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Manganese mining in Corral Quemado: extractivism Processes that resulted in manganese madness among miners (Coquimbo region, Chile, 1941–1969)

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ABSTRACT

This study reviews the working conditions of the miners of Corral Quemado, near Andacollo in the Coquimbo region of northern Chile, during the extraction and processing of manganese between 1941 and 1969. The extractivism's extraction techniques, mineral processing methods, and mining policies are presented and discussed. The poor working conditions in the mines led to significant manganese overexposure, resulting in a condition known as 'manganese madness' in the miners. Prolonged exposure to manganese causes several health complications that affect the central nervous system, resulting in psychomotor problems, body stiffness, involuntary movements, and facial spasms, in addition to psychological issues (compulsive behavior, emotional lability, and hallucinations, among others). Given that the negative effects of manganese poisoning, which were first reported in Europe in 1837, were already well known, the historiography and health condition of the Andacollo miners require attention. The Andacollo miners' precarious working conditions and the manganese toxicity created lasting mining and economic issues, and left a permanent imprint on the miners' bodies. At the time, miners' dramatic working conditions and disabling injuries prompted a series of parliamentary petitions aimed at improving their working conditions.

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The historiographical study of mining in northern Chile in the 19th and 20th centuries has systematically focused on the exploitation of silver, saltpeter, copper and, to a lesser extent, sulfur, gold and iron. However, manganese mining research is scarce and only few studies have examined and characterized the health impact of manganese on mine workers (Mena et al., 1970, 1967; Miranda

et al., 2015; Rodier, 1955; Schüler et al., 1957). This is in contrast to the extensive literature on geological descriptions of manganese mining. In this context, this study uses primary sources to create a new historiographic record of the development of manganese mining in northern Chile during the 20th century, delving into the precarious working conditions and conflicts associated with mineral mining. In addition to causing mining and economic problems, manganese mining in northern Chile left a strong biological imprint on the workers due to the neurotoxic nature of manganese.

This study aims to overcome insular approaches and present a comprehensive view of a dramatic historical process that affected both residents and manganese miners in the Coquimbo region, Chile, and in particular the Corral Quemado mine (Figure 1). Chile ranked second in South America in manganese production after Brazil in the 1960s (CORFO, (1962), p. 266) and Corral Quemado was distinctive in the South American mining business. As a manganese region, Corral Quemado helps us understand not only a regional mining history, but also a localized memory of global capitalism, which has multiple links (Sachs, 2021).

The time period chosen for this study, 1941 to 1969, witnessed the formation of the Compañía Manganesos de Atacama. During the 1960's working conditions improved as a result of a mining strike. This occurred during a crisis, which resulted in a decrease in employment and mineral sales, as well as a decline in the working population and the usual decrease in productivity. Furthermore, by the end of the 1960s, affected miners were given L-dopa medication, which mitigated some of the damage caused by manganese mining and overexposure (Mena et al., 1970, 1967).

Systematic exploitation and mineral handling typically pose a health risk to miners who suffer from various mining-related diseases. In Chile, dramatic cases of occupational diseases were observed in different types of mining, such as silicosis in saltpeter mining (Galaz-Mandakovic, 2020) and copper mining activities (Vergara, 2014). For example, the population of Chuquicamata, the world's largest copper mine, suffered from serious respiratory illnesses as a result of inhaling various types of gases and industrial dust (Galaz-Mandakovic & Tapia, 2022). Miners in coal mines suffered from hookworm (Ortúzar, 2015), while other miners suffered from 'saturnism', which is poisoning caused by an excess of lead in the blood (Fernandois, 1965). Several other mining-related problems have been observed, including the consumption of arsenic-laden water in the north of Chile (Arriaza & Galaz-Mandakovic, 2020); respiratory damage in sulfur mining (Galaz-Mandakovic &



Figure 1. Map of the Coquimbo region, adapted and modified from Luis Riso Patrón (1910).

Rivera, 2020), contamination by sulfur dioxide, nitrogen oxides and carbon monoxide released by the combustion of coal in thermoelectric plants that powered mines (Galaz-Mandakovic, 2021), skin irritations and inhalation of respiratory coal dust particles in foundries resulting in anthracosis and poisoning (Ortúzar, 2015). Other conditions, such as manganism, or chronic manganese overexposure and poisoning, have received less attention in historiography, possibly due to a lack of bibliographic sources or because it affected a regional mine with medium output, in addition to the social marginalization of its workers.

Overexposure to manganese through the skin or airways (inhalation of micro particles or vapors), for example, is extremely harmful to miners' health and can result in manganism (Avila et al., 2013; Mena et al., 1970, 1967; Ramírez & Azcona-Cruz, 2017; Santamaría, 2008; Schüler et al., 1957). This condition affects the central nervous system, producing symptoms similar to Parkinson's disease, including a delirious condition known as manganese madness. Therefore, the safety of Chilean miners at Andacollo was juxtaposed with occupational diseases like manganism.

