing that he only gathered them from a few places where he landed on the coast, are singularly accurate. But I think rather too much is sometimes endeavored to be proved from the negative evidence of his not having observed certain objects. As an instance, it has been asserted that if any of the many forms of the moa still survived, Captain Cook must have been informed of the fact. Yet we find that he lay for weeks in Queen Charlotte Sound and in Dusky Sound, where all night long the cry of the kiwi must have been heard just as now, and that he also obtained and took home mats and other articles of native manufacture, trimmed with kiwis' skins; and that most likely the mouse-colored quadruped which was seen at Dusky Sound by his men when clearing the bush was only a gray kiwi; and yet the discovery of this interesting bird was not made till forty years after Cook's visit. As a scientific geographer Captain Cook stands unrivalled, considering the appliances at his disposal. His longitudes of New Zealand are wonderfully accurate, especially those computed from what he called his "rated watches," the first type of the modern marine chronometer, which he was almost the first navigator to use. The result of a recent measurement of the meridian difference from Greenwich by magnetic signals is only two geographical miles east of Captain Cook's longitude. He also observed the variation and dip of the magnetic needle, and from his record it would appear that during the hundred years which elapsed up to the time of the Challenger's visit, the south-seeking end of the needle has changed its position $2\frac{1}{2}$ deg. westward, and inclines $1\frac{1}{2}$ deg. more towards the south magnetic pole. Captain Cook also recorded an interesting fact, which, so far as I am aware, has not been since repeated or verified in New Zealand. He found that the pendulum of his astronomical clock, the length of which had been adjusted to swing true seconds at Greenwich, lost at the rate of 40 sec. daily at Ship Cove in Queen Charlotte Sound. This is, I believe, an indication of *a greater loss of the attraction of gravity than would occur* in a corresponding North latitude.

The additions to our scientific knowledge of New Zealand, acquired through the visits of the other exploring ships of early navigators, the settlement of sealers and whalers on the coast, and of pakeha Maoris in the interior were all useful, but of too slight a character to require special mention. The greatest additions to science were made by the missionaries, who in the work of spreading Christianity among the natives, had the services of able and zealous men, who mastered the native dialects, reduced them to written language, collected and placed on record the traditional knowledge of the interesting Maori, and had among their numbers some industrious naturalists who never lost an opportunity of collecting natural objects. The history of how the country, under the mixed influence for good and for evil which prevailed almost without Government control until 1840, gradually was ripened for the colonist, is familiar to all. The new era may be said to have begun with Dieffenbach, a naturalist, who was employed by the New Zealand Company. He travelled and obtained much information, but did not collect to any great extent, and, in fact, appears not to have anticipated that much remained to be discovered. For his conclusion is that the smallness of the number of the species of animals and plants then known—about one-tenth of our present lists—was not due to want of acquaintance with the country, but to paucity of life forms. The chief scientific value of his published work is in the appendix, giving the first systematic list of the fauna and flora of the country, the former being compiled by the late Dr. Gray, of the British Museum.

The next great scientific work done for New Zealand was the Admiralty survey of the coast line, which is a perfect marvel of accurate topography, and one of the greatest boons the colony has received from the Mother Country. The enormous labor and expense which was incurred on this survey at an early date in the history of the colony is a substantial evidence of the confidence in its future development and commercial requirements which animated the Home Government. On the visit of the Austrian exploring ship Novara to Auckland in 1859, Von Hochstetter was left behind, at the request of the Government, to make a prolonged excursion to the North Island and in Nelson; and he it was who laid the foundation of our knowledge of the stratigraphical geology of New Zealand. Since then the work of scientific research has been chiefly the result of State surveys, aided materially by the zeal of members of the New Zealand Institute, and of late years by an increasing band of young students, who are fast coming to the front under the careful science training that is afforded by our University Colleges.

In the epoch of their development the Australasian colonies have been *singularly fortunate*. The period that applies to New Zealand is contemporaneous with the reign of Her

Majesty, which has been signalized by enormous strides in Science. It has been a period of gathering into working form immense stores of previously-acquired observation and experiment and of an escape of the scientific mind from the trammels of superstition and hazy speculation regarding what may be termed common things. Laborious work had been done and many grand generalizations had been formerly arrived at in physical science; but still, in the work of bringing things to the test of actual experience, investigators were still bound by imperfect and feeble hypotheses and supposed natural barriers among the sciences. But science is one and indivisible, and its sub-divisions, such as physics, chemistry, biology, are only matters of convenience for study. The methods are the same in all, and their common object is the discovery of the great laws of order under which this universe has been evoked by the great Supreme Power.

The great fundamental advance during the last fifty years has been the achievement of far reaching generalizations, which have provided the scientific worker with powerful weapons of research. Thus the modern "atomic theory," with its new and clearer conceptions of the intimate nature of the elements and their compounds that constitute the earth and all that it supports, has given rise to a new chemistry, in which the synthetical or building-up method of proof is already working marvels in its application to manufactures. It is, moreover, creating a growing belief that all matter is one, and reviving the old idea that the inorganic elementary units are merely centres of motion specialized in a homogeneous medium, and that these units have been continued on through time, but with such individual variations as give rise to derivative groups, just as we find has been the case in the field of organic creations. The idea embodied in this speculation likens the molecule to the vortex rings which Helmholtz found must continue to exist for ever, if in a perfect fluid free from all friction they are once generated, as a result of impacting motion. There is something very attractive in the simplicity of this theory of the constitution of matter which has been advocated by Sir William Thomson. He illustrates it by likening the form of atoms to smoke rings in the atmosphere, which were they only formed under circumstances such as above described, such vortex atoms must continue to move without changing form, distinguished only from the surrounding medium by their motion. As long as the original conditions of the liquid exist they must continue to revolve. Nothing can separate, divide or destroy them, and no new units can be formed in the liquid without a fresh application of creative impact. The doctrine of the conservation of energy is a second powerful instrument of research that has developed within our own times. How it has cleared away all the old cobwebs that formerly encrusted our ideas about the simplest agencies that are at work around us. How it has so simplified the teaching of the laws that order the conversion of internal motions of bodies into phases which represent light, heat, electricity, is abundantly proved by the facility with which the mechanicians are every day snatching the protean forms of energy for the service of man with increasing economy.

These great strides which have been made in physical science have not as yet incited much original work in this colony. But now that physical laboratories are established in some degree at the various college centres, we will be expected, ere long, to contribute our mite to the vast store. In practical works of physical research we miss in New Zealand the stimulus the sister colonies receive from their first-class observatories, supplied with all the most modern instruments of research, wielded by such distinguished astronomers as Ellery, Russell and Todd, whose discoveries secure renown for their separate colonies. I am quite prepared to admit that the reduplication of observatories in about the same latitude, merely for the study of the heavenly bodies, would be rather a matter of scientific luxury. The few degrees of additional elevation of the South Polar region which would be gained by an observatory situated even in the extreme South of New Zealand could hardly be expected to disclose phenomona that would escape the vigilance of the Melbourne observatory. But star gazing is only one branch of the routine work of an observatory. It is true that we have a moderate but efficient observatory establishment in New Zealand sufficient for distributing correct mean time, and that our meridian distance from Greenwich has been satisfactorily determined by telegraph, also thanks to the energy and skill of the Survey Department, despite most formidable natural obstructions, the major triangulation and meridian circuits have established the basis of our land survey maps on a satisfactory footing, so that sub-divisions of the land for settlement and the adoption and blending of the excellent work done by the Provincial Governments of the colony is being rapidly overtaken.

