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IRON ORE DEPOSITS OF THE
RIVER TAMAR DISTRICT.

NOTES BY T. C. JUST. ESQ. 1891

*NOTES by T. C. JUST, (formerly Local Director British and Tasmanian Charcoal Iron Company, Limited), on the Iron Ore Deposits of the River Tamar District, Tasmania, and on the Manufacture of Pig Iron therefrom.**

THE deposits of Iron ore to which this paper relates are those on the western side of the River Tamar, forming a series of ridges underlying to the eastward the line of hills known as the "Asbestos Range," which forms the watershed of the country between the River Tamar and Port Sorell. The principal iron-bearing country is situated upon two arms of the Tamar known as West Arm and Middle Arm, and within five miles of George Town Lighthouse, at the mouth of that river. This district was once generally known as Ilfracombe, but the name now properly applies to the township on the western shore of Middle Arm.

Very early in the history of the Colony attention was directed to these iron deposits, and Lieut.-Governor Collins forwarded a quantity of the ore to England, but what became of it is not known. Mr. Surveyor-General Evans, writing in reference to it (1822) says:—"Within a few miles of Launceston there is a most surprising abundance of iron. Literally speaking, there are entire mountains of this ore, which is so remarkably rich that it has been found to yield 70 per cent. of pure metal. These mines have not yet been worked; the population, indeed, of the settlement will not allow this; but there cannot be any doubt of their becoming at no very remote period a source of considerable wealth to its inhabitants." In a report of Commissioner Bigge, who was appointed many years ago to enquire into the state of agriculture and trade in New South Wales, occurs the following sentence:—"No attempt has yet been made to convert into metal the iron ore that has been found in New South Wales and Van Diemen's Land. At the distance of eight miles from Port Dalrymple, in Van Diemen's Land, considerable quantities of iron ore have been discovered upon the surface, which, upon analysis in this country (England), have been found to consist of pure protoxide of iron, similar to the black iron ore of Sweden, and furnishing a very pure and malleable metal."

In 1872 the late Mr. James Scott and myself took up, under the Mineral Regulations, 400 acres of this iron-bearing land, and formed the British and Tasmanian Charcoal Iron Company, which expended over £80,000 in the endeavour to establish a large iron factory, with what result will be presently explained. Before engaging in such expensive operations every care was taken to ascertain the true quality of the ore, as the following record of analyses will show:—"Mr. G. Foord, Government Chemist and Assayer of Melbourne, described samples of magnetic iron ore sent to him from Anderson's Creek to contain 70 per cent. of metallic iron, and said that if the ore existed in any quantity, and under circumstances otherwise favourable for economic treatment, its high percentage of iron and its freedom from all obnoxious constituents will render it of great value for iron and steel manufacture.

In 1872 Mr. Sydney Gibbons, F.C.S., the well-known analyst of Melbourne, tested six samples of brown hematite ore forwarded from this

* See also pp. 88-90, *ante*, for further particulars regarding the Iron Deposits of Tasmania.—ED.

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locality, which ranged for metallic iron as follows:—49·50 per cent.; 58·5 per cent.; 59 per cent.; 68 per cent.; 52 per cent.; and 69 per cent. Mr. Gibbons declared all to be remarkably fine samples of their kind, free from all features of an objectionable character, such as phosphorus, &c.”

Analyses made in England were even more satisfactory. A sample tested at Lay's Chemical Works, near Stourbridge, in 1872, yielded 50·9 per cent. metallic iron. A sample tested about the same time by Messrs. Johnson and Sons, assayers to the Bank of England, H.M. Mint, &c., yielded 59·50 per cent. Mr. James W. Montgomery, F.C.S., of the Chemical Works, Whitehaven, tested a sample “of magnetic oxide of iron of excellent quality,” and found it to yield 71·80 per cent. metallic iron. A further sample of ore yielded 63·79 per cent., and another sample 63·24 per cent. metallic iron. Dr. John Black, Ph. D., tested a sample of iron from Anderson's Creek in 1873, which, he estimated, would yield of pig iron 64·42 per cent., or of metallic iron 59·47 per cent., or in quantity as follows:—Pig iron, 12 cwt. 99 lbs. per ton of ore, or, in other words, 31 cwts. 5¼ lbs. of ore would be required to make a ton of pigs.

Mr. R. Carter Moffatt, Ph. C., tested two samples of ore, one of which yielded 61·74 per cent., and the other 70·72 per cent. of metallic iron. Other samples were tested with equally favourable results by Dr. Wallace, of Glasgow, and other analysts.

It is remarkable that in but one of the analyses was the mineral chromium mentioned, and then only “a trace;” while in an analysis made by Mr. Alfred H. Allen, F.C.S., the Public Analyst for North Derbyshire and Sheffield (26th January, 1877), showed chromium, none; sulphur, 0·73 per cent.