This study examines the labor processes and negative consequences of manganese exploitation at Corral Quemado, near Andacollo town in the Coquimbo region. Miners at the Corral Quemado mine were exposed to environmental hazards due to the unsafe working conditions and the failure to apply minimum work safety standards. The manganese mining poisoning demonstrates a failure of supervision and lax control by state agency officials. Manganism afflicted the Andacollo miners, causing severe psychomotor complications, body rigidity, involuntary movements, and facial spasms, among other conditions (Mena et al., 1967). Certain production processes, work methods, and labor conflicts that reflect tremendous occupational precariousness have been detailed in extant historical data. The safety conditions for manganese exploitation were lax despite the fact that its negative effects have been known since 1837, when it was first reported in Europe. James Couper observed manganese poisoning in five workers of the Charles Tennant Bleach Manufactory Company in Glasgow, Scotland. The workers were responsible for grinding manganese and had psychomotor disorders as well as compulsive behaviors (Couper, 1837). Couper noted the following:

These facts prove that manganese is a poison to the human species and that when slowly introduced into the organism, it acts like mercury and lead, paralyzing nervous functions. There is, however, some difference in how the lower extremities are initially affected. Mercury paralysis is almost entirely confined to the upper extremities and is accompanied by metallic tremors; [the paralysis caused by] manganese differs from that caused by lead in that this oxide does not act on the intestinal tract in such a way as to produce so-called saturnine colic, and we do not observe the constipation caused by lead. (Couper, 1837, p. 235, translated by the authors)

Furthermore, on 4 May 1927, as part of Law No. 4,055 on Occupational Accidents of 1925, the regulations on occupational illnesses published in the *Diario Oficial* [Official Gazette] of Chile defined in Article 8 a series of illnesses that gave the right to compensation, including diseases caused by chemical agents such as lead, mercury, arsenic, phosphorus, sulfide, bromine, chlorine, chromium, fluoride, iodine, antimony, copper, and manganese. Manganism was defined in Article 8 as 'chronic intoxication: asphyxia, loss of appetite, muscular hypotonia, drooling, tremor of the hands, legs, head, and trunk, staggering gait, and laughter and crying' (*Diario Oficial* [Official Gazette], *Diario Oficial*, 1927; translated by the authors).

In this regard, the objective of this study is to describe and analyze the processes in which the Corral Quemado miners were involved, who paid the health costs of proletarianization by being exposed to the extraction of a neurotoxic mineral. We contend that the relaxed safety conditions for manganese mining in the 20th century established a violent regime of infringement on workers' rights, in which workers were forced to bear the fateful face of an extractivist process that aimed to profit from the global economy. They not only gave their energies and work in this manner, but they were also not adequately protected from the hazards of manganese mining. Their overexposed bodies accumulated the metal that they exploited, leaving them with permanent neurological damages. Local miners, as long-term residents of the territory, were expected to adapt to working

in adverse and harsh environmental conditions. Thus, a tacit ideological production process centered on the disposability of a rural community emerged, with a constant risk of exposure.

Materials and methods

This study employs a historical and anthropological approach to examine nearly three decades of mining processes (1941–1969), with a focus on Corral Quemado, an important Chilean manganese mine. Despite its mining and economic relevance, it is an ‘invisible’ area with no research in Chilean historiography and anthropology.

The primary sources for this study are parliamentary acts from Chile’s national congress (chamber of senators and deputies), unpublished sources from the Archivo Biblioteca Congreso Nacional (National Congress Library Archive, hereinafter ABCN), and primary sources obtained from the Sociedad Nacional de Minería de Chile (National Mining Society of Chile, hereinafter SONAMI) archives. In addition, international journals and interdisciplinary secondary sources that were contemporary to the process studied were consulted.

Mining and uses of manganese in Chile

Manganese mines are spread throughout Chile, from Arica to Valdivia, but the Coquimbo region has seen the most extraction due to the geological uniqueness of the territory. Mining was on a relatively small or medium scale in the 20th century, with the ‘depression in the manganese market being the most common reason that has prevented the development of this mining area’ (Mujica-Amaya, 1980, p. 46, translated by the authors). According to SONAMI (1885, p. 318),

Manganese is generally used in the manufacture of steel; as early as 1885, it was described as a black, reddish or very dark yellowish mineral, or chocolate color; firm, compact, and sometimes found in black powder within certain veins; sometimes, it also has a silver-lead luster. (Translated by the authors)

It is noteworthy that manganese exposure occurred not only during the extraction processes. Some Chilean miners gave it unique uses at the end of the 19th century, and their unscrupulous marketing turned it into a panacea. Advertisements in SONAMI’s bulletins claimed that manganese could be used to preserve meat, cure plant diseases, and prevent putrefaction. With respect to these manganese ‘preparations’, they further claimed:

Tobacco smokers who want to improve the lives of those who live in close proximity to them, as well as those who have the misfortune of exhaling unbearable breath, whatever the cause of this unbearable disease, must rinse their mouth with an aqueous solution of permanganate (...) and they will be disinfected immediately. (SONAMI, Sociedad Nacional de Minería de Chile [National Mining Society of Chile] (SONAMI), 1885, p. 320, translated by the authors)

The advertisements went on to suggest that applying manganese directly to the skin ‘makes the pain caused by mosquito, bee, and other more poisonous insect bites disappear immediately’ (SONAMI, Sociedad Nacional de Minería de Chile [National Mining Society of Chile] (SONAMI), 1885, p. 320, translated by the authors).

Manganese consumption in Chile was low in the 1920s as it only satisfied the demands of glass factories and foundries, particularly the Electro Metallurgical Company, which prepared ferromanganese alloys. During the same decade, manganese mining output declined significantly, increasing price volatility and occupational risk, with the sector being described as having ‘an absolute lack of mechanical means of exploitation, transportation, and organization of companies or tasks’ (SONAMI, 1928, p. 663, translated by the authors). The mineral from Corral Quemado gained visibility in this scene of ups and downs as a result of being one of the most productive centers in Chile, owing to ‘the power of its mantles’ (SONAMI, Sociedad Nacional de Minería de Chile [National Mining Society of Chile] (SONAMI), 1928, p. 665,

translated by the authors), where clearly, mechanization of the mining operation was not a goal for the businessmen.

The Corral Quemado case

Corral Quemado was a mine in the Río Hurtado commune (formerly known as the Samo Alto commune), about 26 km straight line southeast of Andacollo town and 80 km southeast of La Serena city (Figure 1). It was the district's most important manganese mine, followed by El Arrayan, Porvenir, and Fragua, and extracted deposits from the 'manganese basin' (Peebles & Klohn, 1970, p. 29). The most common manganese species were pyrolusite, braunite, manganite, psilomelane, and hausmannite, which included manganomelane and bixbyite (Peebles & Klohn, 1970, p. 25). According to SONAMI (1887, p. 726),

The first known manganese deposits in this province were discovered in the department of Ovalle by Misters Guill, Tripler and Co. (...) this mineral is called Corral Quemado (...) located at a distance of six to seven leagues from the railway that connects Coquimbo to the Rio Grande, or rather, Ovalle. (Translated by the authors)

The British Chilean Manganese Mines Company began a medium-scale extractive process in 1884; however, the entry of Russian manganese into the global commodity market devastated the Chilean extraction sector within the first five years of the 20th century. Corral Quemado exported an average of 12,000 tons per year between 1915 and 1920 (European-American Illustrated Universal Encyclopedia, hereinafter EUIEA, 1920, p. 856). Edwin Salz and Adalberto Schweikart, two Germans, founded a new project in 1937. In 1941, Corral Quemado's assets were transferred to Compañía Manganesos de Atacama SA. The Caja de Crédito Minero, as a state institution, was especially concerned that the manganese find a favorable market, and 'several shipments to Japan were undertaken' (SONAMI, Sociedad Nacional de Minería de Chile [National Mining Society of Chile] (SONAMI), 1942, p. 527, translated by the authors). However, when this market closed as a result of World War II, an agreement was established with the United States Metals Reserve. In this context, Chile, along with other countries (Mexico, Cuba, Canada and Brazil) contributed to 'the war industry and the military power of the United States' (De Mille, 1947, p. 1, translated by the authors), as well as the expansion of railways, metal structures for buildings, bridges and pipelines, among others (Torres, 2017). With a workforce of 625 workers, the company produced 25,650 tons of manganese in 1958 (Figure 2).

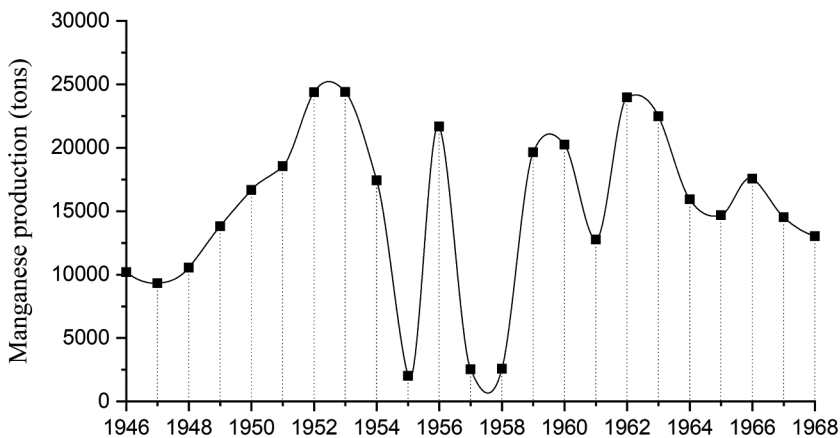


Figure 2. A graphic representation of manganese production at the Corral Quemado mine (1946–1968). (Sources: SONAMI, Sociedad Nacional de Minería de Chile [National Mining Society of Chile] (SONAMI), 1957, pp. 3392 (year range 1946–1957); (D'aubarede, 1969), pp. 176 (year range 1958–1968). Population data: SONAMI, (Schüler et al., 1957), p. 3392; ABCN, *Cámara de Diputados, Sesión 23ª*, 18 July 1961, p. 1784; (D'aubarede, 1969), p. 182).