Further, I have already recalled how much the colony is indebted to the Mother Country for the completeness and detail of the coastal and harbor charts. But there is much work that should be controlled by a physical observatory that is really urgently required. I may give a few illustrations. The tidal movements round the coast are still imperfectly ascertained, and the cause of their irregular variations can never be understood until we have a synchronous system of tide meters, and a more widely extended series of deep-sea soundings. Excepting the Challenger soundings on the line of the Sydney cable, and a few casts taken by the United States ship Enterprise, the depth of the ocean surrounding New Zealand has not been ascertained with that accuracy which many interesting problems in physical geography and geology demand. It is supposed to be the culmination of a great submarine plateau; but how far that plateau extends, connecting the southern islands towards the great Antarctic land, and how far to the eastward, is still an unsolved question. Then, again, the direction and intensity of the magnetic currents in and around New Zealand require further close investigation, which can only be controlled from an observatory.

Even in the matter of secular changes in the variation of the compass we find that the marine charts instruct that an allowance of increased easterly variation of 2min. per annum must be made, and as this has now accumulated since 1850 it involves a very sensible correction to be adopted by a shipmaster in making the land or standing along the coast; but we find from the recently published work of the Challenger that this tendency to change has for some time back ceased to affect the New Zealand area, and as the deduction appears only to have been founded on a single triplet observation of the dip taken at Wellington *and one azimuth observation taken off Cape Palliser, it* would be well to have this fact verified. With regard to the local variation in the magnetic currents on land and close in shore, the requirement for exact survey is even more imperative. Captain Creak, in his splendid essay, quotes the observations made by the late Surveyor-General, Mr. J. T. Thomson, at the Bluff Hill, which indicate that a compass on the north side was deflected more than 9deg to the west, while on the east side of the hill the deflection is 46deg. to the east of the average deviation in Foveaux Strait. He adds that if a similar island-like hill happened to occur on the coast, but submerged beneath the sea to a sufficient depth for navigation, serious accidents might take place, and he instances a case near Cossack, on the north coast of Australia, when H.M.S. Medea, sailing on a straight course in eight fathoms of water, experienced a compass deflection of 30deg. for the distance of a mile. A glance at the variation entered on the meridian circuit maps of New Zealand shows that on land we have extraordinary differences between different trig. stations at short distances apart. For instance, in our close vicinity, at Mount Pleasant, behind Godley Head lighthouse, at the entrance to Lyttelton harbor, the variation is only 9deg. 3min. east, or 6deg. less than the normal; while at Rolleston it is 15deg. 33min., and at Lake Coleridge 14deg. 2min. In Otago we have still greater differences recorded, for we find on Flagstaff Hill, which is an igneous formation, 14deg. 34min., while at Nenthorn, thirty miles to the North, in a schist formation, we find an entry of 35deg. 41min. In view of the fact that attention has been recently directed to the marked effects on the direction and intensity of the terrestrial magnetic currents of great lines of fault along which movements have taken place, such as those which bring widely different geological formations into discordant contact, with the probable production of mineral veins, this subject of special magnetic surveys is deserving of being undertaken in New Zealand. In Japan and in the United States of America the results have already proved highly suggestive. A comparison between this country and Japan by such observations, especially if combined with systematic and synchronous records by modern seismographic instruments, would be of great service to the physical geologist. There are many features in common, and many quite reversed in the orographic and other physical features of these two countries. Both are formed by the crests of great earth waves lying north-east and south-west, and parallel to, but distant from, continental areas, and both are traversed by great longitudinal faults and fissures, and each by one great transverse fault. Dr. Nauman, in a recent paper, alludes to this in Japan as the *Fossa Magna,* and it corresponds in position in relation to Japan with Cook Strait in relation to New Zealand. But the *Fossa Magna* of Japan has been filled up with volcanic products, and is the seat of the loftiest active volcano in Japan. In Cook Strait and its vicinity, as you are aware, there are no volcanic rocks, but there and southward, through the Kaikouras, evidence of fault movements on a larger scale is apparent, and it would be most interesting to ascertain if the remarkable deviation from the normal in direction and force of the magnetic currents, which are experienced in Japan, are also found in New Zealand. For it is evident that if they are in any way related to the strain of cross fractures in the earth's crust, the observation would tend to eliminate the local influence of the volcanic rocks which are present in one case and absent in the other. With reference to earthquakes also, few, if any, but very local shocks experienced in New Zealand have originated from any volcanic focus we are acquainted with, while a westerly propagation of the ordinary vibrations rarely passes the great fault that marks the line of active disturbance. In Japan, also, out of about 480 shocks which are felt each year in that country, each of which, on an average, shakes about one thousand square miles, there are many that cannot be ascribed to volcanic origin. There are many other problems of practical importance that can only be studied from the base line of a properly equipped observatory. These will readily occur to physical students, who are better acquainted with the subject than I am. I can only express the hope that the improved circumstances of the colony will permit some steps to be taken. Already in this city, I understand, some funds have been subscribed. As an educational institution, to give practical application to our students in physical science, geodesy and navigation, it would clearly have a specific value that would greatly benefit the colony. Another great branch of physical science, chemistry, should be of intense interest to colonists in a new country. Much useful work has been done, though not by many workers. The chief application of this science has been naturally to promote the development of mineral wealth, to assist agriculture, and for the regulation of mercantile contracts. I cannot refrain from mentioning the name of William Skey, analyist to the Geological Survey, as the chemist whose researches during the last twenty-eight years have far surpassed any other in New Zealand. Outside his laborious official duties he has found time to make about sixty original contributions to chemical science, such as into the electrical properties of metallic sulphides—the discovery of the ferro-nickel alloy *awaruite* in the ultra-basi rocks of West Otago, which is highly interesting, as it is the first recognition of this meteoric-like iron as native to our planet—the discovery that the hydrocarbon in torbasic and the gas shales is chemically and not merely mechanically combined with the clay base—of a remarkable color test for the presence of magnesia and the isolation of the poisonous principle in mary of our native shrubs. His recent discovery, that the fatty oils treated with analine form alkaloids, also hin ts at an important new departure in organic chemistry. His suggestion of the hot-air blow pipe, and of the application of cyanide of potassium to the saving of gold, and many other practical applications of his chemical knowledge, are distinguished services to science, of which New Zealand should be proud. In connection with the subject of chemistry, there is a point of vast importance to the futur e of the pastoral and agricultural interests of New Zealand, to which attention was directed some years ago by Mr. Pond, of Auckland. That is the rapid deterioration which the soil must be undergoing by the steady export of the constituents on which plant and animal life must depend for nourishment. He calculated that in 1883 the intrinsic value of the fixed nitrogen and phosphoric acid and potash sent out annually was £592,000, taking into account the wool and wheat alone.

