

História da Geociências

The iron ores of Brazil

O minério de ferro no Brasil

Resumo

Em 1910, realizou-se o XI Congresso Internacional de Geologia, em Stockolmo, onde foi apresentado o trabalho “The Iron Ores of Brasil” por Orville A. Derby, Diretor do Serviço Geológico e Mineralógico do Brasil (SGM). Esse trabalho, o primeiro no gênero, foi a página inicial de uma seqüência de estudos geológicos empreendidos pelo Serviço Geológico, então criado em 1906.

O autor faz, de início, uma retrospectiva da intensa demanda do ferro metálico obtido em forjas diversas e do desconhecimento das matérias-primas, citando as ocorrências das mesmas no período colonial e real.

Abstract

In 1910 he held the XI International Geological Congress in Stockolm, where he was presented the paper “The Iron Ores of Brazil” by Orville A. Derby, Director of the Mineralogical and Geological Survey of Brazil (SGM). This work, the first of its kind, was the home of a sequence of geological studies undertaken by the Geological Survey, then set up in 1906.

The author, at first, a retrospective of intense demand of the metallic iron obtained in several forges and the lack of raw materials, citing instances of the same in the colonial and real.

Orville A. Derby

Director of the Serviço Geológico
e Mineralógico do Brasil, Rio de
Janeiro - Brasil

Nota

Esse trabalho foi publicado há 100 anos:

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The colonial records of Brazil register the fact that about 1590 an exploring party, that set out from the town of São Paulo, founded about forty years before, reported the finding of iron ore in a mountain situated about 100 kilometers to the southward. Gold and silver were also reported from the same region, and acting on this information the Portuguese Government took measures to promote the mining industry in the colony by sending out, in 1597, officials especially charged with this mission. The inclusion of an iron founder in the party indicates a special interest in the discovery of iron ore. One or two small forges were set up which commenced to produce iron probably about the year 1600 and continued in activity to about 1629. The place subsequently took the name of *Ipanema* which has ever since been in separately connected with the long, though not brilliant, history of the iron industry in Brazil. There is a reasonable probability that the iron produced here was the first to be manufactured on the American continent.

About the same time a forge was established close to the town of São Paulo in order to work the lean argillaceous ore that abounds in the vicinity, but it does not seem to have had a prolonged existence.

About a hundred years later the rich gold fields of the district of Ouro Preto, the former capital of the slate of Minas Geraes, were discovered and by the year 1700 the rush that ensued was fully established. This opened up to exploration and permanent settlement the most extensive and important of the Brazilian iron fields, that of the *Serro do Espinhaço* or Backbone Range, forming the eastern rim of the basin of the São Francisco river. A large part of the gold mines of this and the neighbouring district are actually in iron ore which, from the difficulties it presented to the miners, must have necessarily attracted their attention to a marked degree, though a century or more elapsed before any recorded efforts were made to turn it to use.

There is, however, a reasonable presumption that long before the definite establishment of the iron industry in this region some metal may have been produced by the primitive African methods with which many of the slaves imported in immense numbers for the working of the gold mines must have been familiar. Eschwege states that in 1811 when he arrived in the district most of the smithies then existing produced their own iron, either directly by the spoonful, in an ordinary blacksmith's forge, or in a primitive furnace constructed especially for the purpose. Two men who were still living at that time, disputed the honor of being the first to introduce the process which was thus presumed to have been a recent event.

Under the direction of Eschwege a company was formed to erect a direct process plant in the neighbourhood of Ouro Preto which commenced to produce metal at the end of 1812 at the rate of about a hundredweight per day. The improvements here introduced were eagerly copied and in a short time the whole milling district of Minas Geraes was dotted with little furnaces. The number of these was estimated in 1864 as 120, many of which are still in operation.

In 1765 the production of iron was resumed at Ipanema in São Paulo but again abandoned after a few years. An attempt made in 1800 to revive the industry, this time by means of a high furnace, was unsuccessful, and in 1810 a Swedish metallurgist, under contract with the Government, constructed four direct process furnaces which continued in operation until 1818 when two high furnaces constructed by the German engineer officer, Frederic von Varnhagen, then in the service of the Portuguese Government, were put into operation. These continued in blast, under Government administration and with a daily production of 3 to 4 tons until 1895.