In this way, the company began a long process of exploitation, which included the establishment of a ferromanganese treatment facility in Guayacán (Coquimbo) in (Rodier, 1955) 'to improve the usability and grade of the mineral as impurities and poor grade led to low sales (. . .) over 500,000 tons of high-quality minerals with 48% grade have been produced since 1942' (SONAMI, 1957, p. 3392, translated by the authors). According to SONAMI, the mining company had a labor force of 25 employees and 600 workers in 1957; however, the payroll had dropped to only 155 workers by 1969 (D'aubarede, 1969, p. 182).

In the 1950s and 1960s, 'the majority of Chile's manganese output came from the Corral Quemado district, which had the country's largest manganese reserves' (Peebles & Klohn, 1970, p. 31, translated by the authors). The deposits in this district were extracted by the Toda la Vida, Guillerma, Orrego, Videla, María, Cisne, Cocinera, Manto Gray, and Loma Negra mines. The concessions covered an area of 18,000 hectares (D'aubarede, 1969, p. 179).

The mineral ore was extracted through sinkholes – numerous vertical and horizontal shafts or dikes (Figure 3) with depths ranging from 30 to 70 m and a network of galleries covering several kilometers (Álvarez, 2010). The exploitation of the ore strata was nearly horizontal, but faulted, varying in thickness from 0.5 to 3 m, proceeding underground through a labyrinth of horizontal tunnels pierced at frequent intervals by vertical shafts leading to the surface. Furthermore, 'miners work on a piece-work basis, providing their own tools and explosives, gaining higher returns from working' (Pederson, 1966, p. 266).

According to Pederson (1966, p. 266), Corral Quemado was operated in a rather primitive manner, producing hand-selected ores with an average tenor of around 48% – sufficiently high in tenor and quality. Drilling was done in the mines with a hammer and bar, a few dynamite charges were placed, and the broken ore was manually sorted outside the mine. The waste was left in the excavated strata, while the productive rubble was wheelbarrowed or carried in baskets to the vertical shafts, where it was hoisted to the surface in buckets suspended from simple cranes. The ore was then trucked to Coquimbo, where it was loaded onto ships bound for various destinations. The manganese obtained at Corral Quemado could demand a higher price owing to its superior quality, which allowed it to compete with African and Indian minerals in the United States. Corral Quemado was a mining camp rather than a town as Pederson (1966, p. 267) stated: 'The company maintains some housing for



Figure 3. One of the many shafts used to extract manganese at the Corral Quemado mine (Source: Archival of Guillermo Guerra L., 2014).

miners and their families, but many miners live in Andacollo and elsewhere'. The mining camp also had a school for children and a store that sold basic necessities. The school, which was close to the camp, posed a real risk to the young students due to the accumulation of mining dust in suspension.

Toward the end of the 1960s, the shaft system became more popular as it had the 'advantage of greatly facilitating ventilation while avoiding the occurrence of manganism' (D'aubarede, 1969, p. 181, translated by the authors). The mines were said to be delaying the mechanization of mining activities as it would replace the workers; 'surely under those circumstances, most of the smaller operators in manganese will be forced out' (Pederson, 1966, p. 268). By 1968, the company had 155 employees and produced only 13,033 tons of manganese (Figure 2).

Effects of manganese overexposure

Although manganese is an essential element for body function, the recommended daily dose is only 1.8 to 10 mg (Agency for Toxic Substances and Disease Registry, hereinafter Agency for Toxic Substances and Disease Registry [ATSDR], 2012; Dobson et al., 2004; Ramírez & Azcona-Cruz, 2017). An overdose can cause intoxication, with the severity varying depending on the dose ingested, exposure time, individual tolerance, and iron concentrations in the body (Dobson et al., 2004; Ramírez & Azcona-Cruz, 2017). Previous studies have also demonstrated that manganese absorption in the brain is increased by iron deficiency (Chen et al., 2018; Dobson et al., 2004; O'Neal & Zheng, 2015). This is important because manganese, when ingested orally or through the respiratory tract, causes liver and respiratory problems, as well as severe neurological damage due to its accumulation in the central nervous system (Normandin et al., 2004). Depending on the size of the absorbed particles, inhaled manganese can be deposited in the upper respiratory tract or the lungs (Ward et al., 2018), entering the lungs as either respirable dust or particulate matter (PM10 and PM2.5; Agency for Toxic Substances and Disease Registry (ATSDR), 2012). Consequently, these particles enter the bloodstream and eventually reach the brain (Chen et al., 2018), where they cause the most damage (O'Neal & Zheng, 2015).