Now that we have to add to that the exported carcases of beef and mutton, bones and all, the annual loss must be immensely greater. The proper cure would, of course, be to bring back return cargoes of artificial manure, but even then its application to most of our pastoral lands would be out of the question. I sincerely hope that the problem will be taken in hand by the Agricultural College at Lincoln as a matter deserving of practical study and investigation. I have already referred to several great generalisations which have exercised a powerful influence in advancing science during the period I marked out for review, but so far as influencing the general current of thought, and almost entirely revolutionising the prevalent notions of scientific workers in every department of knowledge, the most potent factor of the period has been termed the doctrine of evolution. The simple conception of the relation of all created things by the bond of continuous inheritance has given life to the dead bones of an accumulated mass of observed facts, each valuable in itself, but, as a whole, breaking down by its own weight. Before this master-key was provided by the lucid instruction of Darwin and Wallace, it was beyond the power of the human mind to grasp and use as biological research the great wealth of minute anatomical and physiological details. The previous idea of the independent creation of each species of animal and plant to a little Garden of Eden of its own must appear puerile and absurd to the young naturalists of the present day; but in my own College days to have expressed any doubt on the subject, would have involved a sure and certain pluck from the examiner. I remember well that I first obtained a copy of Darwin's "Origin of Species" in San Francisco when on my way home from a three years' sojourn among the red Indians in the Rocky Mountains. Having heard nothing of the controversies, I received the teaching with enthusiasm, and felt very much surprised on returning to my *alma mater* to find that I was treated as a heretic and a backslider. Nowadays it is difficult to realise what all the fuss and fierce controversy was about, and the rising school of naturalists have much cause for congratulation that they can start fair on a well assured logical basis of thought, and steer clear of the many complicated and purely ideal systems which were formerly in vogue for explaining the intentions of the Creator and for torturing the unfortunate students. The doctrine of evolution was the simple-minded acceptance of the invariability of cause and effect in the organic world as in the inorganic; and to understand his subject in any branch of natural science, the learner has now only to apply himself to trace in minutest detail the successive steps in the development of the phenomena he desires to study. With energetic leaders educated in such views, and who, after their arrival in the colony, felt less controversial restraint, it is not wonderful that natural history, and especially biology, should have attracted so many ardent workers, and that the results should have been so good. A rough test may be applied by comparing the number of species of animals and plants which had been described before the foundation of the colony and those up to the present time. In 1840, Dr. Gray's list in Deiffenbach's work gives the number of described species of animals as 5498. The number of mammalia has been doubled through the more accurate study of our seals, whales and dolphins. Then the list of birds has been increased from eighty-four to one hundred and ninety-five, chiefly through the exertions of Sir Walter Buller, whose great standard work on our avifauna has gained credit and renown for the whole colony. The number of fishes and moluzca has been more than trebled, almost wholly by the indefatigable work of our Secretary, Professor Hutton. But the greatest increase is in the group which Dr. Gray placed as annulosa, which, chiefly through the discovery of new forms of insect life, has risen from 156 in 1840 to 4,295, of which over 2,000 are new beetles described by Captain Broun, of Auckland.

When we turn to botany we find that Deiffenbach, who appears to have carefully collected all the references to date in 1840, states the flora to comprise 632 plants of all kinds, and, as I have already mentioned, did not expect that many more would be found. But by the time of the publication of Hooker's "Flora of New Zealand" (1863), a work which has been of inestimable value to our colonists, we find the number of indigenous plants described had been increased to 2,451. Armed with the invaluable guidance afforded by Hooker's "Handbook," our colonial botanists have renewed the search, and have since then discovered 1,460 new species, so that our plant census at the present date gives a total of 3,355 species. It would be impossible to make mention of all who have contributed to this result as collectors, and hardly even to indicate more than a few of those to whom science is indebted for the description of the plants. The literature of our post Hookerian botany is scattered about in scientific periodical literature, and as Hooker's "Handbook" is now quite out of print, it is obvious that, as the new discoveries constitute more than one third of the total flora, it is most important that our young botanists should be fully equipped with all that has been ascertained by those who have preceded them. I am glad to be able to announce that such a work in the form of new edition of the "Handbook of the Flora of New Zealand," approved by Sir Joseph Hooker, is now in an advanced state of preparation by Professor Thomas Kirk, who has already distinguished himself as the author of "Forest Flora." Mr. Kirk's long experience as a systematic botanist, and his personal knowledge of the flora of every part of the colony, acquired during the exercise of his duties at Conservator of Forests, point to him as the fitting man to undertake the task. But quite apart from the work of increasing the local collections which bear on biological studies, New Zealand stands out prominently in all discussions on the subject of geographical biology. It stands as a lone zoological area, minute in area, but on equal terms as far as regards the antiquity and peculiar features of its fauna, with nearly all the larger continents in the aggregate. In consequence of this, many philosophical essays —such, for instance, as Hooker's introductory essay to the early folio edition of the "Flora," the essays by Hutton, Travers and others, and also the New Zealand references in Wallace's works, have all contributed essentially to the vital question of the causes which have brought about the distribution and geographical affinities of plants and animals, and have thus been of use in hastening the adoption of the doctrine of evolution. But much still remains to be done. Both as regards its fauna and its flora, New Zealand has always been treated too much as a whole quantity, and in consequence percentage schedules prepared for comparing with the fauna and flora of other areas fail from this cause. It is absolutely necessary to discriminate not only localities, but also to study more carefully the relative abundance of individuals as well as of species before instituting comparisons. The facility and rapidity with which change is effected at the present time should put us against rashly accepting species which may have been accidental intruders, though wafted by natural causes, as belonging to the original endemic fauna. Further close and extended study, especially of our marine fauna, is urgently required. We have little knowledge beyond the littoral zone, except when a great storm heaves up a gathering of nondescript or rare treasure from the deep. Of dredging we have had but little done, and only in shallow waters, with the exception of a few casts of the deep sea trawl from the Challenger. When funds permit a zoological station for the study of the habits of our sea fishes and for the propagation of such introductions as the lobster and crab would be advantageous. I observe that lately such an establishment has been placed on the Island of Mull, Scotland, at a cost of £400, and that it is expected to be nearly self-supporting. With respect to food fishes, and still more with respect to some terrestrial forms of life, we, in common with all the Australasian Colonies, require a more scientific and a less casual system of acclimatization than we have had in the past. One must talk with bated breath of the injuries that have been inflicted on these colonies by the rash disturbance of the balance of nature. Had our enthusiasm been properly controlled by foresight, our settlers would probably not have to grieve over the losses they now suffer through many insect pests, through small birds and rabbits, and which they will in the future suffer through the vermin that are now being spread in all directions.

BOOK NOTICES.

ELEMENTS OF CRYSTALLOGRAPHY.[1]—This admirable little book will, it is believed, fill a want which has long been felt by teachers and students of mineralogy and chemistry, and for the first time affords to the English-speaking student a clear and readable statement of the elementary principles of crystallography. Hitherto, chemists have too frequently ignored the subject, and failed to recognize its very important bearing upon their work. For this no doubt the crystallographer has been largely to blame; for as a rule he has presented the subject in such a way as to terrify rather than attract the student. Prof. Williams' book is not of this kind, and while he only claims for it a place among elementery works, we are sure that any one who studies it with care will have learned a great deal of crystallography.