Between 1809 and 1814 an attempt was made to establish a high furnace at the Morro de Pilar in the neighbourhood of Serro in Minas Geraes, but the enterprise was abandoned before reaching the productive stage, and until 1888 all the iron produced in Brazil, outside of Ipanema, was made by the direct process. In that year a high furnace with a daily capacity of 4 tons, afterwards raised to 6, was put into blast at Esperança near Itabira do Campo in the state of Minas Geraes and this has continued in successful operation until the present, being now the only establishment of its kind in the whole country.

This inglorious history extending over two centuries is naturally suggestive of the existence of natural conditions unfavorable to the development of an iron industry in the country. Such unfavorable conditions exist, but for our present purpose it is sufficient to say that a deficiency of ore of excellent quality and in good working conditions, as regards mining, is not one of them.

Iron ores of good appearance are known in every state of the Brazilian union and specimens of them figure in every national exposition, but for the most part definite information regarding the deposits is lacking. The greater part of the specimens exhi-

bited in expositions and museums are magnetites, and the majority of those that have been examined have proved to be quite highly titaniferous. A good deal of specimens of hematites of excellent aspect, representing numerous widely separated localities, have also appeared.

Limiting ourselves to the districts regarding which definite information is at hand, it may be said that these belong to the states of Minas Geraes, Bahia, Goyaz, São Paulo, Paraná, Santa Catharina, Rio Grande do Sul and Matto Grosso. The ores known in the first three and the last of these states are predominantly hematites; in the others predominantly magnetites.

With a single exception none of these ore districts have been studied in a way to give the definite information desired for the proposed discussion of the subject of iron ore supply by the International Geological Congress. For the most part our knowledge of them is limited to the mere fact of their existence, their approximate geographical position and the outward aspect of the ore picked up by unskilled observers. These almost invariably report enormous quantities ("whole mountains" is the usual phrase) of most excellent ore, and in many cases it may be presumed that these statements may eventually be proved to have some foundation in fact, but for our present purpose such districts must be left entirely aside.

The above mentioned exception is the district situated in the eastern central part of the state of Minas Geraes in the section of the Espinhaço range that forms the divide between the Rio Doce and São Francisco drainage systems extending over about two degrees of latitude with a width of about one degree of longitude. As already remarked this is also the most productive or the gold fields of Brazil and in consequence is one of the oldest and most densely populated or the interior regions of the country. On this account and also on that of being on the road to the diamond region of northern Minas Geraes, it

has been more frequently visited and described by travelers, scientifically and otherwise, than any other interior region. Notwithstanding this fact, however, it has only been very imperfectly mapped and there is a singular lack of reliable and accurate information regarding its geological and economic features. This lack is now being supplied by the work of a small party of the Serviço Geológico e Mineralógico do Brazil, under the direction of Dr. Luis Felipe Gonzaga de Campos, that for the last two years has been occupied in mapping the district, both topographically and geologically. Thus far only about half of the known iron field has been covered by this work which is a reconnaissance, rather than of a definite character, though including a somewhat detailed study of some of the most prominent of the ore masses. The following brief account of the district is taken almost exclusively from a preliminary report now in course of preparation by Dr. Gonzaga de Campos.

The situation of the district with reference to the seaboard and to the means of communication is shown in the accompanying sketch map (Figure 1). At present the only means of access is by the Central Railroad of Brazil which, starting from the port of Rio de Janeiro, enters the district by its southern border at kilometer 493, traverses it in a north-south direction for a distance of 90 kilometres to Sabará and extends a branch transversely across it which when

completed to Santa Barbara will have an extension of 60 kilometres. This is a Government road with a gauge of 1.60 m for 498 kilometres to the station of Miguel Burnier, and of 1m from that point onward. The Leopoldina Railway, a narrow (1 meter) gauge road belonging to an English company, starting from the same port with a present extension of 630 kilometres will eventually tap the district at its northeast corner at Itabira do Matto Dentro with an extension of about 87 kilometres. The Victoria and Diamantina Railroad, also of 1m gauge and belonging to a French company, is now under construction from the port of Victoria in the state of Espirito Santo toward the same point (Itabira) which it can reach with a total extension of about 630 kilometres. It is understood that the company proposes to complete this line as rapidly as

possible and to equip it especially as an ore carrying-road. If this is done and if the port of Victoria, which is an excellent one, is properly equipped with handling facilities, one of the most important parts of the district will have a satisfactory outlet in the near future.