It should be noted here that soon after the British Tasmanian Charcoal Iron Company was started, Messrs. Evans, Douglas and others formed the Hematite Iron Company, to smelt iron ores on land about five miles distant. They erected a small furnace and produced some excellent pig iron, but not on a scale to be profitable. An analysis of their ores made by Mr. Woodgate in 1880 is given by Mr. Johnston in the Official Record. Out of four samples two show only traces of chromium, while two others exhibit 3 per cent. and 3·4 per cent.; yet the analyses of iron “reduced from the Ilfracombe Ores” show chromium to the extent of 5·1 and 4·6 per cent. respectively, according to the same authority. I think there has been some confusion about the samples treated, and that the pig iron was most probably from the British and Tasmanian Company's works. As a matter of fact, the Hematite Company were taking their ore from an open cutting near the surface. The experience gained at Anderson's Creek showed that the chromium did not present itself until the mine had been considerably opened out. I fear, however, that the ores of the whole West Tamar District are more or less impregnated with chromic oxide, which renders the pig iron hard or brittle, and unmarketable, excepting for very special purposes. Nevertheless, some good iron was made.*

Towards the close of 1875 the Hematite Iron Company shipped to England 200 tons of their pig iron, which realised the very high price of £6 7s. 6d. per ton, ordinary Scotch pig being then quoted at £3 6s. per ton cash at the works. The iron was reported of “good quality,” but the pigs very roughly cast. The analysis of this iron was as follows:—

* The Anderson Creek deposits, containing chromium, form only a very small portion of the Iron Deposits of Tasmania, and there is no evidence of the presence of chromium in other extensive deposits, such as at Heemskirk, Mount Donaldson, Penguin, and other notable localities.—Ed.

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IRON ORE DEPOSITS.

Iron	94·40
Combined Carbon	0·96
Graphite	3·08
Silicon	0·89
Sulphur	0·22
Phosphorus	0·09
Manganese	0·24
Loss	0·12
	100·00
	100·00

The magnitude of the Iron ore deposits at the Iron Hills, Anderson's Creek, (included in the British and Tasmanian Charcoal Iron Company's lease) was well tested during 1873, when three bores were put down on Mount Vulcan, 218 feet above the Creek, and 262 feet above sea level, to depths of 87 feet 6 in., 70 feet, and 49 feet 6 inches respectively. The results from the surface were as follows:—

No. 1 Bore:—19 feet 6 inches ironstone; 19 feet clay with iron pebbles; 10 feet 6 inches conglomerate oxide and magnetic iron; 1 foot 3 inches pure magnetite; 6 feet 9 inches green and blue clay; 1 foot 6 inches pure magnetite; 29 feet decomposed greenstone; then hard rock, believed to be ironstone. Augers broke, and bore was not continued.

No. 2 Bore:—19 feet ironstone; 5 feet 6 inches sand with iron pebbles; 8 feet 6 inches magnetic iron; 24 feet 6 inches decomposed greenstone; 12 feet 6 inches serpentine. Water prevented further boring.

No. 3 Bore:—24 feet ironstone; 6 feet 6 inches clay and iron pebbles; 3 feet 6 inches ironstone; 4 feet black sand and iron; 2 feet 6 inches ironstone; 2 feet soft ironstone; 7 feet brown hematite; in same when bore was discontinued.

Boring was afterwards continued to a depth of 179 feet, showing the same description of country, beds of serpentine rock alternating with seams iron ore. Much of the serpentine carried veins of asbestos. I have not the details of this bore, but it showed very large beds of serpentine. After the first iron ore was struck below the surface, 58 feet of serpentine; then a 5 ft. 6 in. seam of iron ore; then 52 ft. 6 in. of serpentine; and a 6 ft. 5 in. seam of magnetic iron ore. Below this, serpentine and asbestos were again encountered. The bore was discontinued, having proved all that was required for the purposes of the company. Speaking of the one hill, Mount Vulcan, Mr. Robert Scott, the Manager, reported—"By further explorations and borings I found that the quantity of hematite ore might safely be estimated at one million tons, or sufficient to produce 20,000 tons of cast iron annually for the next 25 years. On the top of this hill I bored through 20 feet of hematite, then through 30 feet of clay, and at the time I left the bore was 3 feet into magnetic iron, which latter is not included in my estimate."

I will now proceed to deal with the operations of the British and Tasmanian Charcoal Iron Company. After from £10,000 to £12,000 had been expended in preliminary works, mining, &c., the capital was enlarged to £100,000, and an extensive plant ordered from the establishment of Messrs. A. Barclay and Sons, Caledonian Foundry, Kilmarnock, and erected at Port Lempriere, on the west bank of the Tamar. The works were formally opened on 17th June, 1876, when His Excellency the Governor, Sir F. A. Weld, K.C.M.G., applied the blast to the furnace. This was a large fire-clay cupola encased in heavy plate iron. Its total height was about 76 feet, outside diameter 23 feet, greatest inside diameter 15 feet, and internal capacity

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4500 cubic feet. There were four tuyers, supplied with hot or cold blast by a blast engine of 250 horse power, the air cylinder being 5 ft. 10 in. in diameter, with a stroke of 9 feet. Heating ovens, air receivers, elevators, and all necessary appliances were of the most modern design, the whole plant having specially constructed in Scotland under the supervision of the manager, Mr. R. Scott. A railway, thoroughly equipped, communicated with the mine, and there were two jetties where coal was landed and conveyed direct to a range of 40 coking ovens where it was prepared for the furnace.

The chief difficulty with which we had to deal in treating the red and brown hematite ores of Anderson's Creek was the presence, in unknown quantities, of the mineral called chromite, which contains the metal chromium. Chromite is a dark brown, almost black, crystalline mineral, found in masses in some parts of America and also in New Caledonia; but in Tasmania it is only known in association with our iron deposits, and then at some distance from the surface. The quantity present cannot be determined excepting by an analysis of the products of the furnace, and the appearance of the pig iron produced. A practised eye may distinguish, by the aid of a glass, the mineral running in fine threads through the ore, but it would be impossible to separate it before smelting, and, unfortunately, no means have yet been discovered of eliminating it in the blast furnace in the process of smelting for pig iron.