Questions relating to the mode of molecular arrangement in

[1] The elements of Crystallography for students of Chemistry, Physics and Mineralogy. By G. H. Williams, Ph. D., Associate Professor in the Johns Hopkins University. Pp. viii + 250, with 383 Figs. New York: Henry Holt & Co., 1890.

crystals and the general principles of crystallography are first taken up, and then follows a detailed discussion of the crystallographic systems based mainly upon the symmetry of crystal forms. A chapter is devoted to crystal aggregates, another to imperfections of crystals, and an appendix to the discussion of zones, projection, and the construction of crystal figures. Ths symbols of Weiss are taken as a starting point, those of Naumann, however, being generally employed, and the index symbols of Miller written beside them. A somewhat fuller explanation and illustration of Miller's index system than that found on pages 30 and 31, would probably add to the usefulness of the volume.

The book is well printed and well illustrated, and evidently the proofs have been read with great care.

B. J. H.

Proceedings of the Society.

The first regular meeting of the Society was held on Monday, Oct. 27th, the President Dr. Harrington in the chair.

The Curator presented a report from Mr. H. T. Martin on the mammals, and from Mr. F. B. Caulfield on the ornithological collections in the Society's Museum. He also referred to the rearrangement of the other specimens.

On motion of Hon. Senator Murphy, seconded by Mr. J. A. U. Beaudry, the thanks of the Society were tendered to Mr. Brown, Mr. Martin and Mr. Caulfield for their efforts in the rearrangement of the collections.

The Curator reported the following donations, received since the last monthly meeting:—

Fossils from the Trenton Formation, Mr. E. T. Chambers.
Bobolink, Mr. Tedford.
One pair American Pipits.
Olive-back Thrush.
Varied Woodpecker.
Cedar Waxwing, Mr. G. Dunlop.
Semipalmated Plover.
Buff breasted Sandpiper.
Rose breasted Grosbeak (young).
Cedar Waxwing.
Varied Woodpecker, Mr. F. B. Caulfield.

Cape May Warbler, Mr. E. D. Wintle.

Lake Trout, Mr. J. S. Brown,

Concretions from the Connecticut River, Miss C. Alice Baker.

Apatite from Renfrew, Ont.

" " Templeton, P. Q.

Titanite " Renfrew, Ont.

Phlogopite " Templeton, P.Q.

Dawsonite " " " Dr. Harrington.

Copper ore and boulder from the conglomerate vein of the Calumet and Hecla Mines, Lake Superior, Michigan.

Nickel ore and nickel matte from the Blizzard Mines, Sudbury, Ont.

Specular ore from the Republic Mine, Michigan,

Magnetic specular ore from the Champion Mine, Michigan, Mr. Geo. Sumner.

The usual vote of thanks was tendered the donors for the above.

Notice of motion was given by Mr. Shearer to open the Museum to the public, free, on one day of each week.

On motion of Mr. Brown, seconded by Hon. Senator Murphy, it was decided to leave the question of lending the Elephantine remains to Mr. Whiteaves of the Geological Survey, in the hands of Sir Wm. Dawson.

On motion of Mr. Shearer, seconded by Mr. Chambers, it was decided to invite the British Iron & Steel Institute to visit the museum during their visit to the city.

On suspension of the rules, the following members were elected.

Miss Laing, Dr. Arch. Campbell, Mrs. Lewis, Harry McLaren and F. W. Radford.

Sir Wm. Dawson then presented a paper from Miss Arms of Deerfield, Massachusetts, on "The Clay Concretions of the Connecticut River," to which he added many valuable observations. In the subsequent discussion it was shown that similar concretions occur abundantly in some Canadian localities, notably at Green's Creek, Ottawa, where each nodule is found to contain a fossil, either of fish, plant or other organic remains, while those from the Connecticut River often show no distinguishable nucleus, or if present, it consists of a shell or small pebble.

Prof. Penhallow then followed with some notes on "A Peculiar Growth in a Black Walnut."

After the usual vote of thanks to the authors of papers the meeting adjourned.

The regular monthly meeting of the Society was held on Monday. Nov. 24th. the President, Dr. Harrington presiding.

The Librarian reported the usual exchanges. The following donations of the museum were also reported.

Antlers of Virginian Deer, Mr. Alfred Griffin.

Virginian Horned Owl, Mr. F. B. Caulfield.

The usual vote of thanks was tendered the donors.

On motion of Mr. Shearer, seconded by Mr. Brown, it was decided to open the museum to the public, free, one day in each week.

Prof. Penhallow then presented a very interesting description of a caterpillar fungus (*Sphaeria Robertsii*) from New Zealand. He showed its relation to other fungus pests in various parts of the world, and also pointed out the fact that insects of various kinds are infested by related species. The discussion was an animated and important one, and developed many interesting laws relative to the parasitic action of plants and their relation to disease. He presented one of the specimens to the museum.

Prof. Penhallow also gave the results of observation on soil temperatures carried on by a committee of the Society, under a grant from the Elizabeth Thompson Science Fund. His remarks were illustrated by instruments and drawings. He pointed out the various changes of temperature effected in the soil by atmospheric temperature and solar radiation, and showed that the present line of enquiry has an important bearing upon the growth of vegetation.

The usual vote of thanks was tendered for these papers, and also to Prof. Penhallow and his associates for their work on soil temperatures.

It was decided not to hold the usual monthly meeting in December.

The regular monthly meeting was held on Monday, Jan. 26th, Dr. Harrington presiding.

In the absence of the Secretary, Mr. J. A. U. Beaudry was requested to act.

The Curator reported the following donations :—

Three cases exotic insects, Mr. J. H. Tiffin.

Geological specimens, Miss Laing.

Surf Duck, shot on Lake St. Louis, Mr. Wm. Byrd.

Woven wire tray from Tokyo, Mr. Alfred Griffin.

A vote of thanks was tendered to donors.

The Librarian reported the usual exchanges. Prof. J. T. Donald then presented a paper on "Canadian Argol" and also one on "The Composition of the Ore used, and of the Pig Iron Produced at the Radnor Forges." In the subsequent discussion the President referred to the good quality of the Three Rivers iron and mentioned a stove cast from it which has been in use for the last twenty years.

Sir William Dawson in his remarks stated that in Sweden, the iron contained a quantity of organic matter, and asked if there was any in the Three Rivers iron.

Dr. Harrington exhibited a specimen "bear" blasted from the smelting furnace in Londonderry, N. S., showing a deposit of titanium nitrocyanide.

The meeting adjourned after the usual vote of thanks to the authors of papers.

Proceedings of the Montreal Microscopical Society.

This Society has been holding its regular monthly meetings during the winter, in the library of the Natural History Society.

The first meeting in October was devoted entirely to receiving the statements of the Secretary-Treasurer and the election of officers for the coming year.

The President J. Stevenson Brown was re-elected and Leslie J. Skelton was elected Hon. Secretary-Treasurer.

Papers on the following subjects have been read.

Nov. 10th, Illumination as Applied to the Microscope. J. Stevenson Brown.

Dec. 8th, Facts Connected with Keeping an Aquarium, Very Rev. Dean Carmichael.

Jan. 12th, Practical Hints about Microtomes, Wyatt G. Johnson M.D.

