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A charcoal frontier: the steel industry and forest in twentieth-century Minas Gerais (Brazil)

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Abstract: Focusing on the charcoal-fired steel industry in the Doce River Valley (rural eastern Brazil), this article sets out to understand the relationship between industrial-scale mining and the transition from iron factories to large steel mills. At the same time, it addresses the further destruction of the Atlantic Forest. Studies on the steel industry that highlight the pressure exerted on the Atlantic Forest by charcoal plants are almost nonexistent, however. Turning to technical reports, official statistics, journals, and other media sources and centering attention on Belgo-Mineira company, it highlights a set of data that enables us to measure the impacts of the charcoal-fired steel industry on forests. In order to get a deep insight, the main aim was to estimate the amount of forest extraction to serve the steel industry from 1936 to 1954. The data from this research show that the charcoal-fired steel industry gave a distinctive cast to the phenomenon of the agricultural frontier.

Keywords: Charcoal frontier. Steel industry. Atlantic Forest. Mining. Charcoal workers.

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São Paulo. Vol. 27, 2024

Original Article

DOI: http://dx.doi.org/10.1590/1809-4422asoc0033r1vu27L2OA

Introduction

This research sets out to place in context a frontier experience in the Doce River Valley (DRV hereafter) in eastern Brazil, taking the first half of the twentieth century as a time span. Based on an earlier study coordinated by Strauch (1955), these fifty years can be shown to have been marked by the impact of the implantation of the mineral and metallurgical park in the state of Minas Gerais (MG). Steel mills, in conjunction with the charcoal and firewood supply networks, were central to the social and spatial realm of the Doce River basin's frontier. Coal-fired steel industry expansion and investments in the metallurgical sector in the central region of this state were deeply intertwined (DINIZ,1981, p. 20). At the very center of this area was Belo Horizonte – the state capital – and from the thirties on, this endeavor made possible the emergence of the so-called "Metallurgical Zone." This process simultaneously integrated the state of MG in Brazil's national industrialization process and augmented Belo Horizonte's political influence, due to the link between the political center and the primacy of the state as an economic force (DULCI, 1999). This industrialization project connecting MG's geopolitics to the interests of the elites would only be viable with the conversion of the Atlantic Forest (AF hereafter) into a reducing agent, fuel, and energy. Notably, this forest in the Doce River hydrographic basin had remained virtually unchanged until the period in question (BRITO et al., 1997).

The central concern here is understanding the convergent interests that made the implementation of the steel industry in the DRV possible. At the same time, it is important to estimate the amount of deforestation needed to produce firewood and charcoal and acquire a deeper insight into the socio-environmental interactions involved, taking as a reference the process of forest appropriation by steel industry interests. All these changes also foregrounded the role of charcoal workers, of course. The charcoal burners and the production of the fuel are deeply linked to MG's history, as the folklorist Marcel Thiéblot (1984, p. 53) writes:

> From the forests comes the charcoal that travels along all the state's roads: trucks and trucks that, from the most distant points, converge towards the steel mills. Seeing the coal trucks drive past becomes so natural that local inhabitants pay no attention, but outsiders are amazed!

The scene described by Thiéblot is still commonly encountered by any attentive visitor traveling along MG's roads. Indeed, in the north and northeast regions of the state today, this is the norm – unsurprising given that MG is the largest state producer of charcoal in Brazil, reaching "almost 83% of total national production" (MINAS GERAIS, 2021). Illegal extraction is still intense, with constant seizures of charcoal shipments (ALVES, 2021).

Pereira and Carneiro (2021, p. 40) argue that "there is no doubt about the importance of the charcoal sector for the forestry industry and its contribution to national GDP. This is especially true in MG, since it is the largest producer, and the consumption occurs

within the limits of borders of MG as well." According to the United Nations Food and Agriculture Organization (FAO, 2017), Brazil is the world's largest producer of charcoal. In turn, the state of MG stands out as the largest producer and consumer of charcoal in the country. The main driving force is the demand from steel mills established in the central region of the state.

The close association between the charcoal sector and the steel industry emerged in the first half of the twentieth century. Inevitably, this had a huge impact on the AF biome in the eastern part of MG. The "hunger" for coal of the steel mills' blast furnaces transformed the state's entire landscape. This process is directly linked to the DRV, where demand for firewood and charcoal became the major agent in mobilizing the regional economy. In this way, the "Doce River forests" were transformed into a strategic resource for promoting MG's industrial development (BRITO et al., 1997). Even so, the importance of charcoal for the mining economy, especially for the steel industry, has received virtually no attention in historiography. This in mind, the present research set out to contribute to our understanding of the effects of the charcoal-fired steel industry on the AF.

In a very short time, the "hunger for coal" produced a charcoal frontier and altered the landscape (SOLÓRZANO et al., 2009) of DRV – such is the hypothesis sustained here. A statement collected by Rita Cosenza (2005, p. 64) lends support to this idea: "That hunger for coal. That hunger for wood. Work and more work… That hunger, that greed, greed for wood…" (Interview 6). The term landscape is understood here as emergent from "the relations of populations with their environment" (OLIVEIRA; ENGEMANN, 2011, p. 10). But it is also a "legacy," resulting from successive historical processes – both ancient and more recent – involving interactions between social groups and the natural environment (AB'SÁBER, 2003, p. 9). Most studies on the steel industry address political and economic issues as well and this is particularly true when the subject is industrialization in MG.