At a cellular level, manganese accumulates in the mitochondria and inhibits the phosphorylation and synthesis of adenosine triphosphate (ATP), resulting in muscle mobility loss (O'Neal & Zheng, 2015). In other words, as bioaccumulation increases, an individual's motor capacity declines (Hernández-Bonilla et al., 2011). Furthermore, poor mitochondrial functioning increases the risk of developing neurodegenerative diseases due to manganese accumulation in specific brain regions such as the brainstem and basal ganglia (Blecharz-Klin et al., 2012). This leads to headaches, sleep disturbances, muscle pain and hypertonia, reduced coordination, and hallucinations (Michalke & Fernsebner, 2014).

Manganese madness, a psychiatric syndrome characterized by compulsive behavior, emotional lability, and hallucinations is one of the most unusual effects of manganese overexposure (Barceloux, 1999; Finkelstein et al., 2008). It is therefore critical to emphasize that manganese overexposure causes irreversible damage and degeneration of dopaminergic neurons. This syndrome is characterized by acute changes in motor and neurological behavior (Rodríguez-Agudelo et al., 2006). In the early stages, it can cause irritability, aggressiveness, and memory changes, while the more severe effects include walking difficulties, involuntary movements, facial spasms, pathological laughter, and the so-called 'mask facies' or 'manganese mask', which involves the loss of facial expression or staring with a half-open mouth (Agency for Toxic Substances and Disease Registry (ATSDR), 2012; Avila et al., 2013; Lucchini et al., 2007; Ramírez & Azcona-Cruz, 2017; Saric et al., 1977; Shen & Dryhurst, 1998). The cognitive function of pregnant women and children can also be significantly affected, with a 40% accumulation in the bones and other tissues (nails and brain), especially if they live in areas with high manganese concentrations (Gunier et al., 2014; Menezes-Filho et al., 2011; Riojas-Rodríguez et al., 2010; Solís-Vivanco et al., 2009).

Manganese does not occur naturally in its elemental state, but rather in a variety of compounds, including pyrolusite (MnO₂), manganite (MnO(OH)), rhodochrosite (MnCO₃), rhodonite (MnSiO₃),

braunite ($3\text{Mn}_2\text{O}_3 \cdot \text{MnSiO}_3$), and alabandite (MnS ; Michalke & Fernsebner, 2014; Sernageomin, 2017). Due to its poor solubility, contamination through ingestion is also a possibility in addition to exposure through handling, though to a lower level (Lide, 2008). The World Health Organization (WHO) recommends that manganese levels in drinking water not exceed 0.4 ppm (or mg/L) and the Chilean standard (Official Chilean Standard nch409/1. of 2005; OMS, 2006) recommends a maximum of 0.1 ppm of manganese in drinking water, as well as that the dust in suspension not contain more than 5 mg of manganese per cubic-meter over a period of eight hours (Agency for Toxic Substances and Disease Registry (ATSDR), 2012, p. 9).

The ingested manganese that is not absorbed by the human body is excreted through the feces (Agency for Toxic Substances and Disease Registry (ATSDR), 2012; Malecki et al., 1996). The liver, pancreas, bones, kidney, and brain are the organs that bioaccumulate the most manganese (Agency for Toxic Substances and Disease Registry (ATSDR), 2012; Chen et al., 2018; Yoo et al., 2000; Yoo et al., 2002). Therefore, the symptoms of manganism are positively correlated with the dose ingested: the higher the exposure, the worse the health consequences, which include respiratory failure, liver failure, and neurodegenerative and motor effects.

The major cause of manganese mining poisoning is inhaling the pulverized ore, and the severity of a case depends on a number of parameters, including the length of exposure to the saturated dust and the number and size of suspended particles. Although poisoning can occur through other channels, such as oral or cutaneous pathways, respiratory exposure is the most dangerous one. Once exposed to manganese dust, the illness typically develops within one to two years.

Rodier (1955) classified manganism into three phases: 1) the prodromal period or malaise prior to the declaration of the illness, 2) an intermediate phase corresponding to the emergence of the first objective symptoms, and 3) an advanced period in which the illness is completely established, characterized by severe disorders that result in permanent disability. The first phase is characterized by asthenia (chronic fatigue) and anorexia. In addition, there is a loss of desire to speak, incoherency, and psychotic states. Speech difficulties and stuttering are symptoms of the intermediate stage. According to Rodier (1955, p. 23), 'Nearly at the same time as these speech disorders, changes in the facies may come. These constitute the "masque manganique", a facial expression at once jovial and fixed, which gives the patient a dazed appearance'. Basic body movements, such as going upstairs or downstairs, lifting objects, or walking backwards, are also difficult. Rodier (1955) discovered that 82% of the workers he studied had clumsy basic movements. In the third phase, hypertonia manifests itself as muscular rigidity, locomotion problems, and fixed facial expressions, among other complications that become more complex and serious.