There has been a large attendance at the meetings, a considerable influx of new members and a very general interest shown in extending the usefulness and objects of the society.

Papers have been promised for the remainder of the season by

J. W. Stirling, M.D.

G. P. Girdwood, M.D.

Wyatt G. Johnson, M.D.

At the last meeting His Excellency Lord Stanley, was elected an honorary member.

A committee has been appointed on infusoria, and members or others interested in this branch of microscopical study can have their specimens classified by sending drawings and descriptions to the secretary before any of the monthly meetings.

ABSTRACT FOR THE MONTH OF OCTOBER, 1890.

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 vapour.	‡ 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	59.52	69.9	48.3	21.6	30.2375	30.284	30.202	.082	.4100	81.0	53.5	S.W.	4.8	4.3	10	0	76	....	....	....	1
2	61 72	71.7	51.6	20.1	30.1858	30.247	30.123	.124	.4185	77.3	54.0	S.W.	7.2	5.0	10	0	85	..	....	...	2
3	59.63	63.6	56.7	6 9	29 9985	30.120	29.888	.232	.4535	88.5	56.2	S.E.	9.0	7.7	10	1	69	0.07	.. .	0 07	3
4	58.92	64 2	55.2	9.0	29.7553	29.874	29.654	.220	.4632	92.8	56.8	S.W.	11.1	10.0	10	4	00	0.08	....	0.08	4
SUNDAY....... 5	......	59.2	41.6	17.6	....	......	......	....	.. .	....	....	N.W.	13.4	...	..	..	70	....	....	....	5 ....SUNDAY
6	41 45	47.4	36 0	11.4	29.8845	29.906	29.845	.061	.1860	71.2	32.3	N.	7.6	4.0	10	0	51	....	....	...	6
7	40.37	46.3	33.6	12.7	29.8693	29.910	29.822	.088	.2168	85.2	36.2	E.	12.4	8.3	10	0	00	0.13	.. .	0.13	7
8	43.75	46.0	42.1	3.9	30.0450	30.226	29.848	.378	.2680	94.0	42.3	W.	5.5	10.0	10	10	00	0.29	....	0.29	8
9	45 00	50.9	41.0	9.9	30.2882	30.337	30.237	.100	.2617	83.0	41.5	S.W.	2.4	7.2	10	0	06	....	...	...	9
10	46 90	53.6	40.5	13.1	30.0008	30.218	29.873	.345	.2948	91.3	44.3	S.	7.2	9.2	10	5	00	0.23	....	0.23	10
11	46.98	53.8	42.0	11.8	29.9025	29.936	29.868	.068	.2528	78.2	40.2	W.	15.6	6.7	10	0	16	Inapp.	....	0.00	11
SUNDAY. 12	......	49.9	36.5	13.4	....	......	......	....	......	....	.. .	N.W.	7.2	....	..	..	77	....	.. .	....	12 ....SUNDAY
13	44 17	52.0	36 2	15.8	30.0248	30.114	29.912	.202	.2265	78.5	37.5	N.E.	7.5	1.2	10	0	91	....	....	....	13
14	44.78	49.2	36.7	12.5	29.6847	29.820	29.593	.227	.2805	93.3	42.8	S.E.	10.7	8.3	10	0	00	0.80	..	0.80	14
15	48 63	54.2	41.3	12.9	29.8198	29.943	29.680	.263	.2555	75 5	40.5	S.W.	15.2	3.0	10	0	89	....	....	....	15
16	54.18	60.5	48.3	12.2	29.9080	30.038	29.783	.225	.2825	67.7	43.5	S.W.	9 1	8.3	10	0	76	...	....	....	16
17	49 37	54.0	44.1	9 9	29.6152	29.725	29.527	.198	.3297	93.3	47.5	S.E.	7.5	10.0	10	10	00	0.79	....	0.79	17
18	44.73	47.8	41.9	5.9	29.8703	29.891	29.837	.054	.2892	97.3	43.8	N	1.5	10.0	10	10	00	0.02	....	0.02	18
SUNDAY........19	......	50.0	43.6	6.4	....	......	......	....	......	....	....	N.E.	14.8	....	..	..	00	0.03	....	0.03	19 ....SUNDAY
20	45.03	49 9	38 0	11.9	29.8473	29.982	29.732	.250	.2413	80.7	39.0	N.E.	19.4	8.3	10	0	01	....	....	....	20
21	40.03	46.7	34.0	12.7	30.1623	30.261	30.050	.211	.1835	75.2	32.3	N.E.	3.5	1.5	9	0	88	......	....	....	21
22	40 83	49.0	32.2	16 8	30.3357	30.396	30 303	.093	.1867	74.5	32.5	E.	2.2	2.1	10	0	80	....	....	....	22
23	42.68	52.8	33.1	19.7	30.2303	30.343	30.123	.220	.1935	72 2	33 7	S.E.	5.3	7.0	10	0	58	....	....	....	23
24	42.83	46.4	39.7	6.7	29.9983	30.083	29 918	.165	.1948	70.8	33.8	N.E.	7.3	10.0	10	10	00	....	....	....	24
25	43.17	48.0	37.6	10.4	29.8287	29.916	29.730	.186	1753	63.7	31.3	N.E.	14 6	10.0	10	10	02	....	....	....	25
SUNDAY........26	....	49.8	37.6	12.2	....	......	......	......	... .	....	....	N.E.	12 7	....	..	..	37	....	....	....	26 .... .SUNDAY
27	40.03	44.3	37.6	6.7	29.5718	29.679	29.451	.228	.1745	70.5	31 0	N.	16.6	10.0	10	10	00	Inapp.	....	0.00	27
28	38.80	43.9	36.0	7.9	29.3873	29.414	29.347	.067	.1585	67.2	28.7	W.	16 9	10.0	10	10	07	Inapp.	....	0.00	28
29	38.15	46.0	30.7	15.3	29.4275	29.467	29 378	.089	.1952	84 3	33.7	E.	6.3	8.3	10	0	25	0.08	....	0.08	29
30	38.65	42.5	35.6	6.9	29.5642	29.759	29.381	.378	.1940	83.0	33 7	N.W.	10 2	8.3	10	0	00	0.07	....	0.07	30
31	37.68	43.7	33.7	10.0	29.8657	29.889	29.814	.075	.1868	82.8	32.7	S.W.	9 2	6.7	10	0	43	0.10	....	0.10	31
....Means.	45.85	51.84	40.10	11.75	29.9003	......	......	.179	.2583	80.7	39.8	....	18 85	7.25	..	..	33.8	2.69	....	2.69	Sums ....
16 yrs. means for & including this mo.	45.06	52.00	38.36	13.65	30.0023	.. ..	......	.210	.2411	76.3	....	... .	....	6.50	..	..	¶40.4	3.38	1.57	3.54	16 yrs. 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...........	888	1817	166	745	333	1200	1376	525	....
Duration in hrs..	89	160	31	92	47	122	111	55	37
Mean velocity...	10.0	11.4	5.4	8.1	7.1	9.8	12.4	9.5	

Greatest mileage in one hour was 30 on the 20th.
Resultant mileage, 1038.
Resultant direction, N. 36°.5 W.

Total mileage, 7,050
Average mileage, 9.5.

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

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Nine years only.

