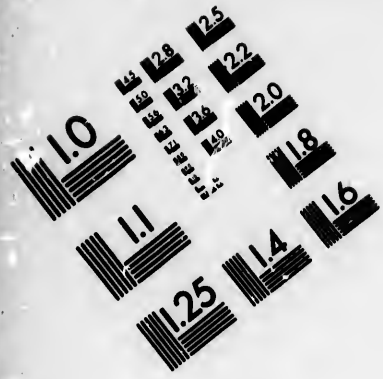

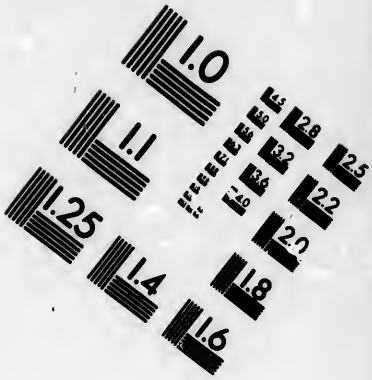

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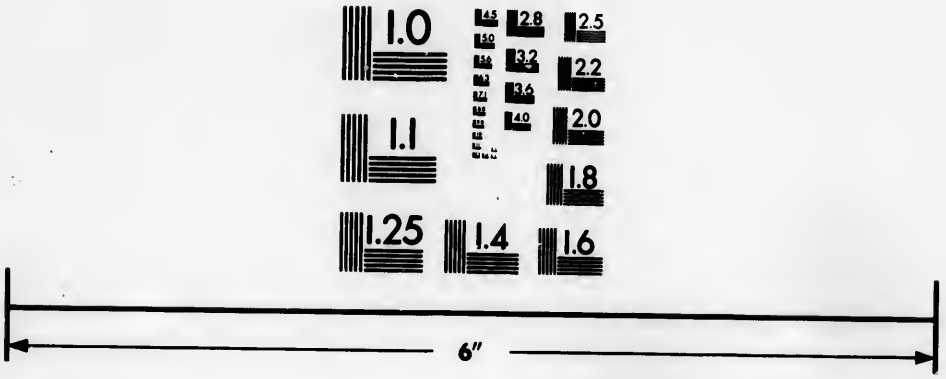

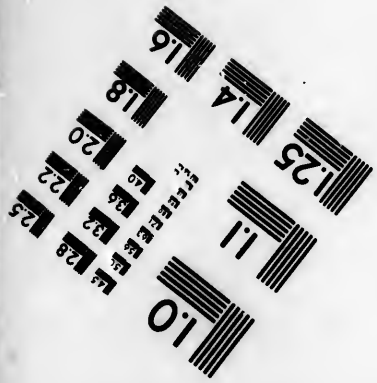

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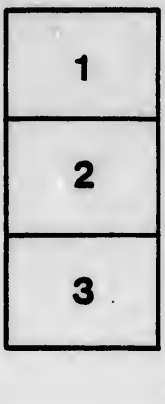
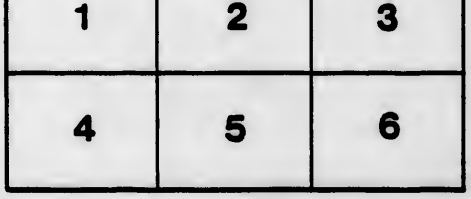




4

AN ESSAY

ON THE

NATIVE COMPOUNDS of Iron

AND

METALLURGY OF IRON.

Especially in connection with the Ottawa Valley.

READ BEFORE THE NATURAL HISTORY SOCIETY OF OTTAWA, ON FRIDAY, DECEMBER 28TH, 1866,

BY

EDWARD VAN-CORTLANDT, M. R. C. S. L.,

CONSULTING PHYSICIAN TO THE CO. OF CARLETON PROTESTANT HOSPITAL AND CURATOR OF THE ASSOCIATION.

OTTAWA:

PRINTED AT "THE OTTAWA CITIZEN" STEAM PRINTING HOUSE, RIDEAU STREET.

1867.

AN ESSAY

ON

SAND COMPACTION

IN

METALLURGY OF IRON.

Especially as connected with the Ohio Valley.

BY

EDWARD VAN-OSTRANDT, M.E. C.S.L.

1877.

NATIVE COMPOUNDS, &c.

—o—o—

What grievous destruction originates from a want of study of the metal that forms so material an instrument in the architecture of both railroads and steamboats. Indeed I know of no subject in the physical sciences that better deserves the establishment of an independent professorship than that of Iron.—THEODRIC ROMEYN BECK.