To understand the topic, the methodological procedure used was primarily documental research grounded in an interdisciplinary approach. The text is divided into three sections. The first presents the connections between the charcoal frontier in DRV and the different regional, national and global interests involved. Here the emphasis is on the importance of mineral deposits for the international iron and steel chain. In the next section, the implementation of the steel plant in DRV is examined, highlighting the centrality of the forest in the realization of this enterprise and focusing on the case of the Belgo-Mineira Steel Mill (BMSM hereafter). Finally, data on pig iron and steel production are explored to estimate charcoal consumption during the first half of the twentieth century. The socio-environmental impacts of the charcoal-fired steel industry is the next and final area examined in the study, along with the experience of the charcoal mining frontier and the alterations to the regional landscape.

The steel revolution and the making of the coal frontier in the Doce River Valley

The development of the steel industry in MG is inextricably linked to the large iron ore deposits known to exist since the end of the nineteenth century. For a long time, the state's central region was called the "metallurgical zone" and concentrated the first forges (MATOS; COSTA, 2019; MARINHO JUNIOR; ESPINDOLA, 2021). In the first half of the twentieth century, the same region was the location for the arrival of the first blast furnaces with the implementation of the coal-fired steel industry. From this starting point, the area of influence of the steel mills gradually moved eastward, down the middle course of the DRV and along the route taken by the Vitória-Minas Railroad. These displacements reached the confluence of the Suaçuí Grande River, downstream of the city of Governador Valadares. Following this route, the DRV became strategic for the implementation of the steel industry. This location was perfectly situated between the ore deposits on the slopes of the Espinhaço mountain range (known as the "Iron Quadrangle") and the forest reserves of the Doce River basin. The presence of the AF was essential for the supply of charcoal.

Mining and steelmaking activities were established in this part of the former province of MG, east of the gold-bearing region explored in the eighteenth century and the colonial towns of Vila Rica (Ouro Preto) and Vila do Príncipe (Serro), encompassing Sabará, Caeté and Itabira do Mato Dentro, where the new industries were able to take advantage of the local iron ore, forest and water resources (GORCEIX, 1880). The domestic and commercial forges spread, producing iron for self-supply or to meet the demand of a local market. In the next century, these establishments followed the same pathway, relying on local inputs like ore, forest and water (BAETA, 1973). However, the winds changed and in the twentieth century a new phase of iron metallurgy was established, part of a larger project for the development of MG and Brazil more widely (BASTOS, 1959).

The local political context was influenced by the economic power of the nations that dominated the steel industry. This becomes clear in the period before the First World War (1914-1919). An interconnection thus existed between the regional, national, and global domains, related to the global iron and steel chain, bringing together entrepreneurs, scientists, investors, and the state. Georg Fischer (2013), argues that national and foreign governments deal with "networks" of experts spanning between Wisconsin (USA) and MG.

The influence and significance of the steel industry in the "age of empires" before the First World War (HOBSBAWN, 2005) were vital to the emergence of DRV in a global context. Potential iron ore reserves in MG had already been identified in the research of professors and students from the Mining School of Ouro Preto even at the end of the nineteenth century. However, its contemporary dimensions can be traced back to the studies conducted by Felippe Gonzaga de Campos for the Brazilian Geological and Mineralogical Service (BGMS), which began its activities in 1906.

In 1910, during the XI Congress of Geology held in Stockholm, the head of the BGMS, Orville Derby, presented a study. Its title was "The iron ores of Brazil," which

contained the data collected by Gonzaga de Campos (DERBY, 2010; SILVA, 2010; FISCHER, 2013). Fischer (2013, p. 9) argues that the iron ore deposits in MG "fascinated scientists, investors and politicians for many years." Naturally, this prompted a "rush to acquire these underground mining reserves." From this time, "foreign companies have endeavored to obtain concessions for essential ore deposits for the iron and steel industry" (COELHO, 2011, p. 69). Moreover, "the largest iron ore deposits were in the hands of large foreign syndicates willing to explore them" (BASTOS, quoted in PEDRO NOLASCO, 1959, p. 107).

Diniz (1981, p. 19) shows that "foreign capital was interested in MG for activities related to the use of natural resources only." Indeed, during this period the exploitation of mineral and forest reserves accelerated in many peripheral countries like Brazil. DRV became one of the centers of attention of the major Western economies. Inevitably, this interest would also be consolidated in the state of MG, feeding the state elite's project for industrialization and, in the same move, the project of national political leaders who saw exports as an opportunity to supply the world market and enrich Brazil. The race for iron ore compelled MG's elites to formulate policies to protect the mineral wealth and encourage the development of the steel industry in the state (DULCI, 1999).

So, it was in this intertwined context involving international, national, and regional interests that the DRV steel park first became established. It was implemented in the first half of the twentieth century, therefore, one of the initial milestones was the BMSM (1921) in the historic city of Sabará. The MG elite's project to industrialize was grounded in the industrialization process, then underway during the Vargas Era (1930-1945). Obviously, these abundant mineral and forest resources were in line with Brazil's relationship with the international context during the era, heavily marked by the two World Wars. This intertwining of the state, national, and international spheres provided the basis for an original experience, namely the charcoal mining frontier in the DRV (BASTOS, 1959; ESPINDOLA, 2015).

