On the physical geography, geology, and commercial resources of Lake Superior / J.J. Bigsby.

divides the waters of the Mexican gulf from those of Hudson's Bay; — and then, bifurcating, one fork proceeds on the north side of Lake Superior eastwards towards Labrador, in groups of broken hills, while the other fork passes south-east as a rough and high country into the lowlands of the United States. It therefore occupies an oblong crescent-shaped hollow, with a general direction rather to the north of east. It has literally thousands of lakes on its north, and hundreds on its immediate south. It is 1750 miles round, 420 miles long, and 163 in extreme breadth. It is 597 feet above the Atlantic. Its greatest known depth is 792 feet. Soundings of 300, 400, 600 feet are common; but extensive shallows and flats prevail in parts.

The hydrographic basin of Lake Superior is singularly small, particularly on the south shore, where the tributaries of the River Mississipi and Lake Michigan often approach within 5 and 10 miles of the lake. It seems to be its own fountain head.

The water is clear, greenish, extremely pure, pleasant to the taste, and soft from the nearly total absence of limestone from these regions. An imperial pint only contains $\frac{1}{5000}$ part of a grain of mineral matters — carbonates of lime and magnesia, sulphate of lime, peroxide of iron, and the oxide of manganese.

The average annual temperature of the water is 40° F.; being about the same as that of the ocean at certain great depths. In June, the lake is often covered with ice; and in the middle of July, the surface-water freezes in the morning — with patches of snow in the clefts of the rocks. At this period of the year, or a few days later, the smaller lakes on the north are steadily at 72° and 74°. F.

Lake Superior is not undergoing secular drainage. It is lowest in April, and highest by a few feet, in September. The great annual variations of rain of these countries produce corresponding changes of level. There are no tides, and no cycle of years for lake-levels.

Barometric changes produce curious local oscillations of level. Thus the furious rapids, called the Falls of St. Mary, on the river of discharge so named, are sometimes left dry. Messrs. Foster and Whitney have seen the oscillation come from the centre of the lake in a wave 20 feet high — curling over like an immense surge, crested with foam, and breaking on the shore, diminishing as it approached it. On this occasion (Aug. 1845) it was the harbinger of a violent storm.*

The amount of water leaving the lake is small; for its outlet is often shallow, and the current weak.

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* A violent gale of wind, concurring with a local rise of level, will sometimes throw large stones or logs of wood 150-200 yards inland, and 30-40 feet above the usual water margin—as in three instances seen by Prof. Agassiz (L. Superior, pp. 95 and 106), and by Dr. Bigsby. (Journ. Roy. Instn. xviii. 15.)

The *Climate* is more arctic than temperate, although the lake is but little to the north of Milan. It is much colder than Sikla in Russian America, 10° further north; because the latter is screened from polar winds. Winter begins in the middle of October by a succession of gales and snow storms; and from November till May the ground is covered with close packed, granular snow: but the earth is not frozen deep, so that, in spring, before all the snow is gone, the forest is in leaf. The annual range of the thermometer is 125° F. the mean 42° 14′ F., the lower extreme — 31°, the higher 94°; all these observations having been made by good observers, with excellent instruments. August is the hottest month.

On a mean of 12 years, the Winds blow about equally from all quarters; from the N.W. the most frequently — from the South the least frequently.

(The principal promontories, bays, rivers and heights of Lake Superior were pointed out on the map.)

The scenery of Lake Superior is striking; — its features are large and open (of which an example was shewn in a Sketch on the East Coast). The eye ranges over high lands and shoreless waters. The scanty and dwarfed woods of the north coast, the rocks, isles, and rivers full of cascades, have an impress of their own — not warm, soft, and umbrageous like those of Lake Erie; but rugged, bare and chill — arctic. The scene is oceanic, — the waves are large and high. Some of the plants, the Lathyrus Maritimus and the Polygonum Maritimum, for instance, on the beaches, and many of the insects disporting about, are those of the distant Atlantic.