The greatest heat was 71.7 on the 2nd; the greatest cold was 30.7 on the 29th, giving a range of temperature of 41.0 degrees. Warmest day was the 2nd. Coldest day was the 31st. Highest barometer reading was 30.396 on the 22nd; lowest barometer was 29.347 on the 28th, giving a range of 1.049 inches. Maximum relative humidity was 100 on the 14th. Minimum relative humidity was 47 on the 23rd.

Rain fell on 15 days.

A few flakes of snow fell on the 28th, and soft hail on the 31st.

Auroras were observed on 4 nights.

Hoar frost on 6 days.

Lunar halos on 3 nights.

Fog on 4 days.

ABSTRACT FOR THE MONTH OF NOVEMBER, 1890.

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 vapour.	‡ 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	37.48	42.0	33.8	8.2	29.8580	29.903	29.805	.098	.1722	76.8	30.8	S.W.	11.4	10.0	10	10	30	0.05	....	0.05	1
SUNDAY...... 2	......	47.7	36.0	11.7	....	......	......	....	....	....	....	S.	9.5	..	..	..	01	0.42	....	0.42	2 ....SUNDAY
3	32.40	40.8	29.0	11.8	29.6947	29.779	29.528	.251	.1487	80.5	27.2	W.	16.3	10.0	10	10	06	....	Inapp.	0.00	3
4	30.32	35.0	25.7	9.3	29.8527	29.980	29.784	.196	.1240	73.5	23.2	S.W.	9.0	5.3	10	0	27	...	...	....	4
5	39.72	48.9	29.1	19.8	29.9528	30.016	29.864	.152	.1678	68.7	30.0	S.W.	21.0	2.0	10	0	88	....	..	....	5
6	36.82	43.4	30.7	12.7	30.2000	30.292	30.023	.269	.1585	71.3	28.2	N.E.	23.2	8.5	10	1	00	....	....	....	6
7	45.90	55.0	29.7	25.3	29.9850	30.201	29.793	.408	.2457	77.2	38.7	S.	18.3	8.0	10	3	41	0.05	....	0.05	7
8	38.60	55.0	24.5	30.5	30.1272	30.443	29.752	.691	.1687	65.2	27.7	W.	23.5	4.0	10	0	61	0.31	....	0.31	8
SUNDAY 9	......	48.7	22.9	25.8	....	......	......	....	.....	....	....	E.	20.1	....	..	..	00	0.99	0.1?	1.00	9 ....SUNDAY
10	30.52	47.0	25.4	21.6	30.2733	30.423	29.929	.494	.1255	71.7	22.5	N.	11.1	2.3	10	0	94	.....	....	....	10
11	26.27	30.7	21.9	8.8	30.3887	30.401	30.371	.030	.1147	81.2	21.3	N.E.	4.2	3.5	10	0	50	....	...	....	11
12	31.07	35.7	21.8	13.9	30.2745	30.399	30.141	.258	.1345	77.7	24.8	S.W.	9.2	8.3	10	0	02	....	...	....	12
13	39.63	44.8	34.2	10.6	29.9652	30.122	29.810	.312	.1808	74.0	32.0	S.W.	14.2	9.8	10	9	06	Inapp.	....	0.00	13
14	40.98	47.7	32.5	15.2	30.0788	30.292	29.851	.441	.1588	61.7	28.7	S.W.	19.2	3.5	10	0	98	Inapp.	....	0.00	14
15	30.82	33.9	28.5	5.4	30.2327	30.346	30.119	.227	.1410	82.2	25.8	N.E.	10.0	8.3	10	0	00	....	1.0	0.16	15
SUNDAY........16	......	35.7	28.7	7.0	....	......	......	....	.....	....	...	S.W.	14.7	....	..	..	50	....	..	...	16 ....SUNDAY
17	34.60	37.5	30.7	6.8	29.8195	30.137	29.439	.698	.1853	92.0	32.5	S.	10.0	8.3	10	0	00	0.37	....	0.37	17
18	34.58	37.3	31.8	5.5	29.6885	29.776	29.528	.248	.1797	90.0	31.7	S.W.	14.1	10.0	10	10	03	0.05	5.0	0.55	18
19	37.20	43.7	30.5	13.2	29.5362	29.647	29.515	.132	.1878	84.2	32.7	S.W.	22.0	8.7	10	6	20	0.05	Inapp.	0.05	19
20	27.52	31.6	23.5	8.1	29.8450	30.034	29.686	.348	.1122	75.0	20.8	W.	22.5	6.7	10	0	32	....	....	....	20
21	27.23	33.5	18.8	14.7	29.9665	30.131	29.746	.385	.1182	79.0	21.7	S.W.	13.4	3.8	10	0	83	...	....	....	21
22	30.80	35.4	26.0	9.4	29.7928	29.832	29.708	.124	.1232	71.2	22.7	W.	16.4	7.0	10	0	40	Inapp.	....	0.00	22
SUNDAY......23	......	27.1	16.8	10.3	....	......	......	....	.....	....	....	W.	17.2	....	..	..	91	....	0.5	0.05	23 ....SUNDAY
24	21.98	32.0	13.9	18.1	29.9522	30.116	29.672	.444	.0927	76.2	15.8	S.W.	12.5	9.3	10	6	00	...	Inapp.	0.00	24
25	36.08	40.0	30.7	9.3	29.6487	29.836	29.580	.256	.1798	84.0	31.7	S.W.	19.2	10.0	10	10	00	0.07	Inapp.	0.07	25
26	21.90	31.3	16.8	14.5	30.1320	30.210	30.003	.207	.0865	73.0	15.0	W.	16.6	4.2	10	0	96	....	....	....	26
27	15.42	18.8	10.3	8.5	30.1703	30.225	30.132	.093	.0643	74.3	8.7	N.	8.5	2.2	5	0	90	....	...	....	27
28	16.48	21.0	9.0	12.0	30.0762	30.158	29.923	.235	.0703	75.2	10.2	W.	9.7	4.8	10	0	87	....	0.3	0.02	28
29	28.50	33.6	20.0	13.6	29.7957	29.843	29.758	.085	.1332	85.2	24.5	W.	12.4	10.0	10	10	00	....	1.9	0.12	29
SUNDAY........30	....	37.0	13.8	23.2	....	.....	......	......	.....	....	....	S.W.	18.6	....	....	....	00	0.10	....	0.10	30.......... SUNDAY
....Means.	31.71	38.39	24.90	13.49	29.9734	......	......	.283	.1430	76.8	25.2	....	14.92	6.74	..	..	36.5	2.46	8.8	3.32	Sums ....
16 yrs. means for & including this mo.	32.05	38.10	25.97	12.12	30.0093	... ..	......	.262	.1543	79.7	....	....	....	7.36	..	..	¶29.8	2.41	13.3	3.76	16 yrs. means for and including this month.

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
Miles............	301	964	267	240	1887	3289	3271	533	
Duration in hrs..	36	61	21	25	127	213	186	44	7
Mean velocity...	8.4	15.8	12.7	9.6	14.9	15.4	17.6	12.1	

Greatest mileage in one hour was 39 on the 8th.
Greatest velocity in gusts, 44 miles per hour on the 7th.

Resultant mileage, 5,720.
Resultant direction, S. 58° W.
Total mileage, 10,752.