At the time of arrival of large-scale iron ore extraction – for export – and the MG steel park, the DRV became the locus of modernization and economic dynamism in MG and Brazil more generally (DINIZ, 1981; COELHO 2011). At this juncture, the potential of AF' lumbering was strategic for the industrialization of MG at time grounded in the steel industry and pig iron plants: "this region is the most abundantly capable of supplying wood charcoal for the 'hunger' of the small blast-furnace industries" (O VALLE..., 1940, p. 52).

On the other hand, the use of charcoal to reduce iron ore in the newly built steel mills, as well as in the dozens of pig iron plants installed in DRV, resulted in enormous intervention in the Atlantic Forest. In Strauch's opinion (1955, p. 95), more complex and more extensive than iron production, the charcoal and firewood industry surpassed all geographical limits: "Almost all the municipalities in the [Doce River] basin are producers of charcoal and firewood; however, those who supply steel companies and the railroads in the region are the most prominent."

So, in the first fifty years of the twentieth century, mining and steelworks had a

huge influence in national, regional and local scenarios in Brazil, while also attaining the international sphere, marked by economic crises, political revolutions, and two World Wars. MG was the epicenter of the development of the steel industry in Brazil and the BMSM was the materialization of this project. All these were manifested in the building of a different frontier, the charcoal frontier in the DRV. This was the background to the growing "intensity of exploitation of natural resources: forest and mineral extracts included (BRITO, 1997, p. 33).

The Belgo-Mineira Steel Mill Company and the development of the charcoal mining frontier along the Middle Doce River

The information available on the website of Sindifer (Minas Gerais State Iron Industry Union) provides a good idea of the importance of the steel industry in MG. The number of pig iron plants in the state exceeds the total in all other units of the Brazilian federation combined, representing 75% of national production. Its industrial park encompasses 63 pig iron plants.

The first half of the twentieth century, almost a century ago, witnessed the emergence of the charcoal frontier and its expansion towards the AF biome, advancing down the DRV (BRITO et al., 1997). In 1917, a group of Brazilian engineers sowed the seeds of the BMSM in the city of Sabará. On December 11, 1921, at a shareholders' meeting held for the purpose of increasing capital stock, foreign capital from Luxembourg was subscribed by Aciéries Réunies de Burbach-Eich-Dudelange (ARBED). This gave rise to BMSM, today ArcelorMittal. The Sabará plant was useful for ARBED to acquire local experience and install a large steel mill later. The same opportunity enabled it to acquire control of raw materials and the trained personnel necessary for its planned expansion (MOYEN, 2007).

Figure 1: BMSM (aerial view), Sabará - MG

Font: IBGE Library. ID: 49409. Location code: 3156700. Available in: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=449409. Accessed on: Jan. 20, 2022.

In 1927, ARBED sent Louis Ensch, a Luxembourg engineer, to Sabará. He would play a central role in the planned expansion of the steel plant. The project came to life in 1937 with the inauguration of the large steel mill in the municipality of Rio Piracicaba, at a site called João Monlevade (MOYEN, 2007). This locality was strategic not only because it provided a healthy environment – principally in terms of being free of malaria – but also because it allowed access to essential raw materials: iron ore upstream and charcoal from the Atlantic Forest downstream in the basin. Three decades later, other large steel mills and dozens of pig iron plants would be installed throughout the DRV (ESPINDOLA, 2015).

The reference to the charcoal frontier needs some explanation: here frontier is understood as the process of integrating new areas into the national market or society. This starts with the movement of fronts (demographic and pioneer) with diverse interests, aiming to promote a unique experience involving a meeting between the natural world and humans (FOWERAKER, 1982). In this sense, a frontier is also perceived as a place of encounters and disagreements between different social groups. This arises from the asymmetric control of the power and economic relations present and that involve political and social conflicts over land tenure and the control of natural resources, in this case, forest resources in particular (MARTINS, 1996; SILVA, 1982). The border is still a fluid space where fronts merge with the supposedly natural geography, giving rise to new territories and landscapes (FREITAG, 2009).

In this scenario, one could argue that BMSM played a meaningful role in the

Middle Doce River (MDR) frontier experience. The company's emergence derived from various conditions that had been converging since the end of the nineteenth century: experiences with forges and foundries; the geological and mineralogical studies with the identification of the area where iron ore deposits were located – named since then the Quadrilátero Ferrífero, the "Iron Quadrangle." This, of course, strongly appealed to the steel industry. At the same time, technical staff, specifically mining and metallurgy engineers, were being trained at Ouro Preto Mining School (EMOP). These were the principal traits of the emergent scenario, also strongly influenced by the modern winds of industrialization in the Brazilian central government from the 1930s (BAETA, 1973; GOMES, 1983; BRITO, 1997; ESPINDOLA, 2015).

Building up BMSM in fact, provided a huge impulse to the production of iron and steel in MG. Its start point was the inauguration of the Monlevade Steel Mill Plant in 1937 (BAETA, 1973). However, it is impossible to dissociate the company's development from the rapid extraction of timber from the AF. From the beginning, an enormous charcoal base was necessary for the industry's survival; that industry was deeply dependent on charcoal.

For the BMSM, it was "an accepted fact that, since the forest is a national wealth, its rational exploitation is as justifiable as the exploitation of the country's mineral resources" (CSBM, 1955, n.p.). This statement was not merely rhetorical: it reflected the thinking of political authorities, technicians, and, to a certain extent, society as a whole. As Warren Dean (1996) contended, converting the forest into fuel, into charcoal reserves, was seen as a way of replacing the depredation of national resources through a "rational" form of exploitation. Neither was this a new idea: the EMOP engineers had advocated this use of natural resources since the end of the nineteenth century.