It is noteworthy that manganese overexposure leads to continuous dysfunction of an organism that is proportional to the dose ingested and bioaccumulation. Continuous exposure, even at low concentrations, causes motor skill and memory loss, whereas chronic exposure at high concentrations causes permanent neurological damage (Agency for Toxic Substances and Disease Registry (ATSDR), 2012; Solís-Vivanco et al., 2009). Moreover, the higher the intake dose, the lower the psychomotor capacity, which, as previously stated, produces symptoms similar to Parkinson's disease (Lucchini et al., 2007; Saric et al., 1977; Shen & Dryhurst, 1998).

Discussion

Manganism in Corral Quemado

The few historical records of manganese mining in Corral Quemado, northern Chile, describe it as a 'subsector' (Ortega, 2014), or an 'occasional activity governed by price variations' (Ortega, 2011, p. 144, translated by the authors). This type of mining, like other low scale mining, relied on the labor of traditional *pirquineros* (artisanal miners; Venegas & Videla, 2021, p. 2).

Manganese miners also worked in copper, silver, and gold mines. The instability of the productive mineral cycles resulted in a significant movement of workers in regional mines and agricultural fields.

Agriculture in a semi-arid territory is heavily reliant on rains, which makes it vulnerable in the face of prolonged droughts. To make matters worse, the high toxicity of manganese mining caused serious injuries that prevented local workers from working elsewhere. Manganese mining centers, as well as copper and gold mines, were located far from urban areas. Andacollo was the largest town, with a population of 6,784 in 1940 and 5,381 in 1960. Therefore, miners belonged to the rural areas, had little education and were regarded as an indigenous population by the urban dwellers. In the town of Andacollo, where the Virgen del Rosario is celebrated, the manganese miners were distinguished by a strong religious devotion (López, 2022).

In 1954, during the parliamentary discussion on the modification of Law 4,055 on work accidents, Senator Salvador Allende stated that, in addition to establishing compulsory insurance against work accidents and professional illnesses, the project sought to give risk a social meaning, particularly in the mining industry: 'We think that a risk of this nature, which has such an extraordinary biological and economic significance, should not give rise to commercial profit' (ABCN, Senate of Chile, Session 32, 7 April 1954, p. 1648; translated by the authors). During the session, it was requested that the Social Security Service support the fixing of the premium and the obligation to cover the various labor risks. In this context, the spirit of the Law 4,055 amendment reflected the 'formation of an awareness among employers and workers aimed at preventing work accidents'.

Senator Salvador Allende added: 'In some provinces of the country, there are extremely painful examples of the consequences that are already being felt. Silicosis and anthracosis are well known pathological risks in some operations, such as copper and coal, that our legislation has tried to remedy in part by providing certain guarantees to workers and establishing certain requirements' (ABCN, Senate of Chile, Session 32, 7 April 1954, p. 1648; translated by the authors). In this way, it was debated that the legislation did not define occupational diseases. Senator Allende provided the following information that specifically targeted manganese mining:

I know personally, and very personally, because I have been concerned with this problem in my capacity as Advisor of the National Health Service, what happens in some manganese mines. About a month ago I was at a meeting of regional heads of the National Health Service in the province of Coquimbo. There I was informed that a few kilometers from La Serena there is a manganese mine in which 65% of the workers have suffered mental alterations as a result of the emanations from the mine, five of these cases are unrecoverable since the mental disorder that has occurred in them is definitive. (ABCN, Senate of Chile, Session 32, 7 April 1954, p. 1648; translated by the authors)

Furthermore, Allende stated that he had discussed with the company's directors and that, in light of the intoxication phenomenon and obvious cases of manganic madness, 'two specialized professionals were deputed from Santiago to take the necessary industrial hygiene actions' (ABCN, Senate of Chile, Session 32, 7 April 1954, p. 1648; translated by the authors).

In that vein, in light of the dramatic examples of intoxicated workers in Corral Quemado, a call was made for the law to be amended to include appropriate medical and surgical benefits, along with pharmaceuticals for the 'physiological and professional rehabilitation of the incapacitated person and the reparation of the economic consequences' (ABCN, Senate of Chile, Session 32, 7 April 1954, p. 1649; translated by the authors).