In winter, Lake Superior might be called the "Dead Sea;" every living thing is gone, save the shivering inhabitants of some few white settlements. The Indian and the wild animals have retreated to the warm woods far away; and the sun looks down, from a bright blue sky, on the leaden waters, now narrowed by huge fields of ice — a small dark speck on an almost illimitable expanse of snow.

On the south shore, there are in the extreme east, high terraces and treeless plains of blown sand for many miles inland and along shore, succeeded by the high sandstone precipices, called the Pictured Rocks, battered into fanciful shapes by the violence of the waves. Then comes a low rocky coast for 200 miles or more, backed by dense forests, often mountainous, as at the Huron, Bohemian, and Porcupine mountains. The scene is dark with the verdure of northern evergreens, and is here and there diversified with small clearings, and the smoke of distant mines ascending among the uplands. The bays are often deep—full of little iron-stained streams; and the promontories stretch for miles into the lake.

The Eastern and Northern shores are different — more naked, steeper, ever abounding in dome-shaped hills, or in ridges, rising by steps, scantily covered with trees either stunted or scorched with

fire. (Large sketches were exhibited representing the lofty basaltic country about Fort William, and the softer hill-scenery of Black Bay.)

With the exception of the Fur trading stations, there are no white settlements on the north shore: — and this from its general barrenness. At the Peek River, soil was imported in bags with which to raise a few potatoes.

The *Fauna* and *Flora* of Lake Superior are semi-arctic — or subalpine. Professor Agassiz has treated of both in his late valuable publication on this lake. He found twenty-three new species of fish, and states that Lake Superior constitutes a special ichthyological district. The reason of this evidently lies in the coldness and extreme purity of the water, its slow departure towards the ocean, and the absence of weedy bays, and of lime rocks.

It would seem that some portion of its animal life are waifs and strays from grand geological periods long passed away — as we see in its herrings, minnows, and the new genus Percopsis. Connected with this subject, Prof. Agassiz conjectures that much of North America was dry land when the rest of the world was under water; and that thus its physical condition was less altered than elsewhere. Dr. Bigsby was inclined to believe this, for had Canada been as long under water as other large tracts, we should probably have had in some part of its vast extent, a member or two, at least, of the mesozoic rocks; but there is no such thing — not a single relic of lias, oolite, or chalk, in the extraordinary heaps of débris which overspread these countries.

*Geology.** The rocks of Lake Superior have been arranged under three principal heads, as follows: —

1. The *Metamorphic.* — Greenstone, chloritic, talcose, clay and greenstone slates, gneiss, quartzite, jasper, rock and saccharoid limestone.
2. The *Aqueous.* — Calciferous sandstone, Cambrian sandstone and conglomerates.
3. The *Igneous.* — Granite, Sienite, Trap, in various states.

The place and extent of these rocks having been pointed out on a map, Dr. Bigsby stated that the geological system of Lake Superior is a consistent and closely connected whole, forming a beautiful and easily read example of geological action in moulding the surface of our globe.

The lake may best be presented at once to the mind as a trough or basin of Cambrian (or Silurian) sandstone, surrounded, and framed as it were, by two orders of rocks, in the form of irregular and imperfect zones; the inner consisting of trap, with its conglomerates; and the outer, of metamorphic, flanking igneous rocks.

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* This branch of the subject was illustrated by numerous coloured Diagrams, and specimens of native copper, and of the rocks of the lake.

1. The *Metamorphic* rocks, with the exception of Quartzite and Jasper, are the oldest in the lake, and support great sheets of the abovementioned sandstone unconformably; all these rocks being upheaved and altered by the intrusion of igneous rocks in instances innumerable. This group of rocks are entirely destitute of the traces of animal life.

The country they occupy on the south shore, with a general NNW. dip, may be best described as a rough table land of the various slates, out of which short hills of granite, gneiss, trap, &c. emerge in great numbers, with an almost constant east and west direction.