The option to use charcoal as a fuel and reducer is just part of several factors: 1) no mineral coal was available, and its import costs were extremely high; 2) the nationalist appeal, a key feature of Brazilian politics in the first half of the twentieth century, drove the search for industrial independence and the use of national resources; 3) the large fluctuations in the prices of fossil fuels on the international market; 4) major military conflicts on a global scale and the policy of nationalism and interventionism, which generated insecurity among the business sector; 5) and finally, of course, the availability of huge forest reserves close to the ore deposits, linked by rail.

Figure 2 – Belgo-Mineira Steel Mill by Tibor Jablonsky and Ney Strauch,1952.

Font: Jablonsky, Tibor; Strauch, Ney. IBGE Library. ID: 12768. Código de Localidade: 313170. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?id=412768&view=detalhes. Accessed on: Apr. 4, 2022.

There was thus a convergence of resources in the region called the "Metallurgical Zone," including the fact that forests were on vacant land, which was the object of specific policies implemented by MG state governments to favor steel companies. According to Strauch (1959, p. 170), citing data from the early 1950s, the 10 largest steel companies took over 402,650 hectares, BMSM alone controlling 235,610 hectares (58.5%). On its land, BMSM established a kind of rational process centered on charcoal production and reforestation, now with eucalyptus trees[1]. Even so, the network of suppliers established by the company in the MDR operated on a different basis. According to Strauch (1958), in 1948, the municipality of Governador Valadares, for instance, 250 km distance from João Monlevade, produced 6,250 tons of charcoal for the steel mills. The demand for charcoal was growing so high that in the same year of 1948 BMSM purchased charcoal from private suppliers in the municipality of Pirapora in the São Francisco Valley, a Cerrado biome far away from its base.

As BMSM's operations were deeply dependent on the MDR forests, the company

1 - Large-scale eucalyptus plantation, introduced into the RDV in the 1940s by the steel company Belgo-Mineira, whose project makes it clear that deforested areas will be used and, at the same time, the conservation of existing forests will be promoted, which have since been treated and defended, and of riparian forests in watercourses, which received the same care (OSSE, 1961, p. 758), is related to the notion of "ecological modernization". About this notion and that of eucalyptus forest transition, see Farinaci et al. (2013).

sought to control the "land with forest" and in this way turn the forest into charcoal reserves. The initial reforestation plans were postponed due to the immediate need for deforestation, since the blast furnaces needed to be fed immediately (POLANCSYK, 2017; ARAÚJO, 1952). Gomes (1983, p. 192) argues that "the biggest 'temptation' was the Doce River basin, with its peerless abundance of ore and its remarkable possibilities in terms of forests and hydraulic energy." Given this situation, it can be said that after the construction of the Monlevade plant, the DRV became the epicenter of MG's coal-fired steel industry (and arguably of Brazil as a whole). From this moment on, the charcoal frontier was the "motor" driving a rapid transformation of the landscape; it also prompted the migration of human groups, influenced state land legislation, and organized policies for new territories in the MDR.

BMSM's concern with purchasing forested land is clear in remarks by its former president:

> When the Sabará Steel Mill started its operations, there wasn't any reforestation plan; even we did not know what to plant. The expectation then was that the cut forest would regrow. Charcoal was purchased from farmers who produced charcoal on their land. With the increased consumption, purchasing land with forest and producing charcoal turned out to be an essential activity. (POLANCZYK, 2017, p. 185, emphasis added)

The charcoal option was thus directly linked to the great availability of biomass represented by the AF. It should be that as well as the relatively short distances involved, there was a supply of cheap labor not under the strict control of existing legislation. On the other side, governmental stimulus also played an important role, aiming to promote the growth of the economy and, at the same time, integrate new frontier areas into the market. In a few decades, this landscape would change drastically largely – albeit not exclusively – through the actions of BMSM.

Strauch (1958, p. 167) highlights the three outcomes of the use of charcoal in the steel industry:

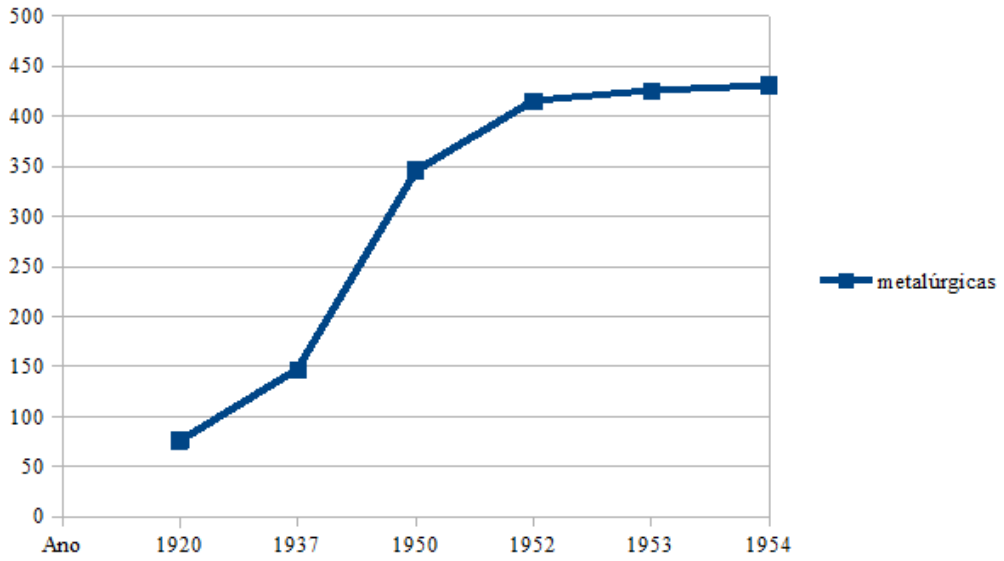
> 1) Generalized deforestation, harmful to the local populations due to the landscape imbalances caused.
>
> 2) Large estates belonging to steel companies as a guarantee of the charcoal supply.
>
> 3) An increase in the prices of firewood and charcoal due to the growing distances from where the fuels are produced.