INTRODUCTION.

If we look around and direct our especial attention to the comparative advancement of the different nations of the Earth at the present time, we shall readily discover that their power, or their weakness, is alone to be measured by the extent to which they have turned the martial metal to account. This fact admitted, the inauguration of the Hull Iron Smelting Works, which may very shortly be looked forward to, will constitute a great and grand opportunity, for the first time, of bringing the mineral treasures of the Ottawa Valley, metallurgically, in bold relief before the world. By a most laudable spirit of enterprize a fractional portion of our inexhaustable wealth as an Iron country is about being practicably demonstrated, and a new field fraught with interest and of the very greatest commercial importance is on the eve of being opened.

Great Britain, which, for the last century has been the grand Emporium for the Iron trade of the Universe, yields her more or less impure ores and compounds from deposits of the most circumscribed dimensions, yet the collateral circumstances of cheap labor and abundance of coal, in juxtaposition to her furnaces, enables her to monopolize almost entirely, the iron trade of the world. And so long as she continues to possess these great and grand essentials "Britannia will rule the waves," in despite of all the powers of the Earth which may be arrayed against her. Aye, though their name be "Legion."

In Canada our Iron deposits are indicated, not by the confines of a few acres of a subordinate material, but by vast inexhaustible mountain masses, entirely made up of ores, which in purity are little short of native Iron, ranging from 70 to 80 per cent of free unadulterated metal, and where, instead of delving deeply into the bowels of the Earth and calling in the aid of most expensive and elaborate machinery, we have but to direct the simplest appliances of art to the scarp-like face of the native bed, and at once and with a trifling preliminary intermediate roasting process reduce the ore to the condition known as *Pig Iron*, and of which more hereafter, when we are describing the metallurgic operations.

IRON.—FERRUM.

In accordance with scientific nomenclature, when the word Iron is used it is understood to mean either the pure native metal or wrought iron, unfinished. The ores of iron are more abundant and far more universally diffused throughout the globe than all other metals or their compounds, so much so indeed that it is scarcely possible to analyse any other inorganic body without detecting ferruginous indications, whilst traces of it are to be met with almost universally in some shape in both the animal and vegetable world. Its importance in the Arts and Sciences is in every respect equal to its abundance, since no known body possesses so many and such various valuable properties and qualities. Notwithstanding all this, however, from the greater facilities of working gold, silver and copper in their native and unaltered conditions, it can easily be understood why they were first made mention of in history, and in common with bronze (an alloy of tin and copper) used for many and various purposes of life long anterior to the so called Iron Age, the martial etymon of which term had always to be reduced from its ores consisting of the carbonates and oxides. From the theories promulgated by sundry Danish, Swedish and Norwegian authors, and in which they have been joined by some of the most distinguished archæologists of northern Europe, to use the words of a celebrated commentator: "The first three stages in the progress of a nation from barbarism to civilization are as clearly identified by their relics of stone, of bronze and of iron as the comparative antiquity of geological strata or period of the world's creation is determined by the fossils which they are found to contain." If any exception can be made to this remark it will apply to India, where the black oxide of iron was worked during the most primeval ages. In Europe it has been most clearly and satisfactorily proved that the Romans, after their invasion of Britain, smelted iron so largely that the rejected scorice of their rude wind furnaces at Dean Forest, in Monmouthshire, supplied twenty or thirty modern works with material for manufacturing iron for upwards of two hundred years.

From the most primitive days of iron smelting down to the commencement of the seventeenth century, charcoal alone was used for smelting purposes; and Cambden, the author of Britannia, who lived in the time of Elizabeth, regrets, in his celebrated work, the destruction of the forests, owing to the great demand for wood for carrying on the iron trade of the country; and even in his day, many furnaces were closed, owing to the scarcity of charcoal. In the year 1618, Lord Dudley introduced coal as a smelting agent at his father's furnaces at Pensnet, in Worcestershire. His improvement, however, only served to awaken the most violent spirit of antagonism amongst the iron-masters; and a short time subsequent to the discovery, when his Lordship died, the secret seemed to die with him.