The metal chromium was discovered by Vanquelin in 1797. It was found in a rare Siberian mineral which contained lead, and was called from its colour red lead, but which is now known as chromate of lead. Chromium is a white metal with a shade of yellow, lustrous, and very infusible. It forms numerous compounds with other metals. Its specific gravity is 5.5. Heated with nitre it forms chromic acid, which is of a red colour, largely used in the arts in the production of various coloured compounds. Chromate and bichromate of potash, for instance, are much employed by calico printers, and the chromates of lead make yellow and red dyes and paints. The oxide of chrome is green, and is used for colouring porcelain and in enamel, while it is said that chromic acid gives its colour to the ruby, and that the green of the emerald is due to oxide of chrome.

It was reported to us that the presence of this chromium would be an advantage in our Tasmanian pig iron, which, it was thought, would bring it into demand for the enrichment and strengthening of steel products, especially such as were required for the manufacture of tools. The Company, therefore, sent large quantities of the iron to England, and had experiments made by the very best authorities and under the most skilled supervision.

Various opinions were expressed at the time these experiments were proceeding as to the value of chrome steel for tools. Mr. Butler, of the Kirkstall Forge Company, spent some months in America, and reported that such tools were used at the works where he was studying, but were found brittle, and laid aside. It is a fact that several chrome iron and steel companies were established in America, and tools made from American chrome steel were at one time offered as a speciality in Melbourne. The chrome there, however, was introduced in the form of chromite ore, found in the vicinity of Baltimore. It is doubtful whether the companies would have worked with an alloy like chromic pig iron.

I now give the result of English experience with the chromic pig iron:—*Mr. William Baker*, an Associate of the Royal School of Mines, London, F.C.S., &c., reported on 18th January, 1877, and referring to an analysis which had been sent to him, says:—"The description of the physical characteristics of this pig iron, viz., that it is hard and white, with large crystalline plates like spiegeleisen, does not correspond to the analysis quoted. White iron contains the carbon mostly in the combined state, and 3 per cent. of

graphite carbon should represent a grey, or at least a mottled iron approaching a softness suitable for foundry purposes. However, *a pig iron with five per cent. of chromium has not yet been known or described*, and as the ores of Tasmania are known to contain Titanium, I am inclined to believe that this is the element, and not chromium, which is present.

The amount of sulphur (0.6 per cent.) is ten times the quantity found in good hematite pig iron, whilst the amount of phosphorus is favourable, and is near the quantities found in our pig irons produced from spathic ores in Durham.

"Supposing the pig iron to contain any amount of chromium, it could only be introduced by the use of ores containing so large a quantity of chrome oxide (chrome iron ore) that the reduction must have been attended with difficulty on account of the infusibility of the slag. There would be, however, no difficulty in removing this element, either in the ordinary methods of refining in the open hearth, or in the process of puddling for malleable iron."

"There are no recorded observations on a pig iron containing even one per cent. of chromium, but alloys have been made in the laboratory which have brought out the fact pretty conclusively that chromium renders steel very hard, and above a certain quantity makes it too brittle to be of any practical value."

"The quantity of chromium which has a useful effect is about 0.6 per cent. I have known tools to be made with this amount, which were certainly superior to tools made of the best Swedish. Lately, some American firm has introduced this steel into the market, but I do not think it is an established fact that it will be a permanent article of manufacture, as I believe the steel is not likely to stand reheating on account of the tendency of the chromium to oxidise, but this may be only a question of proper treatment.

"I should say, from my knowledge of the Tasmanian ores, that, *if smelted with charcoal a superior iron could be produced by skilful management*. For the Bessemer process there should be as much as 3.5 or 4 per cent. of graphite carbon, and about as much silicon. If a pure white iron were made it could be used in the place of spiegeleisen in the melting of steel in pots by the direct process, or for making malleable cast iron. The latter process consists in casting articles, such as wheels, saddlery iron, &c., and heating them in oxide of iron, as done by Crowley & Sons of this town (Sheffield). For this purpose a good white iron is required, free from silicon. The presence of 0.5 per cent., or even a little more chromium, would enhance the value of the white iron [for direct steel-making; but we have no experience of how it would behave in making malleable cast iron."

"In conclusion, I may state that any pig iron containing under .05 of phosphorus is valuable for the Siemens-Martin process, and even to mix with very siliceous or graphitic pigs in the Bessemer process."

In February, 1877, Dr. R. Carter Moffat, of Newarthill, Motherwell, made an exhaustive chemical and spectroscopical analysis of samples of the pig iron which were forwarded to him. He described the samples as "looking very well, No. 1 particularly so. The crystals are very large and plate-like, while No. 2 crystals are small." Having completed his analysis, Dr. Moffat reported it as follows:—

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TASMANIAN OFFICIAL RECORD.