Iron, forest and charcoal workers: socio-environmental impacts in the charcoal frontier zone

At the beginning of the twentieth century, MG experienced a transitional period, shifting from the "Forges Era" to the "Mills Era" (BAETA, 1973). On one hand, this meant the transformation of foundry techniques, moving from forges to blast furnaces; on the other, a switch in charcoal production techniques from pit to pile furnaces. An industrial census conducted in 1920 shows 76 metallurgical plants existed in MG, 32 of which were exclusively dedicated to "iron casting and rolling." Most of the foundries were situated in the "Metallurgical Zone," a specific physiographic region, especially between the Rio Piracicaba, Santa Bárbara, and Itabira municipalities. These industrial centers together concentrated 17 steel mills. However, among all the metallurgical establishments whose data was included in the 1920 industrial census, approximately 42% were foundry and iron rolling enterprises – that is, they were steel industries (MINAS GERAIS, 1925).

Unfortunately, in the years that followed the 1920 census until 1955, the statistical agencies of the State of MG generally dealt with the number of metallurgical establishments without any specification. This makes it difficult to list a precise number of establishments dedicated exclusively to iron casting. However, considering the steel industry to be the most important activity in the MG economic conjuncture in the first half of the twentieth century, the percentage of establishments in this type of metallurgy was always higher. Graph 1 shows the quantitative evolution of metallurgical establishments in MG at that time.

Graph 1 – Numeric evolution of metallurgical industries in Minas Gerais



Font: Elaborated by the authors (Anuário Estatístico de Minas Gerais,1920, 1937, 1950, 1952, 1953, 1954)

In the graph above we can observe an increase in the number of metallurgical establishments from 1937, the year that BMSM began operations in João Monlevade. The 1930s could be characterized as a period marked by the convergence of the MG elite's industrial aspirations – evident since the Agricultural, Commercial, and Industrial Congress of MG (1903) organized by João Pinheiro – and the national modernization and industrialization project launched after the arrival of Getúlio Vargas at the center of power. Focusing on a smaller spatial scale, the 1930s can also be seen as the point when forest devastation in the MDR started to accelerate, driven by the expansion in the metallurgical sector.

It should be remembered that the main fuel until the mid-twentieth century was firewood, used in both domestic and business activities. Consulting the economic data available in the Statistical Yearbook, firewood was equivalent to 19.4% of all extractive production in MG in 1923, showing that it was the main extracted product in the state, even surpassing mining. However, the issue here is estimating the amount of firewood converted into charcoal to supply the metallurgical sector, especially steel mills.

In this context, the steel industry and the forest are inseparable. Brito et al. (1997, p. 50) argue that "our greatest riches were not only the 'iron chest', but also the dense forests." A peculiar landscape then developed, suffering deeply from the impact of the charcoal-fired steel industry, since "all the plants work with wood charcoal" (ANNUÁRIO…, 1925, p. 482).

Charcoal production for the mills predominantly used pile furnaces, which, although a rudimentary technique, met the needs of the steel mills. The plants had high coefficients of charcoal consumption relative to other raw materials. Until the 1950s, for example, the blast furnace coal load at BMSM was 4 to 6 times greater than the rest of the load, such as sintered ore, limestone, and other fondants. This represents, on average, the consumption of 475 kg of carbon per ton of pig iron (C/t) (SIDERURGIA..., 1953, p. 133).

The consumption of charcoal per ton of pig iron (coke ratio) decreased, of course, as innovations in the technical processes of smelting, and charcoaling were developed. Various sources consulted in the research specify the coke ratio for the period and context to which they refer: according to ABM (1975), for example, until 1937, charcoal consumption per ton of pig iron averaged 5 m^3. Engineer Amaro Lanari Jr., in a debate held at the USP Engineering Institute (São Paulo) in 1948, complaining about the lack of studies on charcoal consumption, asserted that it "corresponds to about 4 cubic meters of charcoal per ton of pig iron" (O PROBLEMA..., 1948). At the other end of the scale, a professor at the Minas School, Clodomiro de Oliveira, stated that 3.5 m^3 of charcoal was used for each ton of pig iron in the 1920s and 30s (GOMES, 1983). Araújo (1952), in turn, stated the same coefficients as Clodomiro de Oliveira.

Nonetheless, the present study adopts the ratio of 4 m^3 of charcoal per ton of pig iron, as reported by BMSM itself (CSBM, 1955), to estimate forest extraction. The reader is forewarned, therefore, that the calculations of charcoal and firewood consumption, as well as the areas devastated to obtain charcoal for the steel industry, made in this research are the lowest estimated consumption levels and, therefore, may actually have

been higher, but not lower, than those described.