The part of the region that has been mapped with approximate accuracy is represented in the accompanying special map (Figure 2) in which the iron-bearing formation covers an area of about 5700 square kilometres. The ore field is known to extend to the northward, northeastward and southwestward beyond the limits of the map which thus embraces only from a half to two thirds of its total area.

In its essential geological features the region is constituted by a basement complex of crystalline schists (gneiss,

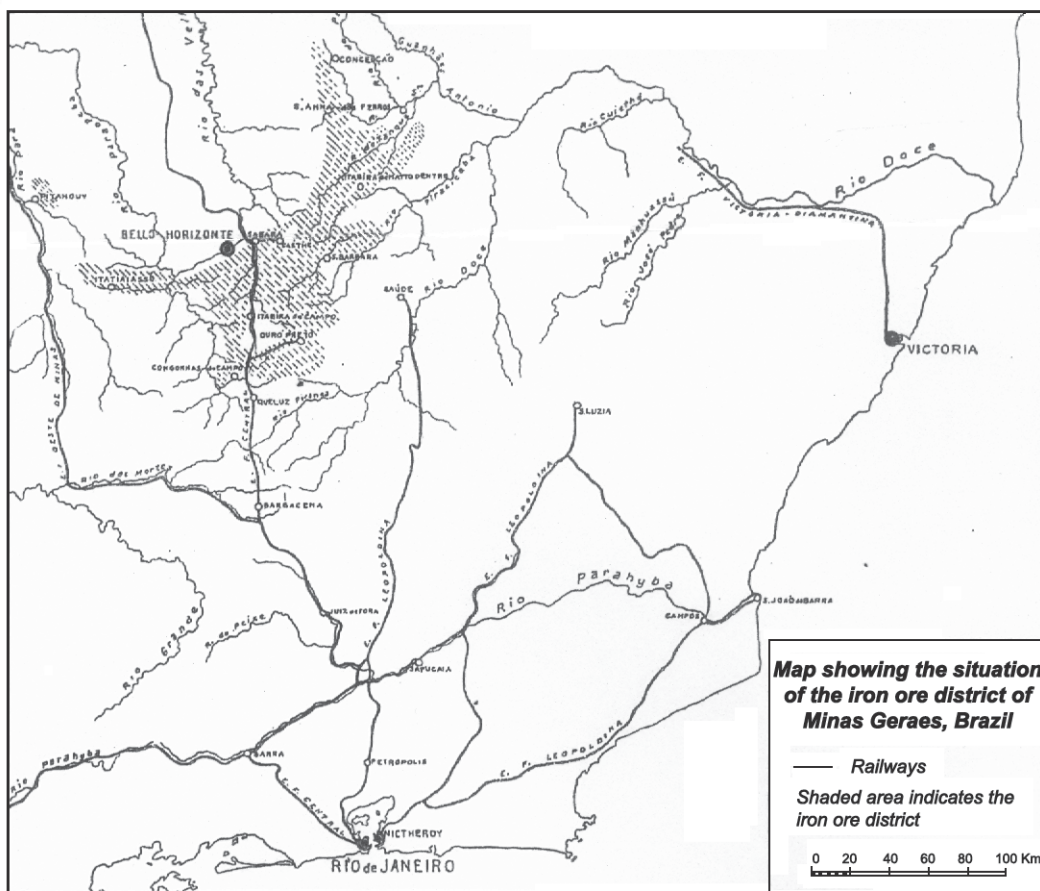


Figure 1 - Map showing thh situation of the iron ore district of Minas Geraes, Brazil.

mica-, amphibole-, chlorite- and talcose-schists) much injected with granite, and overlaid by a heavy series of partially metamorphosed sedimentary beds, profoundly folded and faulted. In this series, which consists principally of quartzites and clay slates with subordinate beds of limestone, a prominent member is the peculiar iron-bearing quartzite to which the name of itabirite has been applied.¹

This shows all possible gradations from an almost pure quartz-rock with scattered flakes of hematite to a massive hematite, free from quartz. The latter presents itself as intercalated layers, or lenses, varying from a few millimetres up to scores of metres in thickness, alternating with leaner quartzose portions. When limestones occur in the series, they also are generally more or less heavily charged with flakes of hematite and are frequently associated with commercially valuable ores of both iron and manganese.