On the east and north shores the metamorphic rocks have a W. and WSW. strike, when visible. The slates of the north side of Michipicoton Bay run WNW., NW., and N.

The Jasper and Quartzite are merely altered sandstone and therefore younger than the other rocks of this group.

2. The *Aqueous* Rocks. The youngest of these is Calciferous Sandstone. It exists as a broad band on the south-east shore, resting on the sandstone soon to be noticed. It is highly magnesian and siliceous in parts. A patch of it in Grand Island contains shells. (Logan.)

The Cambrian Sandstone seems to be the floor or basement of nearly all the lake, for the following reasons :—

1. Wherever it occurs, whether in immense sheets on the east and south shore, or in smaller areas on the north coast, it invariably dips towards the centre of the lake.
2. It can be recognised, paving the lake for some miles from the main in many places.
3. The soundings of Captain Bayfield exhibit, for large spaces, the uniformity of level to be expected from the presence of horizontal strata.
4. Because it constitutes Caribou Island, 40 miles from the nearest main land.

This sandstone is very ancient; and is supposed by Mr. Logan to be Cambrian on the north shore and lower Silurian on the south — a supposition, the latter clause of which, though extremely probable, is not yet established.

It has no fossils; but its ripple marks, impressions of rain-drops, and sun-cracks, are plentiful and perfect.

It is more commonly red, and is composed of the débris of granitoid rocks, in nearly horizontal strata, except near intrusive rocks, when it rises to an high angle, hardens, and even passes into true Jasper, porphyry, gneiss or quartzite. There is reason to think that this sandstone is interleaved with trap. (A Landscape was exhibited of the Sand stone Rocks, south shore.)

The Conglomerate is of the same age with much of the sandstone; and is almost invariably placed between it and the trap.

The conglomerates of Keweenaw and Isle Royale consist of rounded bowlders of trap, with a few Jaspers, cemented by red iron sand; but those of Memince and Nipigon contain also granites, quartzites and sandstones; thus indicating a difference of age.

3. *Igneous* Rocks. Granite every where forms the nucleus of an anticlinal axis, in two parallel lines running E. and W.on the south-east side of the lake, flanked by metamorphic and sedimentary rocks. Both it and Sienite are plentiful.

Trap Rocks. The ancient lavas of the lake are in very large quantities, and are well displayed. They are the great depositories of copper. For convenience sake, they may be divided into three principal forms.

1st. The highly crystalline mountain masses,—sometimes anticlinal and sienitic.
2nd. The bedded trap, at various angles of inclination.
3rd. Dykes intersecting igneous and metamorphic rocks.

They are all portions of one long series of volcanic operations.

Trap creates the great headland of Keweenaw, with its lines of stair-like cliffs and hills. (It was shewn in a large diagram and described as typical of the trap of the whole lake.) The trap of Keweenaw is met with in three contiguous and parallel belts, going WSW., and separated by bands of conglomerate, sometimes very thin, often numerous, and prolonged sometimes for 40 or 50 miles. These three belts have been named the outer, northern, and southern; the last being highly crystalline, or sienitic, and abounding in chlorite. It is an anticlinal to the rocks on both sides. The other two belts are bedded traps, and with their interleaved conglomerates dip northerly. They all coalesce at Portage Lake and after proceeding to Montreal River, 130 miles in the whole, soon after disappear under horizontal sandstone westwards.

The north belt is the most metalliferous; and contains the celebrated Cliff and other rich mines. In the Keweenaw district it is the cross vein which yields the native copper—either in sheets and blocks or mixed in with the usual crystallizations, such as datholite, prehnite, stilbite, quartz, &c.

On the Ontonagon River the metalliferous veins run with the strike. The copper is pure, and has interspersed through its substance, scales of pure silver; but without chemical union.

The copper is confined to the trap, as an universal rule.