In considering the charcoal yield per hectare of "forest," on the other hand, we turn to Araújo (1952), who used diverse estimates compiled by the National Department of Mineral Production to calculate that each hectare of "forest" provided 90 m^3 of charcoal (22.5 tons). This is enough to produce 25 tons of pig iron. We need to consider, however, that the figures presented by Labouriau (GOMES, 1983), Lanari (O PROBLEMA..., 1948), and Araújo (1952) must be considered in relation to several factors: the diversity of ecosystems in the AF within the DRV; the tree species present; the physical and chemical structure of the soils; differences in altitude and climate; humidity variation in each period of the year; the type of logging involved; the charcoal worker's skill; and charcoal transportation, to list just a few.

Accordingly, taking the above into account, the table below provides estimates for the areas of forest devastated considering the amount of pig iron produced per year.

Table 1 - Pig iron production versus deforestation ratio

Years	Pig Iron (ton.)	Forest Suppression (hectares)	Forest Suppression (Km^2)
1936	78.986	3.510	35
1937	98.107	4.360	44
1938	113.478	5.043	50
1939	143.694	6.386	64
1940	158.739	7.055	71
1941	169.955	7.554	76
1942	174.143	7.740	77
1943	203.708	9.054	91
1944	240.076	10.670	107
1945	194.401	8.640	86
1946	211.682	9.408	94
1947	229.501	10.200	102
1948	223.597	9.938	99
1949	221.844	9.860	99
1950	301.517	13.401	134
1951	311.789	13.857	139
1952	320.660	14.252	143
1953	189.861	8.438	84
1954	348.221	15.476	155
Total	3.933.959	174.842	1.748

Font: Elaborated by the authors (Anuário Estatístico de Minas Gerais, various years)

Combining several coefficients, Table 1 shows the estimated deforestation, based on each hectare of forest yielding 90m^3 of charcoal, caused by the production of pig iron

in the 1936-1954 period with the coke ratio of 4 m^3 of charcoal to one ton of pig iron (4 mCV/1tFG). It needs to be remembered that in previous years too, the production of pig iron, although less significant, consumed considerable areas of AF – even more if we consider that the coke ratio was even higher (5 mCV/tFG). However, the region where carbonization was concentrated was still the metallurgical zone.

Pursuing this analysis, Araújo's assertion (1952, p. 24) that the consumption of charcoal for steelmaking "can be blamed for the deforestation of 1,870 km^2" between 1901 and 1950 may have been wrong. The figure would actually be much higher. Strauch (1958) also suggests an annual consumption of 100 km^2 of forest, which would correspond to 5,000 km^2 of forest clearance over the same period cited by Araújo. However, this is a figure exaggerated by the fact that the calculation only considers the coefficients for the 1950s.

It might be concluded that during the "Piles Era," the amount of deforestation was relatively small compared to the geographic area of Minas Gerais state, even if we consider the DRV alone (41,800 km2). However, when we take a higher level scale, mainly the MDR, it becomes apparent that the impact of carbonization was deep and had a drastic influence on the landscape and in the experience of the frontier expansion as well.

The specialized literature maintains that the location of a steel mill industry is fundamental to its existence and must be guided by raw material availability. Of course, the main point is to be "close to the raw material that weighs more in the total costs of the inputs" (BAER, 1970, p. 38). In this case, the location of BMSM and other steel mills was influenced by the sources of charcoal. The fuel was central to the operation of the blast furnaces, making up 60% of their load until 1950 (LANARI, 1951). Thus, the need for charcoal to satiate the steel industry's hunger – and, consequently, the opening of forestry exploration fronts to produce the material – allow us to define the Doce River frontier as a "carboniferous" zone. Charcoal was not the only reason for the incursion into the "Doce River forests," but the charcoal plants played a decisive role. The advance of charcoal kilns opened up economic frontiers and these were linked to multiple interests, particularly agriculture and the timber industry. Linked to the charcoal kiln is the central character of the charcoal mining frontier, the charcoal worker, label ed "the desert maker," as one source denounced at the time (O VALLE..., 1940).

It is somewhat astonishing that such a central character received so little attention in research. When we consider the Doce River frontier, an essentially artisanal activity predominated in charcoal production until the 1950s, including both the working tools (axes, sickles, rakes, shovels, forks, and hoes) and the techniques for building the piles used in the carbonization process. According to Lanari (1946) and also Louis Ensch (SIDERURGIA..., 1952), 70% of steel workers' labor was concentrated on the production of charcoal, rising to almost 100% in the forests. This underlines the huge importance of open charcoal kilns in the middle of the woods, without which the steel mills would have been unable to function. At the time, the Atlantic Forest was occupied by thousands of charcoal workers, recruited by large companies that "in the midst of immense forests, order us to develop their technique without a clear manner" (THIÉBLOT, 1984, p. 50).

At the time, these charcoal workers were occupied with various tasks at the charcoal kiln sites, exercising "intense activity, without interruption and without rest" (SOUZA, 1946, p. 151). In this sense, we can suggest that the forest (and specifically the charcoal kiln) represented the center of the social life of charcoal workers. Their work was intertwined with household chores and family life, due to the fact that the kilns had to be kept under constant vigilance. Hence, the presence of families at the charcoal kiln sites was the norm (GUIMARÃES; JARDIM, 1982). Approaching a little closer, it becomes clear that the dedication of charcoal workers to the tasks involved in operating the charcoal kilns forced them – temporarily, at least – to build their dwellings at the charcoal kiln sites. Always smelling the smoke and soot resulting from the combustion of wood; always ready to dismantle their temporary home and leave to settle at a new site, following the ceaseless advance of the logged areas.