Taken as a whole, the itabirite beds, which are often of great thickness, become, when exposed to the weather, extremely friable, and as the region is one of heavy rainfall (1500 to 2000 millimetres) they have been extensively denuded. In consequence of this, the massive portions, when

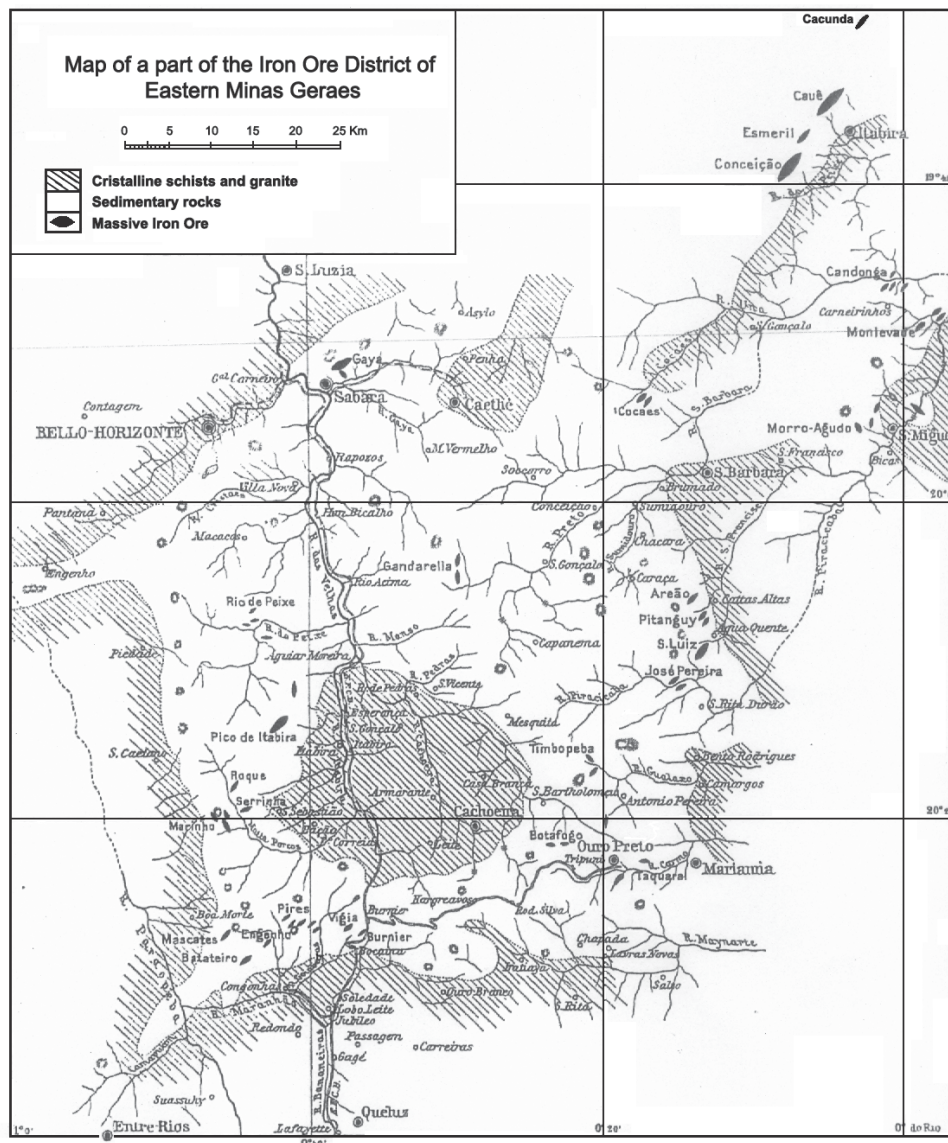


Figure 2 - Map of a part of the iron ore district of Eastern Minas Geraes.