	No. 1.	No. 2.
Metallic iron.....	89.72	97.82
Metallic chromium	9.27	1.43
Sulphur and phosphorus	traces.	traces.
Nickel, cobalt, manganese	—	none.
Tin, antimony, and molybdenum.....	—	traces.
Nitride of titanium	} 1.01	} 0.75
Titanic acid		
Silica		
Oxides of vanadium and carbon.....		
	<u>100.00</u>	<u>100.00</u>
Specific gravity (water 1).....	7.55	6.10

The great hardness of these samples is due, I believe, to the presence of chromium and titanium. The other ingredients found on analysis do not, in my opinion, exercise any specific action. The presence of vanadium, found in both specimens, is rather an unusual constituent. It is likely to be derived from the ores. Titanium, in even less than one per cent., increases the hardness and strength of the iron very much; chromium renders it very hard. Vanadium is, I understand, in great repute for wire-drawing."

(It may be mentioned that the mineral vanadium takes its name from a Scandinavian deity Venadis. The metal was discovered in 1830 by Professor Sefström, of Fahlun, in iron prepared from the iron ore of Taberg in Sweden. This mineral has also been found in a lead ore from Wanlockhead in Scotland, and in a similar mineral from Zimapan in Mexico. Vanadium is a white brittle metal closely resembling chromium.)

Dr. Moffat reported his opinion "that the chromium will not be extracted satisfactorily in the blast furnace. It may be got rid of in part by the use of fluxes put in a few hours previous to running off the metal. A mixture of soda ash and nitrate of soda, in proportions varying with the quantity of chromium and metal in the furnace thrown in, say one hour before tapping the molten pig, may have the effect of oxidising the chromium, in which case the remaining slag will be coloured yellow. The titanium will not, I feel sure, be removed to any great extent.

Very great attention was given to our Tasmanian chromic pig iron by Mr. Edward Riley, who had a laboratory and assay offices at No. 2, City Road, London, and at 14A, Finsbury-square, and was considered one of the best authorities on iron in England. Early in February, 1877, Mr. Riley forwarded an analysis of two samples of pig iron, as follows:—

	No. 1.	No. 2.
Carbon	4.200	3.270
Silicium976	.124
Sulphur207	.562
Phosphorus.....	.055	.054
Iron	88.343	91.362
Chromium	6.287	4.143
Manganese.....	Nil.	Nil.
Copper	Traces.	Traces.
	<u>100.068</u>	<u>99.515</u>

Sample No. 1 was described as white pig iron, with bright silvery crystalline structure, somewhat similar in appearance to spiegeleisen, and by any practical man would be considered the same. Sample No. 2 was white iron with a dull white fracture—what I should call dirty white iron. Judging wholly from its appearance; one would form a favourable impression as to the quality of No. 1 pig, and an unfavourable impression as to No. 2.

Uses as Pig-iron.—As to the effect chromium has on pig-iron, we have no very definite and conclusive information. Pig-iron containing chromium has been used in the United States for making very hard castings. For this purpose the pig must necessarily be grey, and any application of your iron in this direction would bear a mixture. I cannot help thinking an application to a limited extent may be found for making hard castings, and probably chilled castings.

Uses as Wrought-iron.—As to the results of puddling chromium pig (white pig is specially adapted for puddling), I must admit I am unable to give you a very definite opinion. My impression is that the bulk of the chromium will be puddled out—still some will probably be retained, and this, in conjunction with the high percentage of carbon, will, in my judgment, make a hard rigid iron with a high tensile strain. Should this be combined with toughness (a very necessary requisite) it may prove to be valuable for special purposes.

Application for making Steel.—The appearance and character of the No. 1 pig would naturally suggest its use for the manufacture of steel. Unfortunately, the percentage of sulphur is rather high. I am inclined to think the sulphur may to some extent be eliminated, or so modified that some very good chromium tool-steel may be made by an admixture with your pig. Chromium steel has been introduced into this country from America, and the report I had of a tool used in a coal-cutting machine was very satisfactory. The steel I found on examination to contain a very notable amount of chromium. It is asserted by some American patentees that chromium plays the part of carbon, and that chromium steel contains no carbon. This is not correct; still I think chromium may play an important part in tool-steel. Experiments are now being carried out at Sheffield.

As to use in the manufacture of Bessemer Steel.—It has been asserted that an alloy of chromium has the same effect as spiegeleisen in the Bessemer process, and it has been called Chromeisen. As to the success of this application I have no definite information. Looking at the composition of your pig I fear the sulphur would be an objection, and it is very doubtful if chromium would have the effect of modifying the sulphur, as manganese does. It is possible, however, that a mixture of chromium pig might be used with spiegeleisen or ferro-manganese, as a mixture with other pig-iron when in the converter. Its application (except in special cases) in this direction will, I think, be as much due to the high percentage of carbon as to the chromium. This may all blow out: should it not do so, then possibly a little chromium in the steel might make it adapted for the manufacture of rails, giving the rails hardness, with a low percentage of carbon. This will, however, depend on the chromium not interfering with the toughness of the metal, or making it liable to break by impact."

Mr. Riley does not in this communication suggest the possibility of getting rid of the chromium, considering it desirable first to ascertain whether it "may not be a positive advantage." He says, "it is possible the presence of chromium in the ore may prevent the production of grey pig, or at any rate may make the manufacture difficult." . . . "As your iron is quite a new material it will be requisite to try some very careful practical experiments with it under scientific guidance."

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In a communication, dated March 13th, 1877, Mr. Riley criticised the report of Dr. Moffat as "written by a chemical enthusiast," and says, "he is in error as to the titanium, the substance he has mistaken for it being chromium;" and states that even if he did discover the minerals named, "they have not the slightest practical bearing on the question."