Nearly a century afterward, to wit, in the year 1713, Abraham Darby, an iron-master, again introduced coal as a smelter at his works at Coalbrooke Dale, but the experiment again proved not only unpopular, but unremunerative, and English iron, after what was looked upon, at best as an innovation of the accepted customs of the trade, fell greatly in price in the market. About the year 1750 however, the metallurgy of iron was destined to undergo not only a great and permanent change, but one which, to use the words of a graphic writer, "has given to iron the interest of a romance." We allude to the introduction of Coke, an agent to which we are more or less entirely indebted for all the wonders in conjunction with the iron trade of the past and present age. When the best description of iron is required, it can only be obtained through the agency of wood charcoal. This fact, independent of its not containing any detrimental ingredients, is generally supposed to be referable to its producing the most fusible and purest slag at the expense, however, of the largest consumption of fuel—a matter of great consideration in England where, owing to the ruinously high price of charcoal, coke is almost universally employed for smelting purposes. The iron smelting of Canada must necessarily be looked upon conversely; but even here the high price of labor and the increased and increasing price of wood, cannot fail sooner or later to reduce us—metallurgically speaking—to the condition of England as it was in the days of Cambden. How far Peat as a smelting agent, will serve the purposes at present associated with wood, has yet to be proved. We live in a wondrous age, and if our predictions are not over sanguine, our aspirations at least are eminent.

IRON PROPER.

It is a curious fact in connection with the history of iron that whilst it is so extremely ductile as to admit of being drawn out into a wire smaller than a human hair that it cannot, like gold, be beaten into very thin leaves. It is the most tenacious of all known metals, inasmuch as a wire of only the 787 of a line in diameter is capable of sustaining a weight of 550 lbs. It is peculiar to iron to assume a pasty consistence below the melting point. It is forgeable at a bright red heat, whilst at a white heat it will admit of union by pressure alone without forging. This process is called welding. Iron altogether free from carbon cannot be welded without great difficulty, as may be illustrated in what is known in the trade as burnt iron.

Such is the affinity which iron has for oxygen gas that a piece of the metal at welding heat cannot be exposed for a single moment to the atmosphere (even during the instant of time intervening between its leaving the fire and reaching the anvil) without its acquiring a scale of oxide of iron and which always acts as an impediment to the welding process. To obviate this obstacle smiths are in the habit of thrusting the heated metal instantly on withdrawing it from the fire into silecious sand, which, by its chemical affinity, acts as an excellent flux.

Iron may be volatalized by exposure to volcanic action and combustion in oxygen gas, and at a white heat will readily burn in the atmosphere. After fusion iron is rendered crystalline and the larger the crystals the more readily can the metal be fractured, whether by concussion, by vibration, or by frost. One of the most remarkable characteristics of iron is instanced in its susceptibility to magnetism, and such is the influence over the metal by this agent that the passage of an electric current through iron wire that its tenacity is said to be augmented more than 300 in 2,500. When reduced to the condition of steel, iron admits of being rendered permanently magnetic, which quality, however, is destroyed entirely by the immersion of the magnetized metal into boiling Almond Oil. Melting heat of iron not ascertained but supposed to be about 1,550. Having now described most of the peculiarities proper to iron, we proceed to speak of the principal conditions under which it is found. As iron in its pure native form is almost entirely referrable to a meteoric origin, and as it is our present intention at some future day to read an essay before the Ottawa N. H. Society on Ærolites, and in which it will be duly represented, we reserve what we have to say regarding it, especially as it serves little or no economic purpose; nor shall we now, as it is foreign to the subject of this essay, which is intended to be purely practical, enter into any digression in connection with either the chemistry or the chemical affinities of iron, but at once proceed to describe the circumstances under which this all-important metal is met with in nature.

MAGNETIC OXIDE OF IRON.

Synonoms: Magnetite, Black Oxide of Iron, Oxydulous Iron, Octahedral Iron.

In pure metal this oxide is the richest of all the ores of iron, and the one with which in Canada we have by far most to do, its formula being Fe 3. O 4, leaving 73 per cent of pure iron. It is this variety of iron ore which produces the native loadstone; it is infusible before the blow-pipe, but is soluble in nitric acid, and is the only ore of iron which exercises polaric influence. It occurs in dark, heavy masses or black octahedral cryatals, and is found in the older primary rocks, with us in the Laurentoids, which begin at Gaspe and end in the Rocky Mountains. The Dannemora Swedish iron produced from this ore is looked upon as the best in Europe, but there can be no sort of question that within fifty miles of the city of Ottawa we have an equally pure and rich material, which, for reasons easily understood, it would be better not to particularize at this individual moment. The rock formations in which the magnetic oxide of iron is found never contain coal, and this amongst other reasons, no doubt, accounts for the iron produced from it being ever of a superior quality, inasmuch as all the furnaces have to be worked by wood charcoal, which agent as is well known does not contain sulphur, an elemental constituent always detrimental to metallurgic operations. The Magnetic Oxide of Iron is also, and not unfrequently, found largely distributed from oceanic action in the form of Black Sand, and our friend, Robert Bell, has been fortunate enough to obtain the title deed of a deposit of this description, which sooner or later, unless we mistake, as a direct producer of Steel, will