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

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Nine years only.

The greatest heat was 55.0 on the 7th; the greatest cold was 9.0 on the 28th, giving a range of temperature of 46.0 degrees. Warmest day was the 7th. Coldest day was the 27th. Highest barometer reading was 30.443 on the 8th; lowest barometer was 29.516 on the 15th and 30th, giving a range of 0.927 inches. Maximum relative humidity was 100 on the 9th. Minimum relative humidity was 44 on the 14th.

Rain fell on 13 days.
Snow fell on 10 days.
Rain or snow fell on 19 days.
Rain and snow fell on 4 days.
Aurora was observed on 1 night.
Hoar frost on 2 days.
Lunar halo on 1 night.
Fog on 2 days.

ABSTRACT FOR THE MONTH OF DECEMBER, 1890.

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

DAY.	THERMOMETER.				*BAROMETER.				† Mean pressure of vapour.	‡ Mean relative humidity.	Dew point.	WIND.		SKY CLOUDED IN TENTHS.			Per cent. 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	0.00	14.3	—8.6	22.9	29.8803	29.962	29.805	.157	.0307	68.7	—8.0	W.	15.1	1.8	10	0	94	....	....	....	1
2	—10.45	—6.2	—14.6	8.4	30.2240	30.450	30.077	.373	.0185	72.3	—17.5	W.	14.3	1.0	5	0	94	...	....	....	2
3	—1.68	9.4	—11.8	21.2	30.0982	30.492	29.531	.961	.0353	83.2	—5.7	W.	14.6	8.3	10	0	00	....	10.8	0 90	3
4	10.03	12.2	7.5	4.7	29.7835	30.106	29.471	.635	.0562	82.3	5.7	W.	30.2	3.7	10	0	80	....	2.4	0.24	4
5	9.35	14.0	1.6	12.4	30.3407	30.437	30.272	.165	.0497	75.3	2.8	W.	4.1	3.7	10	0	53	....	Inapp.	0.00	5
6	4.20	14.9	—5.8	20.7	30.1392	30.437	29.902	.535	.0482	89.7	1.7	W.	9.9	9.0	10	0	00	....	1.8	0.16	6
SUNDAY....... 7	......	16.5	9.9	6.6	....	......	......	....	....	....	....	W.	21.9	....	..	..	92	....	..	....	7 ....SUNDAY
8	5 02	10.5	0.8	9.7	30.2710	30.409	30.076	.333	.0465	85.7	1.7	W.	5.0	3.5	10	0	49	....	Inapp.	0.00	8
9	12.78	25.0	—0.2	25.2	29.7788	30.032	29.642	.390	.0768	91.5	10.7	W.	10.8	10.0	10	10	00	....	1.2	0.05	9
10	27.22	29.6	24.5	5.1	29.4425	29.622	29.326	.296	.1407	94.8	26.0	S.	12.3	9.8	10	9	00	....	2.5	0.25	10
11	25.73	29.6	22.8	6.8	29.5897	29.634	29.533	.101	.1167	84.2	21.7	W.	8.2	9.8	10	9	00	....	0.1	0.00	11
12	5.28	24.0	—3.5	27.5	29.9123	30.129	29.653	.476	.0457	73.8	—1.5	W.	20.4	4 5	10	0	60	...	0.7	0.05	12
13	1.95	7.8	—4.4	12.2	30.1355	30.205	30.018	.187	.0368	77.5	—3.8	W.	16 5	8.3	10	0	41	....	0.1	0.01	13
SUNDAY 14	......	30.0	5 0	25.0	....	......	......	....	.....	...	....	S.W.	14.7	....	..	..	00	....	3.2	0.27	14 ....SUNDAY
15	18.38	30.6	7.6	23.0	30.3017	30.524	29.955	.569	.0895	85.5	14.5	S.W.	8.1	8.3	10	0	00	....	0.1	0.01	15
16	2.27	9.0	—5.9	14.9	30.4992	30.602	30.404	.198	.0438	90.5	—0.2	N.E.	9.9	5.3	10	1	05	....	..	....	16
17	15.15	21.8	5.5	16.3	30.2455	30.395	29.993	.402	.0763	85.8	11.7	N.E.	15.6	9.5	10	1	00	....	Inapp.	0.00	17
18	22.08	27 9	11.7	16 2	29.7733	29.926	29.676	.250	.0903	74.3	15.3	W.	26.3	5.5	10	0	49	....	....	....	18
19	2.58	12.0	—1 5	13.5	30.3262	30.523	30.141	.382	.0300	61.0	—8.0	W.	27.4	0.7	4	0	85	....	....	....	19
20	5.22	14.0	—5.9	19.9	30.3832	30.573	30.144	.429	.0370	65.3	—4.2	S.	11.9	1.7	10	0	84	....	....	...	20
SUNDAY.......21	......	35 1	13.2	21.9	.. ....	......	......	....	.....	....	.. .	S.	21.0	....	..	..	00	0.05	1.3	0.29	21 ....SUNDAY
22	17.70	35.4	12.9	22.5	29.9478	30.072	29.775	.297	.0793	78.3	11.5	W.	24.2	7.8	10	1	84	.....	....	....	22
23	23.40	33 1	12.8	20.3	29.5765	29.666	29.503	.163	.1073	83.7	19.0	S.W.	[illegible] 7	7.7	10	1	39	......	2.6	0.14	23
24	6.03	21.1	2.8	18.3	30.0682	30.270	29.839	.431	.0358	62.2	—4.3	W.	24 0	0.8	7	0	93	....	....	....	24
25	—2.93	3.9	—5.5	9.4	30.5742	30.677	30.425	.252	.0270	72.3	—10 2	W.	18.0	0.2	1	0	95	....	....	....	25
26	—4.55	4.7	—13.0	17.7	30.3682	30.672	29.925	.747	.0315	88.5	—7.3	N.E.	12.8	8.3	10	0	00	....	1.6	0.15	26
27	13.22	17.5	4.2	13.3	29.4890	29 712	29.368	.344	.0675	85.0	9.7	W.	21.7	10.0	10	10	00	....	1.8	0.17	27
SUNDAY.......28	.....	15.6	—7.9	23.5	....	......	......	....	.....	....	....	W.	26.9	....	..	.	95	....	0.1	0.01	28 .... .SUNDAY
29	3.27	10.8	—4.6	15.4	29.8855	30.250	29.657	.593	.0385	75.2	—3.2	S.	14.5	8.5	10	2	00	....	2.0	0.09	29
30	—9.47	—4.6	—14.0	9.4	30 4930	30.526	30.419	.107	0213	77.8	—14.7	N.E.	7 8	7.7	10	0	15	......	....	....	30
31	—9.02	—5.8	—15.0	9.2	30.4103	30.518	30.251	.267	.0213	77.0	—14.8	N.E.	17.1	2.7	10	0	91	.	..	....	31
....Means	7.14	16.57	0.66	15.91	30.0718	......	......	.372	.0555	79.3	1.80	....	16.35	58.7	..	..	41.9	0.05	32.3	2.79	Sums ....
16 yrs. means for & including this mo.	18.29	25.35	10.92	14.42	30.0195	......	......	.293	.0963	82.3	....	... .	....	7.11	..	..	¶28.4	1.34	24.5	3.75	16 yrs. 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..	451	1441	119	272	1122	1581	6861	317	
Duration in hrs..	26	95	15	28	76	80	374	19	31
Mean velocity...	17.3	15.2	7.9	9.7	14.8	19.8	18.3	16.7	

Greatest mileage in one hour was 44 for four consecutive hours on the 4th.
Greatest velocity in gusts, 52 miles per hour on the 4th.