The miners themselves described the disadvantages of working in a manganese mine. Ángel Álvarez Cortes, who started working at Corral Quemado in 1957 (hired by the mine administrator, Julio Campusano Chávez), states the following:

Several friends who had worked in that mine did not recommend it for good reasons. Because manganese is a heavy metal, solid, gray in color (...) The high-grade ore in the earth's crust is hard, silver in color, and when it is soft it is black, oily like coal, which dirties everything and causes toxic disease due to exposure to the dust and smoke of this metal, whether in mines or foundries. (SPRH, Servicio País Río Hurtado (SPRH), 2021, p. 58, translated by the authors)

Álvarez witnessed his coworkers' intoxication: 'Advanced manganese poisoning is known as manganism, and it can cause extensive mental incapacity after months (or even weeks) of exposure, though it usually appears after two years or more' (SPRH, 2021, p. 58, translated by the authors).

Another miner, Angel Araya, commented:

We felt sorry for having arrived there, but as the peasant saying goes, 'he who rides an untamed horse must endure if he bucks,' so willingly or not, we continued to work in the mine (...) as *apir* crew, that is what they called us because we were about 13 young people who worked on the task and took out 80 tons of manganese minerals a day, which meant that there were 80 buckets, which were filled with 80 baskets, therefore, each *apir* had to take out 80 laps of 80 kilos daily for the same salary. (Servicio País Río Hurtado (SPRH), 2021, p. 59, translated by the authors)

Similarly, another miner named Ramón stated: 'I used to work with manganese. One died of suffocation in the mine. I became bored there. The mines were extremely suffocating' (Armstrong et al., 2009, p. 75, translated by the authors). Manganism manifests itself as acute and chronic respiratory problems such as bronchitis, pneumonia, and asthma (Ramírez et al., 1999). As a result of these health problems, many miners chose to leave the mines early, violating their contracts. They primarily went to the town of Andacollo in search of new employment (Álvarez, 2010). Those who remained in the manganese mines chose to strike in June 1961 to protest the precarious working conditions at the Corral Quemado mine.

Although certain Chilean communist deputies supported the Corral Quemado workers' union, they remained unprotected. In addition to health concerns, the miners demanded better salaries. The last agreement between the workers and employers expired in December 1960, when the request to increase the salary by 5% was rejected by the Honorable Board of Conciliation and Arbitration, and no agreements were reached (ABCN, Chamber of Deputies, Session 23, 18 July 1961a, p. 1784).

The strike lasted 137 days (Figure 4), 'breaking a record of duration and also of the insensitivity of the rich men to grant their workers the minimum wage to which they are entitled', Deputy Florencio



Figure 4. Corral Quemado miners on strike, accompanied by their families. They walked to Serena city to demand better health and wages. 19 July 1961. (Source: *Periódico de la Compañía*, 28 December 2020, p. 1).

Galleguillos commented in the parliament. 'To reach a solution to their long conflict, these workers had to travel from the mountains to the capital of the province, the city of La Serena, where they were able to meet with the Minister of Labor', he added (ABCN, Chamber of Deputies, Session 68, 11 April 1962, p. 4859; translated by the authors). 'Desperate, the workers had to walk for miles and miles starving so that the government would pay attention to the reasons for the strike' (ABCN, Senate of Chile, Session 25, 31 July 1961b, p. 2188; translated by the authors).

After a hunger march, they settled in La Serena's Plaza de Armas with their wife and children, waiting for the government to take action to meet their demands. They did nothing but defend their work and bread for themselves and their families with such an attitude. (ABCN, Chamber of Deputies, Session 23, 18 July 1961a, p. 1792; translated by the authors)

It is noteworthy that 392 miners were working at the Corral Quemado mine at the time of the strike (ABCN, Chamber of Deputies, Session 6, 6 June 1961c, p. 409). In the context of this conflict and the miners' health crisis, Deputy Cipriano Pontigo stated:

The Manganesos Company of Corral Quemado, which in the years of its existence has increased its capital by 700%, has achieved its boom thanks to the efforts of the workers, to whom today it denies an economic improvement. Nearly a hundred workers who have helped to amass that wealth have fallen ill with manganism, a disease for which, like cancer and silicosis, medicine has not yet found a cure. These workers and their families have been abandoned, thrown out on the street, completely unable to work, many have gone mad. (ABCN, Chamber of Deputies, Session 23, 18 July 1961a, p. 1791; translated by the authors)

Therefore, in addition to the toxicological consequences of manganese exposure, the complaints emphasized that the miners' vulnerability increased as they were physically disabled, unemployed, and abandoned.