prove highly remunerative. In Virginia, Pennsylvania, and New Jersey, in the neighboring Republic, this ore is largely worked, and as it is this compound of iron which is on the eve of bringing the metallurgic importance of the Ottawa Valley prominently before the world, through the instrumentality of the Hull Forges We look upon it as being entitled to more than ordinary attention at our hands.

"There is," says Sir W. Logan, "a bed of Magnetic Oxide of Iron, about 90 feet thick, on Lot No. XI, VII Concession of Hull; it is surrounded by Gneiss, and appears to present the form of a dome, through the summit of which an underlying mass of limestone protrudes. It is in the Laurentian series. The ore contains between 60 and 70 of iron. It began to be worked in 1854, and was smelted at Pittsburgh, whither it was sent by Kingston, on Lake Ontario, to which it was conveyed by way of the Rideau Canal. Up to 1858, about 8,000 tons of the ore had been thus exported, but the opening of the Newborough mine, more favorably situated in regard to the shipping port, stopped the working, and no ore is now, 1862, exported from Hull." This is a condensed history of the Iron bed now in process of being worked by the Hull Iron Smelting Company, and about to constitute a new and all important epoch in connection with the Ottawa Valley.

Specular Oxide of Iron, Synonymous with Red Hematite, Oligistic Iron, Iron Glance, &c., &c.

This ore of iron is to be met with both in the stratified and the crystalline rocks. It has a metallic lusture, is infusible before the blow-pipe, but smelts with borax The great locality of this ore is the Island of Elba, where it has been worked for 16 centuries. In our own immediate locality, it is found most abundantly in the Township of MacNab, at Arnprior; we have seen, also, some very fine specimens from Torbolton and Fitzroy. Specular iron ore is not so rich in metal as the magnetic oxide, as it yields only 55 per cent of pure metal. When it assumes a fibrous character it is called and known as Red Hematite, and is generally found in reniform masses, as in Saxony and in Cornwall, and at Ulverton, in Lancashire, England. When mixed with argillaceous compounds, or other impurities, it is familiarly known by the name of Red Lead. At Ticonderago, in the neighboring Republic, it is found in considerable quantities, and pulverized and used as a polishing powder. Most of the plate iron and iron wire of England are manufactured from this ore. It is extensively used in the button trade as a polisher, and the ore most in use for this purpose comes from Spain. The ore before alluded to as existing in MacNab Township is very valuable in itself, and every facility for working it exists on the spot. The specular oxide has heretofore proved somewhat refractory in the furnace, but the inconvenience is overcome by mixing with it the other ores of iron. For this purpose the magnetic oxide has been largely shipped, both from the Hull Mines and from Mud Lake, Rideau Canal, when an iron answering all required purposes has been the result.

Bog Iron Ore, Hydrated Per Oxide of Iron or Brown Iron Ore.

This ore is generally found in detached portions at the bottom of shallow lakes and morasses, thence its name, Bog iron. It possesses sundry characteristics common to specular ore, and produces about the same amount of iron. It is made up of numerous aggregated fibres, and in colour is invariably some shade of brown; it is very brittle and possesses no magnetic power. On some occasions we meet with it in a more or less pulverized condition and assuming the appearance of an ochre, but it differs from all the other ores of iron in containing water in large quantities, not simply absorbed, but constituting a characteristic part of the ore, being chemically combined with it in the proportion of one sixth.

Bog iron ore is found in limited quantities in England, France and Siberia, but in Germany, France and Austria it is extensively worked. At Salsbury, Connecticut, United States, it exists to an unlimited extent, and has been worked beyond a century, and yielding from this locality alone, the large quantity of upwards of two thousand tons of iron annually.