Souza (1946) explains that:

> The charcoal worker always lives in the forest, in solitude, dwelling in poor huts made of wattle and daub, covered with thatch, without any comfort, to say nothing about hygiene. Some of them, when the landowner permits, have their own small plantations and domestic animals. Even so, it is more common for them to plant nothing and purchase everything in the nearest town. (SOUZA, 1946, p. 151)

The charcoal kilns had to be watched day and night. While one was charring, another was often already being assembled and an older one was already in its cooling phase. The charcoal worker and his family thus moved about ceaselessly and were completely dependent on what the forest offered since, as we can readily see, he could not leave the site. At the same time as they cut down the forest to obtain firewood, they enjoyed what the remaining standing forest had to offer: food, water, and the means to work and live with minimal comfort. The charcoal worker had a contradictory relationship with the forest. After all, the dwelling of the charcoal worker and his family, as well as almost everything that existed in it, came from the forest. On the other hand, his work consisted paradoxically in the devastation of the forests. While he cannot be blamed for the "ravage" once he was working in the service of the steel mills, he cannot be admired either as though he "lived in harmony with nature" – like Thiéblot's charcoal worker (1984, pp. 73-74).

The charcoal worker is someone with little capacity for action within the economic system in which he is embedded. As Thiéblot (1984, p. 74) argued, the charcoal worker "is the enslaved wage-earner, who takes on any job, sells his strength and sweat, with ax and hot kiln." However, frontier charcoal workers do not appear in the statistics. Data from the 1920 census, compiled by the II Statistical Yearbook published in 1925, concerns the labor employed in the industry. This document does not mention charcoal workers, woodcutters, *carreiros* or waggoners, or indeed other workers linked to wood carbonization – probably hidden in the agricultural category – but indicates a total of 11,060 workers, exclusively men, employed in metallurgy in the year of 1920 (MINAS GERAIS…, 1925, p. 70).

Counting the number of employees in metallurgy, therefore, and using the estimate provided by Lanari (1946), there were on average seven times more workers dedicated to carbonization than smelting. Hence, we can infer that approximately 70,000 workers were involved in the charcoal "industry" in 1920, without mentioning those involved in charcoal transportation. It is a significant amount, "made invisible," however, by official statistics. Despite being an important contingent of workers for BMSM, they lived in precarious conditions in the forest without legalized contracts or guarantees. Unlike the foundry workers – who enjoyed various forms of assistance from BMSM, which included housing, hospitals, schools, and even leisure clubs – the charcoal workers still worked with the axe, in very poor housing, facing all kinds of illnesses and adversities in the forest, working on the steel industry's frontlines.

In Brazil, the profession of charcoal worker is possibly one of those that has least changed over the decades. Indeed, the precariousness of the work can be observed even in the present day. Slavery in the charcoal industry is still a reality. Several factors explain this phenomenon: the isolated nature of the work, the poor qualifications of the workers, the huge size of the available workforce, and the scarcity and poverty of the areas where the charcoal plants operate. All of this exemplifies the exploitation of labor in its most undignified and devastating form by capitalists (SAKAMOTO, 2007).

As the text has shown, the charcoal frontier was decisively marked by the conversion of forests into wood charcoal. Similarly, the steel mills converted peasants, farmers, loggers, merchants, and all kinds of other people into "desert makers." Citing one of our aforementioned earlier sources:

> And all, more or less, are charcoal workers. The cargo troops on the road carry coal, the forest clearings are full of charcoal like a railroad yard, the children are smeared with charcoal, the landscape is charred like a chimney sweep, the horizons are filled with smoke rising from the *sapêcos*, the trains that climb up carrying charcoal. And everything is charcoal and firewood. (O VALLE..., 1940, p. 63)

Conclusion

The study has shown that by approaching the history of the steel industry and the frontier experience through the theoretical-methodological tools of environmental history, we can provide fresh answers to the question of the socio-environmental impacts on the charcoal frontier. At the same time, this foregrounds aspects that studies of the history of the steel industry have overlooked. Furthermore, measuring the devastation caused by the steel industry brings to light new perspectives and problems for studies of the industrialization of MG and Brazil. The path followed was also traced by those who provide a history of the forests that once covered a large area of MG state, particularly the entire DRV.

It is worth emphasizing here that the theoretical approach of environmental history takes nature and society to be indissociable dimensions. What we call the methodological tools of environmental history, therefore, comprise the set of analytic means and concepts

that this theoretical perspective offers to articulate social and environmental processes. This approach provides a critical socio-environmental dimension to the analysis of the historical sources. The research used documents produced in the first half of the twentieth century, including newspapers, magazines, newsletters, technical reports, photos, statistical yearbooks, and, in particular, the land deed archives of Minas Gerais state. Also, important was the documental research at the ArcelorMittal Memory Center (formerly Belgo-Mineira) where we had access to the company's internal documents.