Resultant mileage, 6,915.
Resultant direction, S. 84° W.
Total mileage, 12,164.

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

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Nine years only.

The greatest heat was 35.4 on the 22nd; the greatest cold was 15.0 below zero on the 31st, giving a range of temperature of 50.4 degrees. Warmest day was the 10th. Coldest day was the 2nd. Highest barometer reading was 30.677 on the 25th; lowest barometer was 29.326 on the 10th, giving a range of 1.351 inches. Maximum relative humidity was 100 on 4 days. Minimum relative humidity was 54 on the 24th.

Rain fell on 1 day.
Snow fell on 19 days.
Rain or snow fell on 19 days.
Rain and snow fell on 1 day.
Hoar frost on 2 days.
Fog on 8 days.

METEOROLOGICAL ABSTRACT FOR THE YEAR 1890.

Observations made at McGill College Observatory, Montreal, Canada. — Height above sea level 187 ft. Latitude N. 45° 30′ 17″. Longitude 4h 54m 18s.55 W.

C. H. McLEOD, *Superintendent.*

Month.	Thermometer.					* Barometer.				† Mean pressure of vapour.	‡ Mean relative humidity.	Mean dew point.	Wind.		Sky clouded per cent.	Per cent. possible bright sunshine	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.	Month.
	Mean.	¶ Deviation from 16 year means.	Max.	Min.	Mean daily range.	Mean.	Max.	Min.	Mean daily range.				Resultant direction.	Mean velocity in miles per hour.										
January	14.86	+ 3.07	52.3	− 21.6	17.34	30.1399	30.717	29.201	.400	.0824	79.6	9.5	N. 75° W.	19.6	64.6	33.8	1.64	7	31.3	21	4.40	4	24	January
February	19.08	+ 3.60	45.0	− 9.1	16.95	30.0184	30.702	29.092	.400	.1025	80.4	13.8	S. 52° W.	18.6	63 5	44.9	2.85	10	27.4	12	4.45	2	20	February
March	26.51	+ 2.64	43.0	− 4.0	13.67	29.9663	30.561	29.329	243	.1158	71.9	18.5	S. 55° W.	16.9	62.8	45.9	0.48	5	11.7	12	1.53	2	15	March
April	40.01	+ 0.41	66.9	21.1	16.66	30 0415	30.456	29.220	.236	.1534	60.1	26.5	S. 61° W.	17.9	49.8	56.8	1.80	12	3.0	5	2.11	2	15	April
May	51.59	− 2.99	74.1	28.3	16.81	29.8991	30.311	29.558	.195	.2664	68.7	40.7	S. 38° W.	14.0	65.4	42.3	4.85	18	..	..	4.85	..	18	May
June	64.45	− 0.01	85.3	40.8	17.25	29.9106	30.270	29.632	.160	.4252	69.7	53.4	S. 85° W.	12.2	60.7	57.2	2.72	14	..	..	2.72	..	14	June
July	68.57	− 0.42	88.6	49.4	17.52	29.9253	30.259	29.501	.143	.4915	69.9	57.7	S. 39° W.	12.6	59.4	58.4	2.78	17	..	..	2.78	..	17	July
August	64.82	− 2.14	88.8	47.4	16.11	29.9595	30.261	29.533	.178	.4409	70.8	54.5	S. 83° W.	11.3	50.8	58.1	8.08	20	..	..	8.08	..	20	August
September	57 79	− 0.72	80.0	38.1	14.79	30.0786	30.450	29.666	.160	.3846	77.9	50.5	S. 49° W.	11.3	57.5	51.6	3.57	11	..	..	3.57	.	11	September
October	45.85	+ 0.79	71.7	30.7	11.75	29.9003	30.396	29.347	.179	.2583	80.7	39.8	N. 36° W.	9.5	72.5	33.8	2.69	15	..	..	2.69	..	15	October
November	31.71	− 0.34	55.0	9.0	13.49	29.9734	30.443	29.515	.283	.1430	76.8	25.2	S. 58° W.	14.9	67.4	36.5	2.46	13	8.8	10	3.32	4	19	November
December	7.14	−11.15	35.4	− 15.0	15.91	30.0718	30.677	29.326	.372	.0555	79.3	1.8	S. 84° W.	16.4	58.9	41.9	0.05	1	32.3	19	2.79	1	19	December
Sums for 1890	...	....	....	....	....	...	....	....	....	....		....		....	....	....	33.97	143	114.5	79	43.29	15	207	Sums for 1890
Means for 1890	41.03	− 0.60	....	....	15.69	29.9904	....	....	.246	.2433	73.8	32.7	S. 66° W.	14.60	61.1	46.8	....	....	....	....	3.61	..	17	Means for 1890
Means for 16 years ending Dec. 31, 1890.	41.63	....	....	....	...	29.9765	....	....	....	.2493	74.4	....	....	* 15 34	61.4	§ 46.1	28.13	134	124.6	84	40.25	15	202	Means for 16 years ending Dec. 31, 1890.

* Barometer readings reduced to 32° Fah., and to sea level. † Inches of mercury. ‡ Saturation, 100. § For 9 years only. * For 4 years only. ¶ "+" indicates that the temperature has been *higher;* "—" that it has been *lower* than the average for 16 years, inclusive of 1890. The monthly means are derived from readings taken every 4th hour, beginning with 3h. 0m, Eastern Standard time. The anemometer and wind vane are on the summit of Mount Royal, 57 feet above the ground, and 810 feet above sea level.

The greatest heat was 88.8 on August 4th; greatest cold 21.6 below zero on January 10th; extreme range of temperature was therefore 110°.4. Greatest range of the thermometer in one day was 41.8 on Jan. 13th; least range was 3.7 on Feb. 27th. The warmest day was July 1st, when the mean temperature was 76.45. The coldest day was Jan. 10th, when the mean temperature was 15.73 below zero. The highest barometer reading was 30.717 on January 28th the lowest was 29.092 on February 5th, giving a range of 1.625 for the year. The lowest relative humidity was 15 on April 15th. The greatest mileage of wind recorded in one hour was 67 on January 13th, and the greatest velocity in gusts was at the rate of 104 m. p. h. The total mileage of wind was 127,618. The resultant direction of the wind for the year was S. 66° W., and the resultant mileage 50,720. Auroras were observed on 18 nights. Fogs on 42 days. Hoar-frost on 23 days. Thunder storms on 20 days. Lunar halos on 13 nights. Lunar coronas on 1 night. Solar halos on 4 days and contact arc on one day. The sleighing of the winter closed, in the city, on April 1st. The first appreciable snowfall of the autumn was on November 9th. The first sleighing of the winter was on December 3rd. There was a slight earthquake on September 26th, at 3 h. 3 m.

The yearly means above, are the averages of the monthly means, except for the velocity of the wind.