The iron obtained from Bog Ore is said to excel in toughness and hardness, and to be preferable to red iron ore on that account, whilst the purer varieties on being melted with charcoal may be readily converted into steel of an excellent quality

Bog iron is of more recent origin than any of the other ores of iron, and its deposition

is going on continually, even at the present time, in shallow lakes and swamps. In the south-western parts of New Jersey, where bog iron ore occurs in great abundance, many spots previously exhausted are explored again successfully after a lapse of about twenty years. And what is more curious in connection with it than all we have said is that it is brought to the condition in which we find it through the intervention of an infusorial animal called *Gallionella ferruginea.*

Bog iron ore is used in all quarters of the globe, generally for castings, which are said to take a sharper impression from the phosphoric acid which bog iron always contains.

The oldest Canadian Smelting Works are still extant at the St. Maurice forge, Three Rivers, and the ore used is the hydrated peroxide. The first forges were commenced by the French in the year 1737. They have since necessarily passed into other hands and another company has even started work in juxtaposition to the original. Both of them are said to be doing a good business.

Bog iron ore exists on the Ottawa at Cote St. Charles, on an eight feet bed, lots 16 and 17, the property of Mr. R. Lancaster, from whence this specimen comes. It is also to be met with in various other localities on the Ottawa.

"To metallurgists the good quality of the wrought iron of the St. Maurice forges," observes Sir W. Logan, "appeared the more deserving of attention, as the ore from which it is derived, being a hydrated peroxide, is usually accompanied by a small amount of phosphorus in the form of phosphate of iron. It is difficult to remove the impurity which in too large a quantity renders the ore by what is known as Cold Short. It, however, serves one good purpose, inasmuch as when it exists in moderation it renders the metal very fluid when fused, and helps to give a fine surface to the castings and bring out all the details of ornamental patterns in bold relief, whilst it does not seem to render the casting brittle, or to deteriorate its power of resisting the effect of sudden heating and cooling."

The hydrated peroxide of iron of which we are speaking is also found (generally in a state of ochre) in the moulds left by the decomposition of shells and madrapores, the shape of which are assumed by the mineral. It is also found in the condition known as Pea Iron.

IRON PYRITES.

Bisulphuret of iron, commonly known as the mundic of miners, is found in small cubical crystals in veins amongst slate and coal fields, where by oxidation and its conversion into sulphate of iron it not unfrequently, by raising the heat to a great degree, causes the spontaneous ignition of the coal. It is also found accompanying the ores of many other metals and often replaces the remains of animal and vegetable substances. In Terra del Fuego the natives produce fire by rubbing a piece of iron pyrites very briskly against a piece of flint and catching the sparks upon dried moss, a striking approximation to our flint and steel. Some specimens of this compound of iron were recently shewn us, which were made up of small cubes, but which assumed the form of perfect spheres, varying very little in size. The deposit was represented as being considerable, and the proprietor told us that he contemplated turning this pristine material into coat and vest buttons, an original idea to say the least of it.

Gold in a state of very minute division, supposed to be the result of solution from natural causes, is sometimes met in conjunction with this compound of iron. Such is said to be the case in some situations in the Township of Madoc, where auriferous deposits have recently been discovered. In those cases, however, where gold is found imbedded in opaque quartz, the color of the matrix depends upon the presence of per-oxide of iron.

Iron pyrites is never used for the purpose of obtaining metallic iron, but is employed in the manufacture of Alum, Copperas and Sulphuric Acid, metallurgically speaking therefore it is valueless.

METALLURGY OF IRON.