The frontier phenomenon in Brazil converges with the historical formation of the national territory as a whole, including, therefore, the state of MG. However, when considering the frontier in the Doce River basin, we need to move beyond the idea of the agricultural frontier since in this region a mining-metallurgical frontier was constituted. Going back to the eighteenth century, this specificity can already be discerned since gold-mining also required the establishment of forges and the production of iron. In the nineteenth century, with the depletion of gold deposits, agricultural activity and the cost of transport acted as an incentive to increase the number of forges in the western portion of the Doce River basin. In the first half of the twentieth century, already in the era of the industrialization and growth of the MG state capital Belo, Horizonte, the rudimentary forges gave way to steel mills and dozens of pig iron factories.

This long-term movement emerging from the mining-metallurgical frontier in DRV resulted in the production of a landscape marked by forest devastation. DRV had ore deposits, forests, and a railroad (EFVM) whose route layout, connecting the center of MG, the Metallurgical Zone and the port in the state of Espírito Santo, created a sociotechnical system that made the development of this mining and metallurgical frontier possible. Founded in 1921, BMSM represented the synthesis of this sociotechnical system: fully responding to the intentions and ambitions for politician developmental of diverse successive MG governments from João Pinheiro. Obviously, there was also the influence of various economic and political sectors that came to power nationally with the 1930 Revolution.

Research on the charcoal-fired steel industry from the viewpoint of environmental history is essential, given the spectacular longevity of the MG plants. Few of these steel mills followed the path most commonly taken in other countries, namely the transition from charcoal to mined coal. It is necessary to consider the improvements that took place with the use of a thermo-reductor of vegetable origin by the steel mills. Recently, serious environmental problems, particularly the climate crisis, have presented new demands to the charcoal-fired steel industry. The thermo-reducing element of plant origin has become an alternative source of renewable energy and reduction in CO2 emission. Forests planted to produce charcoal, by absorbing carbon dioxide for their growth, contribute to mitigating carbon dioxide emissions generated in the production of iron and steel.

This research is also an attempt to demonstrate the socio-environmental impacts of the charcoal steel industry on charcoal workers who inhabit the forest and live in dispersed and isolated communities, far away from Brazil's urban and commercial centers. In the Doce River basin, working conditions were – and in the north of MG still are – charac-

terized by rudimentary techniques, fragile social ties, insecure and non-legalized work relationships, too often a "contemporary form of slavery," as argued above. In sum, this study is a contribution to an integrated socio-environmental understanding of the Brazilian steel industry, taking into consideration aspects that go beyond just economic issues.

Acknowledgements

Our sincere thanks to the institutions that made this work possible: CAPES, FAPEMIG, IFMG, UNIVALE e UFSC.

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Submitted on: 08/12/2022
Accepted on: 20/12/2023
2024;27:e00033

AMBIENTE & SOCIEDADE 25 anos 25 años 25 years

SciELO

A fronteira do carvão: siderurgia e floresta em Minas Gerais (Brasil) do século XX

Lenício Dutra Marinho Júnior
Haruf Salmen Espindola
Eunice Sueli Nodari

Resumo: Com foco na indústria siderúrgica a carvão vegetal no Vale do Doce River (Leste de Minas Gerais), este artigo propõe compreender a relação entre a mineração em escala industrial e a transição das fábricas de ferro para as grandes siderúrgicas e o processo de devastação da Mata Atlântica. Estudos sobre a indústria siderúrgica que destacam a pressão exercida pelas carvoarias sobre a Mata Atlântica são quase inexistentes. Recorrendo especialmente a relatórios técnicos, estatísticas oficiais, periódicos e centrando a atenção na empresa Belgo-Mineira, apresentamos um conjunto de dados que nos permite mensurar os impactos da indústria siderúrgica a carvão vegetal sobre a floresta. Para obter uma visão mais profunda, o objetivo principal foi estimar a quantidade de extração florestal para servir à indústria siderúrgica entre 1936 e 1954. Os dados desta pesquisa mostram que a indústria siderúrgica a carvão vegetal deu um aspecto distinto ao fenômeno da fronteira.

Palavras-chave: Fronteira do carvão. Indústria siderúrgica. Mata Atlântica. Mineração. Carvoeiros.

São Paulo. Vol. 27, 2024
Artigo Original

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SciELO

Frontera del Carbón: siderurgia y silvicultura en Minas Gerais (Brasil) del siglo XX

Lenício Dutra Marinho Júnior
Haruf Salmen Espindola
Eunice Sueli Nodari

Resumen: Centrándose en la industria siderúrgica a carbón en el Valle del Río Doce (este de Minas Gerais), este artículo propone comprender la relación entre la minería a escala industrial y la transición de las fábricas de hierro a las grandes acerías y el proceso de devastación de la Mata Atlántica. Los estudios sobre la industria siderúrgica que destaquen la presión ejercida por las centrales de carbón sobre la Mata Atlántica son casi inexistentes. Utilizando en particular informes técnicos, estadísticas oficiales, publicaciones periódicas y centrándonos en la empresa Belgo-Mineira, presentamos un conjunto de datos que nos permiten medir los impactos de la industria siderúrgica sobre el bosque. Para obtener una visión más profunda, el objetivo principal fue estimar la cantidad de extracción forestal para servir a la industria del acero entre 1936 y 1954. Los datos de esta investigación muestran que la industria del acero al carbón dio un aspecto distinto al fenómeno de frontera.

Palabras-clave: Frontera del carbón. Industria metalúrgica. Mata Atlántica. Minería. Trabajadores del carbón.

São Paulo. Vol. 27, 2024
Artículo Original