The North shore of Lake Superior is eminently trappose; and especially about Fort William, where a region at least 120 miles long consists of basalt, amygdaloid, porphyries, jasper, conglomerate, and sandstone in the same mutual relations as on the south shore.

The trap dykes, traversing granites and other crystalline rocks indifferently are a singular feature on the north shore and abound chiefly from Written Rocks to the bottom of Michipicoton Bay. By their dark and undeviating course through the grey, red, or green rocks of the rugged coast, they strike the eye of the most incurious — if only as ruined staircases, crossing bays and headlands and climbing hills for miles. Their size, number, and direction are irregular. They may be solitary, or twenty in company — sometimes all parallel and close together. They often run with the general trend of the coast.*

Mr. Logan divides them into three varieties, according as they are homogeneous, sienitic or porphyritic.

Professor Agassiz distributes the dykes of the whole lake into six systems — each with its own mineral character and direction — its own epoch of upheaval; and each he announces to have been an important agent in giving shape and direction to the district in which it occurs. He truly says that the general outline of the lake is the combined effect of many minor geological events taking place at different periods. With some truth in it, this theory does not seem to take into sufficient account the pre-existing metamorphic and granitic rocks, and it overlooks the variety observed in the directions of the dykes in the same neighbourhood.

Dr. B. stated that if he might be allowed to hazard an opinion, it would be, that this curious assemblage of dykes — abounding as much in the S. as on the N. coast — pervading all the crystalline rocks indiscriminately, had ascended independently from the unseen, distant, mass of trap beneath. They appear in many ways peculiar, and have no visible connexion with the traps he had been describing.

Before the emergence of either traps or granites, Lake Superior received its *great* outlines from the metamorphic rocks, — thrown into their present position by still earlier upward movements: for on the eastern half of both shores of the lake they strike E. and W. with little variation, while on the western half, these far extending rock-masses strike WSW. and SW. — giving thus, to the lake, a general eastward direction, with a gentle curve to the north, as stated before. This done, Cambrian Sandstone slowly took possession of the trough of the lake — just as we see a certain shell marl is doing now. The anticlinal Granites, which appeared afterwards, only concurred in the same effects; — shaping and elevating the adjacent lands.

In after-geological times important modifications arose in the form of the lake. Promontories were pushed out, and islands raised up by successive outbursts and overflows of trap from separate fissures of great length — those for example of Keweenaw, Thunder Mountain, and Isle Royale — all intercalated with conglomerates,

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* Vide Quart. Journal of Roy. Inst. Vol. XVIII. p. 244. Bigsby on Lake Superior.

formed in agitated seas between eruptions; — at different and most probably *distant* times, judging from the fact that some of the conglomerates are altogether trappose, while others abound in granite and other bowlders.

We thus obtain the *general* order of all these events, and little more; but the knowledge is worth having. From the position of the up-lifted mural cliffs, we see that the upheaving impulse came from the south-east.

Drift. The groovings and striæ are almost always northerly here. New proofs are daily accumulating to shew still more decisively the northerly origin of the foreign drift of Lake Superior. One of these is the fact that the limestone bowlders on the north shore are upper Silurian,* and derived from the large calcareous basins some hundreds of miles north of Lake Superior: from whence Dr. B. had brought characteristic fossils. Another is found in the occurrence of bowlders of iron ore, in heaps, on the north side of certain cliffs, but which are absent on the south side — the original site of the ore, being to the north of the cliffs, and near Lake Superior.

A Sketch was exhibited of a Wisconsin prairie, dotted with northern blocks dropped from icebergs.—From Dr. D. Owen.

Commercial Resources. — Agriculture will only be carried on in parts of the south shore. Large quantities of white fish, and of furs are annually exported.