He says, further, "The Titanic Iron and Steel Company was an utter failure, and was wound up, and although I have, for clients of mine, for years endeavoured to introduce and use titaniferous iron ores, I have utterly failed to do so." "I can tell you as a fact, from my own personal knowledge, that from £250,000 to £350,000 have been sunk in titanic iron ores in Norway and Canada from which there is no return whatever.

"Some experiments were made with your pig iron at Sheffield by Mr. William Cook. He mixed it with ordinary foundry iron, and made castings with it for machinery. For this purpose it was not in my opinion at all adapted, and the result was precisely as one would anticipate—a weak casting. White pig iron such as yours could only be used for hardening pig iron or making chilled castings."

The experiments made were not very satisfactory. "I saw a bloom that, I was informed, was made by puddling a mixture of half chromium pig and half hematite pig; the bloom was not welded, and could not be worked."

"I should observe that the chromium pig melts with difficulty, and remains unmelted after the iron used as a mixture is fluid. This hardly gives the chromium pig fair play. It should be melted with other pig in a refinery, and then puddled after having been made into metal.

"Four heats in four furnaces were puddled whilst I was at Messrs. Cook's works, one ninth of chromium pig being used as a mixture with hematite pig and pig made at the works. The chromium pig was charged first so as to give it more time to melt. Soon after melting, and before the boil, samples of the cinder were taken. These were found to contain chromium.

"The puddled bar was rolled, cut up, and made into No. 2 iron. The bar contained a very decided amount of chromium. The above experiments prove that some of the chromium leaves the pig, but a certain amount remains even in the finished bar iron.

"There was no marked improvement in the quality of the iron, and the chromium pig retarded the puddling process, the heat requiring rather more work."

Mr. Riley made a number of experiments with a view to reducing the percentage of sulphur in the pig iron. Of these he says:—"In melting your pig (the same sample as that analysed) with 10 per cent. of ferro-manganese, containing 73 per cent. of metallic manganese, the sulphur was reduced from .207 per cent. to .035 per cent. This amount would not, in my opinion, be of much moment in the manufacture of the best qualities of steel." In another experiment, using spiegeleisen instead of ferro-manganese, the sulphur was reduced from .10 per cent. to .075 per cent.

Respecting a small experiment made at Messrs. Henry Bessemer's works at Sheffield, Mr. Riley reported:—

"To make experiments in a 5-ton Bessemer converter was evidently too costly, as the whole of the steel might be spoilt. Some Bessemer metal, after the blow and before adding the spiegeleisen, was run out of the converter into ingots. Forty pounds of this metal was melted with 4 lbs. of your pig in a steel pot and cast into a 3-inch ingot. The ingot was too soft to break with a sledge. When broken under the steam-hammer it had one or two blow-holes all through it. A piece of the ingot when heated to redness crumbled to pieces under the touch of the hammer. I examined this metal and found it

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contained only .27 per cent. of carbon, thus showing both mechanically and chemically it was soft steel.

"A second experiment was made on 30 lbs. of blown metal, same as before, and $1\frac{1}{2}$ lbs. of chrome pig. When the mixture was melted, on running into an ingot it rose a good deal. The ingot, when broken under the steam-hammer, was spongy, and when heated to a red heat and touched with the hammer it went all to pieces."

From these experiments it was considered that chrome pig would not play the part of spiegeleisen in the manufacture of steel.

Mr. Riley examined three samples of ores from which the pig iron dealt with was made.

No. 1 was hard and dark red in colour (with occasionally crystalline structure similar to micaceous iron ore, and slightly magnetic). This, on analysis, was found to contain only traces of chromium. He was of opinion that if calcined this ore should smelt well—should make grey pig, and pig, for all practical purposes, free from chromium.

No. 2.—Brownish red ore, more open in structure, with dark blackish and brown fracture, contained a very appreciable amount of chromium.

No. 3.—Small clayey red ore, similar in appearance to red hematite, contained even more chromium than No. 2.

On the 15th March, 1877, Mr. Riley read a paper on Tasmanian Chrome Iron before the Chemical Society at Burlington House, Piccadilly. In this he detailed the experiments already narrated, and said, "The Americans have made some important experiments on chrome in steel, and he had seen many fine samples of these, although the effect of chrome on steel is not very distinctly known. . . . One very peculiar feature in the Tasmanian iron is that such a large percentage of sulphur should exist with the quantity of carbon in the iron. The carbon is 4.200 per cent., and the sulphur .207, and this rather puzzled him to account for, as the carbon under ordinary circumstances should drive out the sulphur. . . . Here we have an alloy of chrome and iron, and I can't help thinking that we shall yet find some practical application for it."

The Chairman (Professor Abel, of Woolwich Arsenal,) remarked that the pig was shown to be in possession of very peculiar properties, and, regarding the effect of chrome on steel, thought that, as in the formation of some other compounds, the chrome might pass into the steel and produce hardening effects, although then it might no longer be distinguishable as chrome.

Mr. Riley observed that one use of the pig in America was to make very hard pig-iron, and was of opinion that it might be serviceable for chilled shot purposes.

Professor Abel said that as a very low class of pig would serve to make chilled shot, an expensive iron was not required.