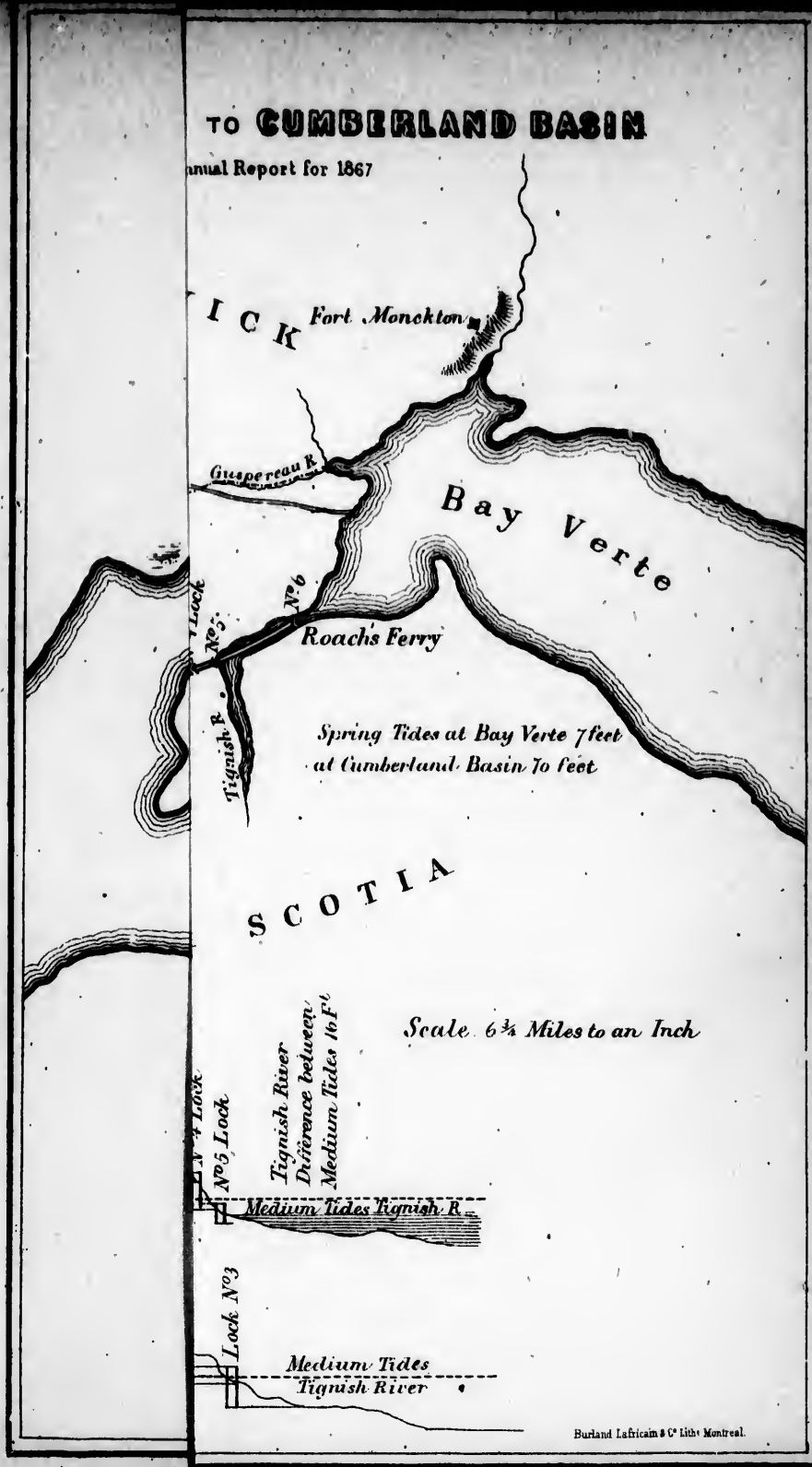
Iron masters employ iron under three different conditions, viz.: crude cast, or pig iron, steel, and wrought iron, the difference between which is always referable to the relative amounts of Carbon in connection with them. Cast Iron contains a larger proportion than steel, so much so indeed as to have been called *steelified steel*, from its containing a large amount of carbonaceous matter, it is therefore extremely brittle, and not at all malleable. To reduce this material to the state of malleable iron, it must be freed from the carbon entirely; this is done by keeping it continuously in a state of fusion,

stirring and kneading it all the time. By this process the oxygen and carbon are caused to unite, and are expelled in the form of carbonic acid gas; the molten mass is then subjected to the action of large ponderous hammers and rollers, by means of which all other impurities are got rid of. The iron is now no longer crystalline or granular, but fibrous and ductile, and is known as forged or wrought iron, and susceptible of being welded and worked by hammers in any form. (Illustration—the hammered work of the Parliamentary buildings by Midford).

The third condition to which iron is capable of being reduced is *steel*. The process it undergoes in this case is exposing it to heat in contact with carbonaceous matter, practically illustrated by bedding iron in alternate layers with charcoal, and exposing them in *luted* crucibles for six or eight days, during which time they are subjected to a very strong heat. This process is familiarly known as *cementation*. During this operation, the iron combines with the carbon, and is converted into blistered steel. This again is rendered more perfect and malleable by subjecting it to the hammer, or it is fused and cast into small bars, known in the trade as cast steel.

[The first smelting of the Hull Iron Mines took place on Friday, the 18th of January, 1867, on which occasion between two to three tons of this ore were smelted, since which up to this time the quantity has been doubled.