The chief staple of Lake Superior is native Copper. For ages before the appearance of Europeans in America, this metal was supplied from hence to the Indian nations far and near. The tumuli of the Mississipi, &c. contain the identical copper of this lake. Traces of ancient mining in Keweenaw, Ontonagon, and Isle Royale are abundant, in the form of deep pits (a ladder in one), rubbish, stone mauls, hammers, wedges, and chisels of hardened copper. In a native excavation, near the river Ontonagon, with trees five hundred years old growing over it, lately lay a mass of pure copper 81 tons in weight, partly fused and resting on skids of black oak.

Modern explorers have hitherto only found two centres of metallic riches on the south coast, — that of Keweenaw and of Ontonagon. In the first are the valuable mines of the Cliff, North American, North-western and other companies. In the Ontonagon centre is the Minnesota and fifteen other mines.

At the Cliff mine three large steam engines are employed (1852); with 250 men; — and at the North American mine, two engines, with 160 men. Most of the other mines, forty in number, are assisted by steam power. Three thousand miners are in work altogether, and the general population is fast increasing. Native copper is the principal object. Silver is always present, and occasionally in masses of considerable size. According to authentic

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* Containing Pentamerus, Spirifer, Leptæna (alternata) atrypa, various corals, minute trilobites, orthoceræ, and some cytherinæ.

accounts, dated February, 1852, many new mines have been opened lately; and all are worked more systematically than heretofore, — generally by contract.

There are now in the Cliff mine masses of pure copper within view estimated to weigh 700 tons in the whole; and on the lands of the Minnesota Company, one block weighing 250 tons. The copper shipped in 1851 was about 1600 tons, valued at £130,000. This copper is stated to be of great excellence in the manufacture of wire, ordnance, and ship-sheathing.

The large beds of specular and magnetic iron ore, on the south-east side of the lake, are as yet only worked on a small scale.

At this moment the business of mining has ceased on the Canadian side of the Lake. There is little doubt, however, but that profitable deposits will, sooner or later, be discovered here.

[J. J. B.]

In the Library were exhibited: —

Falls in the Black River, Lake Superior, and other Views in Canada, by Dr. J. J. Bigsby, M.R.I.

Roman Glass Vase, a small Bottle, and a Lamp found in the church-yard of St. Stephen's (near St. Alban's) about 6½ ft. deep, a quarter of a mile from the Roman Verulam. The Vase contained pieces of bone and was much broken; it was repaired by Mr. Doubleday of the British Museum as far as possible. Not any part of the rim was discovered. [Exhibited by S. R. Solly, Esq., M.R.I.] [See a Pamphlet by M. H. Bloxam, Esq., on the Roman Sepulchral Remains found near St. Alban's, 8vo. 1849, — presented to the R. I. Library by Mr. S. R. Solly.]

Specimens of British Glass and Porcelain. [Exhibited by Mr. Apsley Pellatt.]

Models of Marine Engines: — Double Cylinder Engine and Vibrating Engine — and Engine of the "Great Western." [Exhibited by Messrs. Maudslays and Field.]

Rough Models of Nasmyth's Steam-hammer and of Maudslay's Vibrating Cylinder, from the Royal Institution Laboratory.

Diagrams of Nasmyth's Steam Pile-driver. [Presented by Mr. Nasmyth.]

Model of the Disk-Engine by Mr. R. Addams.

A Group of Humming-birds, from S. America, and a Group of Tanagers from neighbourhood of Rio Janeiro, Mounted by Messrs. Leadbeaters.

Mr. Varley exhibited a Vial Microscope in which were shewn the circulation of the sap of a Plant, and a group of Trumpet animalcules. The rapid motion of their cilia by which they catch their prey was perceived.

[FOR THE USE OF MEMBERS.]

Royal Institution of Great Britain.

1852.

WEEKLY EVENING MEETING,

Friday, March 26.

SIR JOHN P. BOILEAU, Bart., F.R.S., Vice-President, in the Chair.

PROFESSOR E. COWPER,

On the Principles of the Construction and Security of Locks.