The conclusions arrived at by the Chemical Society, after discussion, were—

- (1.) That the chrome pig-iron would not supply the place of spiegeleisen.
- (2.) That the sulphur in the iron could be easily reduced.
- (3.) That an inferior iron being quite good enough for chilled shot, it would not come in there.
- (4.) That something might be done in the direction of its application to the manufacture of steel.

At the annual meeting of the Iron and Steel Institute held in London in March, 1877, Mr. E. Riley introduced the subject of the chromium pig iron made by the British and Tasmanian Iron Company. He repeated much of the information above given, and said, "The above Company have recently

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commenced smelting pig iron, on a convenient site for shipment, on the coast of Tasmania. Some difficulty has been experienced in producing grey iron, the general character of the iron smelted being very similar to spiegeleisen, some having a fracture consisting of two interlaced-shaped crystals, the colour silvery white. The analysis, which he detailed, showed 6.287, 6.55, and 7.050 per cent. of chromium. This was a metal that hitherto has been only found as mere traces in pig iron. Various reports have been received from America as to chromium pig iron being used when any hard castings are required. Also chromium steel has been manufactured by the Chromium Steel Company, Brooklyn, and has been spoken very highly of. Samples sent to this country, on examination, were found to contain a little chromium; others assert that no chromium is present in the steel. The railway bridge across the Mississippi, at St. Louis, is stated to be built with chromium steel. Our information as to the effect of chromium on either iron or steel is very meagre, and the information I can supply is not very positive in its character. Experiments have been made in puddling 14 pig. A mixture of half chromium pig and half hematite puddled with difficulty (this might be anticipated from the high percentage of carbon), requiring much time. The ball from the mixture would not weld on account of a thick cinder, and could not be made into a bloom. The cinder, however, from this heat seemed to affect the quality of the iron in the next heat, where an ordinary mixture of good grey forge-pig was used. . . . Chromium steel is now being manufactured at Sheffield, and an alloy of chromium and iron, called by some, chromeisen, is being sold to mix with steel so as to add a certain amount of chromium to it. It is asserted by Mr. Julius Baur, the patentee for chromium steel, that chromium plays the part of carbon, and may be used to harden the steel in its place, having the advantage of not being burnt out by heating like carbon. He also claims for it the specialities of easily welding either to itself or to iron. I must say that our experience is so small that I can offer no opinion as to the properties claimed for it; should they prove, on further trial, to be correct, then it seems to me that the Tasmanian pig iron will become a most useful source for the metal chromium. The sulphur in our analyses given is a little high, namely, .207 per cent.; this I have found can be readily reduced by melting the pig with ferro-manganese. An experiment made by melting with 10 per cent. of ferro-manganese reduced the sulphur .035 per cent. Mr. S. Kerr states that an alloy of chromium and iron can be used in the place of spiegeleisen. Experiments made with metal from the Bessemer converts before adding spiegel, and the chromium pig iron melted in steel pots, showed that the chromium has none of the properties of manganese, the ingots made from the mixture when heated to a red heat crumbled under the hammer. A sample of alloy called chromeisen sent to me from Sheffield, and now being sold for adding to steel, I found to contain only 7 per cent. of chromium, although asserted to contain from 20 to 25 per cent. of this metal, and to contain also a very considerable amount of sulphur. In conclusion, I think the metal chromium deserves a fair trial, and the Tasmanian pig, which can be supplied in quantity, is a most ready and cheap source for the metal."

"Mr. Allen (Sheffield) was very much pleased to hear how sulphur could be extracted by the aid of ferro-manganese. He had suggested the use of the manganese ore with this chromium ore, and he would like to know whether the puddled iron retained the chromium?"

"Mr. Riley said he had already stated as much."

"Dr. Percy said he wished to draw attention to the fact that two years ago they examined some very fine Russian sheets of iron, and these contained 0.2 per cent. of chromium. This component had the extraordinary property of giving to iron intense hardness, but beyond a certain quantity, it made the

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metal brittle. The other day a gentleman from the United States told him that he had had no difficulty in tempering the steel, and he had come to the conclusion that for its own particular purpose this metal was unequalled."

The exhibition of specimens of our chromium pig iron at the meeting of the Iron and Steel Institute referred to brought it very prominently before the trade. Representatives from Belgium, France, Germany, and America were present, and Messrs. M'Ewan and Co. wrote—"Everyone was quite astonished at the beautiful appearance of it. Dr. Percy himself, the greatest authority in England, wondered at first what could give iron such a splendid appearance. Up till this moment nothing but congratulations on the appearance of the iron has reached us, but we are sorry to say the experiments have not been satisfactory."

Messrs. Sir John Brown and Co., of Sheffield, were (in 1877) engaged in experimenting with chromium steel, being interested in several American patents. Their operations were conducted privately, all that was known being that it was asserted chromium increased the tensile strength of steel. The firm were very reticent. Samples of Tasmanian pig iron were forwarded to them, and Mr. Ellis, the manager, reported that he did not see how they could use it in the manufacture of chrome steel. Subsequently they wrote to M'Ewan and Co.: "It is possible we might bring it into the manufacture of iron, and shall therefore be glad to know at what price you can supply it."

Messrs. William Cook & Co., of Sheffield, reported on some of their experiments on 26th February, 1877—"Mr. Cook had 12 pieces of machinery made of iron containing one-seventh of chrome pig. These pieces were broken in less than one day's work: the lot should have lasted 28 days. Mr. Cook thinks it is even more dangerous for castings than in malleable iron."