As an article of commerce this iron, if not subjected to either constant vibration or great friction, will, after undergoing the hammering process, be rendered susceptible of being drawn out into long bars, and which, instead of crystals, will be found to be made up of fibres running in the direction of their length. The circumstance, however, of the metal continuing to assume the fibrous instead of the crystalline form, cannot be guaranteed for any indefinite period. On the whole it will be found to be a material of very superior excellence, and one which cannot fail to command a high position in the market, and establish for the Ottawa Valley a name and a reputation as an iron country scarcely surpassed in the world.


TO CUMBERLAND BASIN
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Bay Verte
No 6
No 5
Roachs Ferry
Tignish R.
Spring Tides at Bay Verte 7 feet
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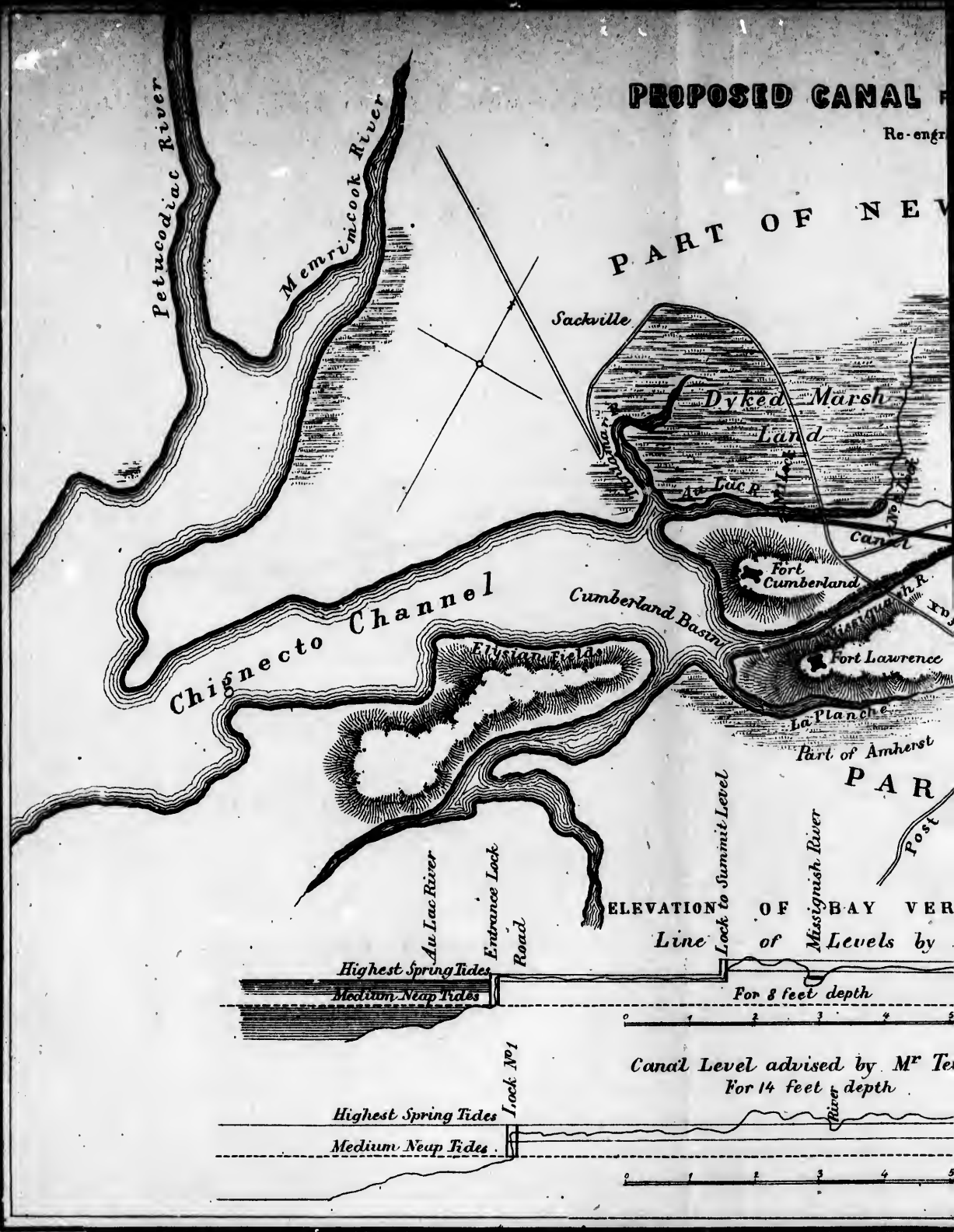
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Fort Lawrence
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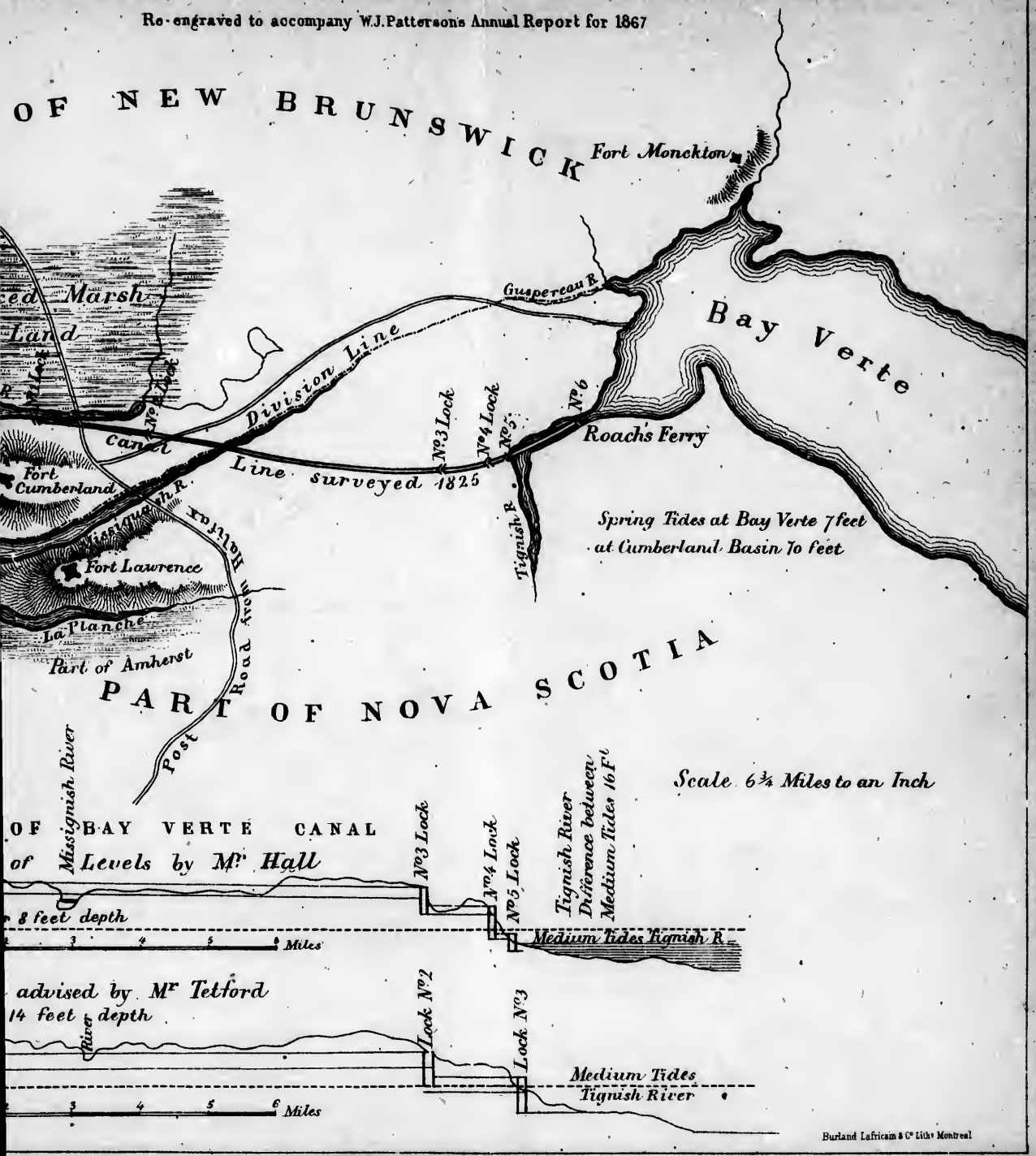
Line of Levels by
Au Lac River
Entrance Lock
Road
Lock to Summit Level
Missiguish River
Highest Spring Tides
Medium Neap Tides
For 8 feet depth
0 1 2 3 4 5
Canal Level advised by Mr Te
For 14 feet depth
Lock No 1
River
Highest Spring Tides
Medium Neap Tides
0 1 2 3 4 5

ED CANAL FROM BAY VERTE TO CUMBERLAND BASIN

Re-engraved to accompany W.J. Pattersons Annual Report for 1867



Burland Lafricain & Cie Lith. Montreal