PROFESSOR COWPER, after pointing out the peculiarities of construction in the more celebrated Locks of ancient and modern times, explained the mode by which Mr. Hobbs had succeeded in picking Bramah's, and other locks, and suggested additional means of security against such a procedure. His remarks were elucidated by numerous large models and diagrams.

Long continued illness has unfortunately prevented Professor Cowper from supplying an abstract of his discourse.

In the Library were Exhibited: —

Wooden Lock and Key made by the negroes of Jamaica, and another of a different form — Lock of wicket of the Castle of Pownghur — Key found in the thatch of an old house, St. Andrew's. — Profile of General Wolfe sketched in pencil by Harvey Smith, one of his Aide-de-Camps, a short time before his death at Quebec, — from the United Service Institution.

Wire Models to illustrate the Cleavage of the Diamond, &c. — and Large Pieces of Topaz Rock and Crystal of Beryl. [Exhibited by Mr. Tennant.]

Portrait on copper of Maurice of Nassau, probably by Mirevelt. [Exhibited by John Hicks, Esq. M.R.I.]

Bust of Thomas Carlyle, Esq. by H. Weigall, Esq.

Specimens of Printing in Colours by Blocks, by Messrs. C. B. and G. Leighton.

Design of Galloway's Tubular Boiler as adapted to Steam-boat purposes, by Mr. R. Armstrong.

A Set of Talbotype Apparatus; the Camera with improved Sliding Front — Talbotype, Negative and Positive, and various Portraits, by Mr. Henneman.

Boxes, and other Articles manufactured from Muslin and Cotton *Maché*, by Mr. G. Hart.

Paintings on China. [Exhibited by W. T. Copeland, Esq.]

WEEKLY EVENING MEETING,

Friday, April 2.

33.

Sir Charles Fellows, in the Chair.

Sir Charles Lyell,

On the Blackheath Pebble-bed, and on Certain Phænomena in the Geology of the Neighbourhood of London.

There are two kinds of flint-gravel used for making roads in the neighbourhood of London, both of them in certain places superficial, but which are of extremely different ages. The yellow gravel of Hyde Park and Kensington so often found covering the "London Clay" may be taken as an example of one kind; that of Blackheath, of the other. The first of these is, comparatively speaking, of very modern date, and consists of slightly rolled, and, for the most part, angular fragments, in which portions of the white opaque coating of the original chalk flint remains unremoved. The more ancient gravel consists of black and well-rounded pebbles, egg-shaped or spherical, of various sizes, exhibiting no vestige of the white coating of the original flints, yet showing by the fossil sponges and shells contained in them that they are derived from the Chalk. In the pits of Blackheath and the neighbourhood, where this old shingle attains at some points a thickness of 50 feet, small pieces of white chalk sometimes occur, though very rarely intermixed with the pebbles. If we meet with thoroughly rounded flints in the more modern, or angular gravel, it is because the latter has been in part derived from the denudation of the older bed.

The researches of the Rev. H. M. De la Condamine have shown that the sand and pebble-beds of Blackheath and Greenwich Park, inclose in some of their numerous layers, freshwater shells of extinct species, such as Cyrena cuneiformis, &c. agreeing with fossils which characterize the Lower Eocene beds at Woolwich. At Lewisham the pebble-bed passes under the London Clay, and at Shooter's Hill this clay overlies it in great thickness.

At New Charlton, in the suburbs of Woolwich, Mr. De la Condamine discovered a few years ago a layer of sand in the midst of the pebble-bed, where numerous individuals of the Cyrena tellinella were seen standing endwise, with both their valves united, the posterior extremity of each shell being uppermost, as would happen if the mollusks had died in their natural position. Sir Charles Lyell described a bank of sandy mud in the delta of the Alabama river at Mobile, on the borders of the Gulf of Mexico, where, in 1846, he had dug out, at low tide, specimens of a living species of Cyrena, and of a Gnathodon, which were similarly placed, with their shells erect, a position which enables the animal to protrude its siphons