The same firm, in a lengthy report dated 12th March, 1877, say: "The chrome iron cannot be worked by itself so as to produce malleable iron. The metal it yields, when subjected to the operation of puddling, appears to be entirely destitute of the property of welding, and consequently can neither be hammered nor rolled. A mixture was made containing one-ninth of chrome iron, the other metal being of good average quality. On working this charge in the puddling furnace, it was found that chrome exercised a very powerful influence in retarding the fining of the iron, and also largely increased the percentage of waste. The resulting iron rolled into bars very fairly, but when drawn into wire it was found to be very defective, owing to the imperfect manner in which the particles of metal had welded together. Castings containing one-seventh of chrome were rendered considerably harder, but at the same time were so exceedingly brittle as to be utterly unsuitable for machine work. The various experiments we have made have tended to show that chrome iron is not only of no value by itself, but even exerts a very detrimental influence upon otherwise good iron."

Messrs. William Siemens & Co. were solicited to interest themselves in the chrome iron, but for a considerable time they refused. Ultimately, they purchased 50 tons of the iron which was delivered from the last shipment, but I never heard the result of any experiments made with it.

Mr. R. F. Mushet, of Cheltenham, the great English authority on steel, and one who had a great deal to do with the establishment of the Bessemer process, reported on the Tasmanian ores thus, under date 8th March, 1877:—"I have received the analysis of Tasmanian ores. These ores are generally very good, and that described by Messrs. Baird No. 1 is a magnificent ore, and if pure in bulk would be most valuable for direct steel making. Grey iron made from these ores generally would be suitable for the Bessemer process. I much regret that the iron is white in place of grey, and that it has been smelted with coke in place of charcoal, as I hoped it might have

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been. * * * The presence of 6.287 of chromium, if really in the iron, is likely to confer value upon the metal beyond that of ordinary pig iron. But the ores do not show the presence of chrome oxide in quantity sufficient to account for more than, at most, one-sixth of the percentage found by Mr. Riley; and Mr. Riley, on the other hand, may have been in error. As to the ores being quite free from titanitic acid that is unquestionably an error; but the analysts have mistaken this acid for a portion of the silicic acid present in all the ores. This is a common mistake."

Messrs. Charles Cammell & Co., of Sheffield, had a small lot of the chromium pig iron for the purpose of experiments, but never reported very fully as to results. In a letter to Messrs. McEwan & Co. they said: "We endeavoured not to produce a steel by substituting chromium for carbon, but simply to improve the carbon steel by the introduction of a small quantity of chromium, which we were given to understand was of great efficacy. So far as we went with the experiments we noticed no decided improvement."

Messrs. Neilson Bros., Mossend Ironworks, under date 14th March, 1877, report:—"The assay shows a high percentage of chrome, and is very high in sulphur, which, you will find, it is difficult to reduce. For making steel such a quantity is fatal. The phosphorus is also high." * * * On 29th March the same writer reported:—"I am sorry to say the account of the Tasmanian pig is not favourable when wrought by itself. It is almost impossible to work it alone without mixing it with flux, cinder, or hammer slag. We charged it alone, but could not get it to work. After melting the cinder was like glass, but after adding good clean slag it wrought better. The puddled bar that was made from it is very black in colour and loose in the fibre. I think it would make a very good mixture with North of England pig, but will not do by itself for puddling. If you could reduce the sulphur it would be very much improved."

A trial of the iron was made by the Patent Shaft and Axletree Company, Wednesbury, the manager of which reported on 15th March, 1877:—"We have not had time to try it in any other way but puddling, and it does not answer well in this, being of such a dry nature that the bar was not sound at all, though the portions were considerably tough and fibrous. Possibly with a suitable mixture it might yield far different results in this respect. Puddled alone the yield was below that of other good irons."

Under date 11th April, 1877, the Manager of the Steel Company of Scotland, Newton, wrote respecting a trial under the Martin-Siemens process. "I used 25 cwt. of hematite and 5 cwt. of chromium pig and worked it with ore. Supposing all the chromium to have gone into the steel there would have been 1.1 per cent.; but I find 0.219 per cent. chromium, 0.048 per cent. sulphur, 0.490 per cent. manganese, and 0.45 carbon; so it is evident the chromium oxidises to a considerable extent, though not so readily as manganese. Adding the chromium pig at the end, I could regulate the amount put into the steel; but I wished to ascertain its rate of oxidation in the bath. One of the ingots (I only had two) was rolled into rails last night. The rails appeared very good, but harder than usual, with a steel of 0.45 carbon. There have been no mechanical tests made of it yet. If we were making rail steel we could only use a portion of this pig in a charge, about one-sixth, and we could only add that to hematite pig. If we were making steel from more impure irons (viz. $\frac{1}{4}$ Scotch) so that the steel contained 0.25 or so of phosphorus, I scarcely think we could then use chromium pig. I am inclined to try making tool steel with it." In a postscript the manager says: "I have just seen one of the chromium rails punched; it seems pretty tough, and is altogether a very good solid-looking rail."

Messrs. Ward & Payne, of Sheffield, under date 12th April, 1877, give

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IRON ORE DEPOSITS.

the result of trials with Tasmanian pig iron and ferro-manganese for steel for the manufacture of tools.

No. 1 Ingot.

36 lbs. Swedish iron.
9 lbs. chromium pig.