they occur, stand out as prominent topographical features; the rain and wind swept slopes become covered with a rubble of iron ore due to the

breaking up of the thinner intercalated layers, more or less completely freed from the associated siliceous elements by rain and wind action, and the

¹ This name was originally proposed by Eschwege, in 1822 (*Geognostisches Gemälde von Brazillien*) for the massive pure iron ore of which the peak of Itabira do Campo, amongst others, is composed, and which is associated with a schistose rock composed of granular quartz and scaly hematite which he discriminated as iron-mica schist (*Eisenglimmerschiefer*). By common usage the name has come to be applied to the latter rock, and it is only in this sense that its retention can be justified as a convenient term for a rock type that would otherwise have to be designated by an awkward and misleading descriptive name. Through variation in the relative proportions of the constituent elements this type of rock grades off on one side to a purely quartzose and on the other side to purely hematitic phase. The phases sufficiently rich in iron to be commercially valuable may be conveniently designated as Itabirite Ores.

bottom lands of the valleys become charged with deposits of iron sand separated by the natural sluicing of the streams. There are thus produced from the same series of beds three classes of ore, namely:

- Quarry ore in the peaks and other natural exposures in situ of the massive portions of the rock.
- Rubble ore on the denuded surfaces.
- Sandy ore in the valleys where sluicing action has taken place.

To these must be added a fourth class, the so-called “canga” (contraction of *tapanhoacanga* = Negro’s Head) due to the cementation by limonite of the rubble ore into a hard ironstone conglomerate. It is probable also that still a fifth class might be recognized in the outcrops of quartz-hematite rock sufficiently friable to permit the separation of the metallic mineral by sluicing.

In the accompanying sketch map of the region only such bodies of quarry ore as were met with in the course of the operations of mapping are represented, to the number of 52. A considerable number of others that are known to exist but that have not been seen by the survey officers and that cannot be accurately located are omitted and no account is taken of the patches of rubble ore and of “canga” that occurs in great numbers throughout the district independent of massive ore outcrops. The shaded zone on the map represents the approximate limits of the area of crystalline rocks that nearly surrounds the elevated sedimentary plateau and which also appears in a sort of island in its midst. These crystalline areas of older rocks contain no iron ore but in places, particularly in the southern part in the neighbourhood of Queluz, there are important deposits of manganese ore that have been extensively mined. In the sedimentary area, on the contrary, iron ore of one kind or another is much more abundant and wide spread than is indicated by

the map. The outcrops figured are on belts of the iron-bearing formation that are so generally covered by superficial deposits of rubble ore and “canga” that by picking one’s route, it is possible to traverse the area mapped from one side to the other and along various lines, without leaving, except for short intervals, one or another of the various kinds of ore deposits above enumerated.

The breaks in the limits of the ore district represent prolongations of it into the surrounding country that have not yet been mapped. The one on the southwest extends off to the considerable mountain mass of *Itatiaia* which is known to be composed in large part of the iron-bearing formation and is reputed to contain large workable deposits of ore; that on the north includes the main ridge of the Espinhaço range in the direction of Conceição and Serro along which several iron mountains are known to occur, while the one on the northeast embraces the *Candonga* district which is also reputed to be rich in ore.

From the above description it is evident that attempts to estimate the amount of ore in the district must be extremely fallacious. Practical iron men and geologists who have visited parts of the district (no one has an intimate knowledge of it as a whole) hesitate to pronounce impossible estimates that at first sight seem utterly preposterous. Prof. Henri Gorceix, founder and for many years director of the Mining School of Ouro Preto, who had a very intimate knowledge of the district, stated in a public lecture in 1881: “I have estimated in five billion tons the iron ore that *Minas Geraes* might furnish, and I fancy that I should not be exaggerating if I should double this estimate.” Prof. Richard Penrose, the well known economic geologist, who rode with me over a small part of the district mainly included in a large property, for which the owner’s estimate was of “hundreds of millions of tons”, says in a private letter: “I do

not know just what the extent of their property is, but though one cannot see such quantities of ore actually blocked out, yet I would not consider such a statement as impossible of future realization in the regions you and I visited last year. I think such quantities *might* be produced. Of course where the iron alternates in thin lamellae with the siliceous layers, it is undesirable as an ore, because it is too siliceous. If, however, we exclude such material and count only the larger bodies of pure ore that occasionally occur in it, such as the iron ore peak (Itabira do Campo) which we visited, and then consider the area of country over which the iron formation extends, the possible tonnage is immense.”