Produce.—A steel that looks well; works fairly in forging. Its hardening and edge-enduring properties not sufficiently ascertained.

No. 2.—A blank.

40 lbs. chromium pig.
4 lbs. ferro-manganese.

Product.—Worthless.

No. 3 Ingot.

40 lbs. Swedish iron.
4 lbs. pig.
2 lbs. ferro-manganese.

This is a very tough ingot, very difficult to break.

Article tried, Chisel for Stone.—Hardened at a low heat and tempered blue. Made an edge that would cut the hardest stone—granite.

Joiners' Firmer Chisels.—Cuts wood fairly well in a short trial. Should doubt its enduring quality. It would want sharpening much oftener than our best steel chisels.

Hammers.—Did not stand the hardening; cracked; face came off; too hard for these goods.

No. 4 Ingot.

42 lbs. Swedish iron.
6 lbs. pig.
2½ lbs. ferro-manganese.

This produces when hammered and rolled a very fine-grained beautiful-looking steel.

Tried it for—

Joiners' Firmer Chisels.—Found too hard when tempered very low. Stood the edge just fairly, but doubtful.

Files.—Too hard again; the teeth stripped off in filing cast steel. Would have filed iron well enough.

Engineers' Chipping Chisel.—Would not stand this test at all. Too brittle.

Turning Tools.—Does not seem adapted for this use. Wants more tenacity, although, when cold, it breaks tough, and, under the hammer, works soft.

Mr. Spencer, of Newcastle, also reported having made some fine tool steel from Tasmanian iron, but I never saw the details.

I had some tools made from the cast iron which were exhibited at the Sydney Metropolitan Exhibition in 1877, and attracted a good deal of attention. They showed the hard and tough qualities of the iron only.

Other trials of the iron were made at several works, from some of which the reports were meagre and unsatisfactory, others confirming what has already been shown.

Mr. J. Fowler and Co., of Leeds, tried it for cast malleable castings.

Mr. William Menelaus, Dowlais Iron Works; Messrs. James Watt and Co.; Messrs. Crowley and Sons; Messrs. Vickers and Co.; Messrs. Brown, Baily, & Dixon; and the *Chillingworth Company,* all received the iron and experimented with it, but without more satisfactory results than already shown.

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The opinion was pretty freely expressed in England, as well as in the Colonies, that the Company ought to be able to make grey pig iron from selected ores, if great care was taken as regarded the fluxes, coke, lime, &c. used, and many who profess to be authorities declare that it could be done now. Need I say that before admitting a failure we exhausted every known possible means of manipulation. Mr. Robert Scott, the manager, was an old experienced iron works manager in Scotland, and was largely interested in the success of the enterprise. Whilst the furnace was in blast I spent weeks with him at the works, and discussed with him night and day the experiments which were put in operation. We had a skilled analytical chemist there for some time, carefully examining what went into the furnace and what came out of it. The closest supervision was given, and details watched most minutely, but we never could get the iron sufficiently grey or soft, nor could we secure uniformity or quality. A great deal of iron was made equal to the best Scotch pig, but this would represent but a small proportion of a tapping, the bulk being white, crystalline, and hard. The ores for the furnace were carefully selected, and charged both raw and calcined; the quality of the limestone was watched narrowly, as also other fluxes which were tried. The fuel used was chiefly coal from Bulli Bulli, New South Wales, which was carefully coked on the works, and the coke seemed of very excellent quality—at least experts declared it could not be better. I should mention that Bulli Bulli coal was decided on after exhausted trials of the coal from the Newcastle mines, none of which produced anything like as good coke. Operations were not confined to smelting with coke. Charcoal made from the native wood growing around was tried on several occasions, also mixtures of fuel, but all to no purpose—the product remained hard and unmarketable in quantities such as were produced.

I should mention here that as an alloy the pig iron was found very valuable in the colonies for particular purposes, and the foundry masters would have become regular customers for small quantities for mixing with other irons. In the production of such articles as stamper-heads, and false bottoms for quartz mills, or anything where extra hardness is required, the chromium pig was found excellent when used in the correct proportion with ordinary pig iron; but, of course, a demand of this kind would have been quite insufficient to dispose of the output of a furnace such as ours.

Reluctantly, and with bitter disappointment, we had to declare ourselves beaten in the endeavour to make saleable pig iron out of the iron ores of the Ilfracombe District, and the splendid plant had to be broken up and sold. The large circular water tanks seen along the Main Line Railway were once the shell of the first great blast furnace erected in Tasmania, and the iron columns on which they are supported once formed the elevator by which the ores and other materials were hoisted to the tunnel-head or mouth of the furnace. " 'Tis an ill wind that blows nobody good,"—and Mr. Grant got a great bargain in those materials.

I have often regretted that before operations were stopped I did not have an opportunity of testing the quality of the dense masses of specular iron ore found at Penguin Creek and in the neighbourhood of the Rivers Blythe and Gawler. I had an idea that if these were mixed with the Ilfracombe ores a marketable product might be the result. I was anxious that this should be tried, and Mr. Scott approved of the proposal, but after what had happened we did not feel inclined to depend upon laboratory trials only. The cost of mining a quantity of the ore and conveying it round to the works would have been considerable, and as the finances were exhausted the idea had to be abandoned. I commend it to anyone who may in the future feel inclined to tackle the Iron Industry in Tasmania.