The cubic contents of a limited number of the ore bodies have been estimated by competent observers on the basis of actual approximate measurements of their outcrops, but for the most part this has been done by private parties and the information is not available. The following examples of estimates made by Dr. Gonzaga de Campos of the Serviço Geológico are believed to be as reliable as can at present be made and will serve to give an approximate idea of what the figures may mount up to when the district becomes better known.

These estimates for nine of the deposits are in Table 1.

Taking the mean specific gravity of these ores as 4 this volume represents 988.000.000 tons. The above list includes several of the largest known deposits so that the contents of the others cannot be estimated on a proportional basis, but it seems quite safe to assume for them at least an equal volume which would double the above figures. In these estimates no account is taken of the presumed underground extension of the visible ore bodies.

No attempt has been made to estimate the volume of the rubble ore deposits which are known to be the both numerous and extensive throughout the district. So far as the writer has

learned only one such deposit has been actually measured by competent mining engineers and this is said to carry "20.800.000 tons of rubble ore, easy for stopping, carrying 50% iron". From what is known of the district it seems quite safe to assume that there are scores of deposits of equal importance and that in the aggregate the volume of rubble ore is at least equal to that of the quarry ore.

As regards the "canga", Dr. Gonzaga de Campos estimates roughly that it covers about 10% of the area occupied by the iron-bearing formation which is about 5700 square kilometres. For the purposes of calculation, however, he takes 5% with a mean thickness of 2 metres which gives 570.000.000 cubic metres which calculated with the mean specific gravity of 3 gives 1.710.000.000 tons of ore whose mean iron contents will probable oscillate in the neighbourhood of 50%.

As regards the quality of these ores the existing analyses are naturally of hand specimens only, but all, mineralogists and metallurgists alike, who have examined the outcrops agree that on immense rock faces, such as represented in the accompanying photograph of the peak of *Itabira do Campo* (Figure 3), no differentiation of richer and poorer portions are perceptible to the eye.

Most of these analyses are deficient from an industrial point of view as in the majority of them the phosphorus contents is given vaguely as "traces" without accurate determination; and no reference is made to titanium, leaving it doubtful whether this element had been especially looked for, or not. The oxide of iron contents is generally given as from 67 to 99.5 %, the remainder being almost exclusively silica. In two cases in which, at the writer's suggestion, special tests were made for titanium, none was found, and from this and other considerations it seems safe to assume that as a class these ores are practically free from it.

Table 1 - These estimates for nine of the deposits.

Gaya	72.000.000 cubic metres
Conceição	80.000.000 cubic metres
Esmeril	19.000.000 cubic metres
Caué (Itabira Peak)	33.000.000 cubic metres
Pitanguy	14.000.000 cubic metres
São Luiz	8.000.000 cubic metres
Peak of Itabira do Campo	8.000.000 cubic metres
Rio de Peixes	10.000.000 cubic metres
Cocacs	<u>3.000.000 cubic metres</u>
	247.000.000 cubic metres

The most reliable phosphorus determinations at hand are from samples, from two different localities, submitted to the Krupp Works and to those of the United States Steel Corporation, both of which give the same result, namely 0.0024%. In this connection it may be mentioned that some years ago the writer was consulted by the eminent French metallurgist, Mr. F. Gautier, who was then in charge of the Esperança Works working on rubble ore from near the Itabira do Campo peak, as to where he could obtain for admixture an ore higher in phosphorus.

In short, the quarry ores the district here considered may be safely set down as existing in immense quantities and as of high and, within certain limits, uniform quality.

As no special study has been made of the other classes of ore of this district, very little can be said of them beyond the fact that they exist in immense quantities. From a practical point of view it is probable that, with the exception of the rubble class, they should only be considered as reserves

for the future, or as contributors to a limited extent as admixtures.

As regards origin and composition, the rubble class of ore is practically identical with the quarry class. In mining it would naturally be impractical to free the high grade ore entirely from an admixture of earth and pebbles of lower grade ore and this would somewhat reduce the metallic product, but this reduction would presumably be more than compensated, in most cases, by a reduced cost of mining and transportation, since in general this class of ore lies in more favorable positions than the other. Thus, from an industrial point of view, it seems tolerably safe to set the rubble ores down, as regards quantity and quality² as comparable with those of the quarry class.

The "canga" class of ore is naturally of lower grade than the others, owing to a greater or less admixture of fragments of quartzose and argillaceous rocks which it would be impracticable to separate in mining, and to the presence of water in the characteristic limonitic cement. Good

²With reference to the estimate mentioned on a previous page of the quantity of available ore with an average contents of 50% iron, in one of the rubble ore fields, it should be noted that this particular field contains a large amount of ore of the "canga" class which has evidently been included in the estimate.

observers estimate the mean iron contents of this class of ore at about 50%. As already remarked the apparent quantity of this class of ore is immense and, so far as can be judged by a simple ocular inspection, probably in excess of that of any other class.

From lack of definite information regarding the deposits of sandy ores and of the technical conditions in which they could be utilized, this class must be left out of account in the present brief sketch. Suffice it to say that should a demand arise for this class of ore the district in question could supply it in great quantities.

Aside from the district above discussed and of its various prolongations that have not yet been examined, hematite ores are known to exist in various other districts of the state of *Minas Geraes* and in various other states of the republic. These are generally considered, in most cases without sufficient evidence, to be substantially identical, as regards geological conditions, with those above described. Nothing is definitely known regarding their extent, but those of the western part of the state of *Minas Geraes*, the central part of the state of *Goyaz*, the São Francisco region of the state of *Bahia* and the Carumbá district of the state of *Matto Grosso* are presumed to be extensive.

With the present means of transportation, or with those that are likely to exist in the near future, the greater part of these deposits must be regarded as inaccessible. The exceptions are those situated along the river São Francisco in the state of *Bahia* and near the banks of the river Paraguay in *Matto Grosso*. The former can be reached by 575 kilometres of railway from the port of *Bahia* to Joazeiro and by a certain amount of river transportation up stream from that point, and also by 1010 kilometres of railway from the port of *Rio de Janeiro* to Pirapora and down stream navigation from that point. The *Matto Grosso* ore deposits,



Figure 3 - The iron ore peak of Itabira do Campo seen from the southwest at a distance of 180 metres. (Photo: Rosière, C. A. 2009).

situated in the Urucum mountains, are about 30 kilometres distant from the sea port of Corumbá which is 3197 kilometres distant from the sea port of Buenos Aires in the *Argentine Republic*.

The iron ore formation seen many years ago by the writer at various points along the river São Francisco is believed to be identical with that of *Minas Geraes*, and some of the deposits may prove to be comparable with those above described as regards quantity and quality, but on this head nothing definite can be said as the examination was of the most cursory character. That of Urucum in *Matto Grosso* occurs in association with manganese ores and with limestone and in this respect offers a certain analogy with that of *Minas Geraes*, but it differs in the fact that the siliceous admixture, where it occurs, is in the form of jasper rather than that of granular quartz. The deposits are reputed, on good authority, to be extensive, but the quality, judging from chance specimens that have come to hand, is not as high as in the *Minas Geraes* ores.

As already remarked, magnetite is a very widespread mineral in Brazil and many of the occurrences are reputed to be extensive. The most accessible, and so far as known the most extensive, of these occurrences are situated in the coast region of southern *São Paulo*, *Paraná*, and *Santa Catharina*. Of these the only one known personally to the writer is in the first of these states and is too highly titaniferous to be industrially available. Various other occurrences that are only known by hand specimens and the statements of interested parties partake, though in a less degree, of the same defect, but among the samples examined are some of a manganese type that seem to be promising. Nothing, however, is definitely known regarding the economic conditions of this type of ore. The districts tributary to the ports of Paranagua in the state of *Paraná* and of São Francisco in that of *Santa Catharina* are well worthy of examination in this respect, as there is a reasonable probability that workable deposits of good ore may be found in them and in this case their proximity to the seaboard would give them a great advantage over the known deposits of hematitic ores.