A laborer who works in the manganese sector is fatally condemned, after a long or even a short period of activity, to contract such a terrible disease that it is not even considered an occupational disease and for which the company has not contemplated any financial compensation, nor has it taken any preventive measures aimed at defending the life and health of these workers. (ABCN, Chamber of Deputies, Session 23, 18 July 1961a, p. 1791; translated by the authors)

The company was also criticized for denying workers economic benefits and claiming that the price of manganese and ferromanganese had fallen in the world market, making it financially unviable to face this new higher expense. Deputy Pontigo made the following statement:

I ask, Mr. President, do these workers, whose efforts helped to amass the immense fortune that this company has today, have they, not the right after working a large part of their lives doing these heavy tasks, to now obtain even a minimum share of the profits that the Manganese Company of Corral Quemado previously had? (ABCN, Chamber of Deputies, Session 23, 18 July 1961a, p. 1791; translated by the authors)

The Deputies were also concerned that, despite the fact that the miners' situation had been presented to the Minister of Labor and Social Welfare, there was a weakness in Jorge Alessandri's government: 'We presented these facts to that company that treats its workers insensitively and almost cruelly. I say this because this company has refused to respond to the demands that the workers have made at any time' (ABCN, Chamber of Deputies, Session 23, 18 July 1961, p. 1791; translated by the authors).

On 21 July 1961, Senator Salvador Allende noted the following about manganese mining, 'Psychosis is one of the causes of mental alteration. I recall this because our rudimentary, scarce, and delayed industrial hygiene and safety methods certain tasks to be done in ways that, without debate, should not be tolerated' (Allende, 2015 [1961], p. 32; translated by the authors).

The senator portrayed Corral Quemado as a mine with deplorable working conditions: 'Throughout the existence of this company, there have been frequent cases of mental disorders and psychosis among its workers as a result of toxic absorption' (Allende, 2015 [1961], p. 32; translated by the authors).

During the strike period, union leaders sought support from various networks, including international organizations such as the Soviet Union (Ulianova, 2020). However, the results were not as expected, and the precarious working conditions persisted.

Impact of manganese on Corral Quemado miners

In response to this unusual and bleak long-standing phenomenon at Corral Quemado, a group of Chilean doctors examined 114 manganese miners who showed signs of manganism (29% of the worker population) for physical and neurological damage (Figure 5), between 1960 and 1965. Manganese exposure had resulted in a loss of body function in 14 miners, who showed severe rigidity and abnormal movements (cogwheel phenomenon). They were all men ranging in age from 23 to 60 years (median = 37 years). The miners were transported from Corral Quemado to the Neurology Department of the Catholic University in Santiago, where they were intensively studied for 20 to 30 days (Mena et al., 1967).

Among those hospitalized with chronic manganese intoxication, 12 miners had retired after a chronic intoxication diagnosis. Their ages ranged from 18 to 56 years, and the time between cessation of exposure and hospitalization ranged from 2 to 25 years. The thirteenth patient was examined immediately after completing his mine work. 'This last patient, as well as 9 of the 12 pensioners, was subjected to measurements of total body loss of ^{54}Mn , while under study in the hospital as inpatients' (Mena et al., 1967, p. 129).

The manganic madness manifested itself in various ways in the miners, with nervousness and irritability being a constant behavior, and incited arguments between the miners that escalated to physical violence. A series of compulsive acts were also observed:

'For example, one patient chased passing cars until exhausted, others ran during the night or could sleep only in the open air, and others displayed compulsive singing and dancing. All patients were conscious of their abnormal behavior but were unable to control it' (Mena et al., 1967, p. 131).

Similarly, the miners' symptoms included fits of laughter and/or tears for no apparent reason, as well as hallucinations, muscle weakness, headaches, mobility issues, and language problems, especially modulation difficulties. The first symptoms were muscle weakness while working intensely in the mine, as well as an inability to do housework. This, in turn, caused severe anxiety. Normal mine tasks, such as climbing or going downhill, proved difficult for the miners. 'All patients described their difficulty as "stiffness," "heaviness," or "weakness" of the legs, but only a few reported falls' (Mena et al., 1967, p. 131).

Other symptoms reported by patients included sialorrhea (excessive saliva production), clumsiness, tremors, and sexual impotence. In addition to insomnia, the miners reported daytime sleepiness, muscle cramps with lower back pain, and short-term memory loss. These symptoms posed a significant risk in the mine as the miners made mistakes while working with explosives (Mena et al., 1967). They also had a tendency to fall stiffly on their backs when given a small push.

Irwin Polk wrote the following in The Daily Register of New Jersey newspaper about the workers of Corral Quemado:

First the miners develop a psychosis which goes away after a short time. The mental disorder is followed, however, by a group of signs and symptoms of nervous system disease, including difficulty in walking, abnormal gait, weakness of the muscles, dull, monotonous speech pattern, a wooden, expressionless face, and a marked shaking usually of the hands and arms, but sometimes of any part of the body. (The Daily Register, 25 September 1969, p. 24)

During this study, we also examined a video of four miners receiving the L-dopa treatment. The video depicts the severity of the miners' conditions, including stiffness, loss of balance, and locomotion issues, as well as how they improved after the treatment (Miranda et al., 2015). The use of L-dopa medication was documented in 1969 by the Chilean magazine *Ercilla*, which also noted that the transformation was finished a few months after taking the medication. 'After three months of leaving

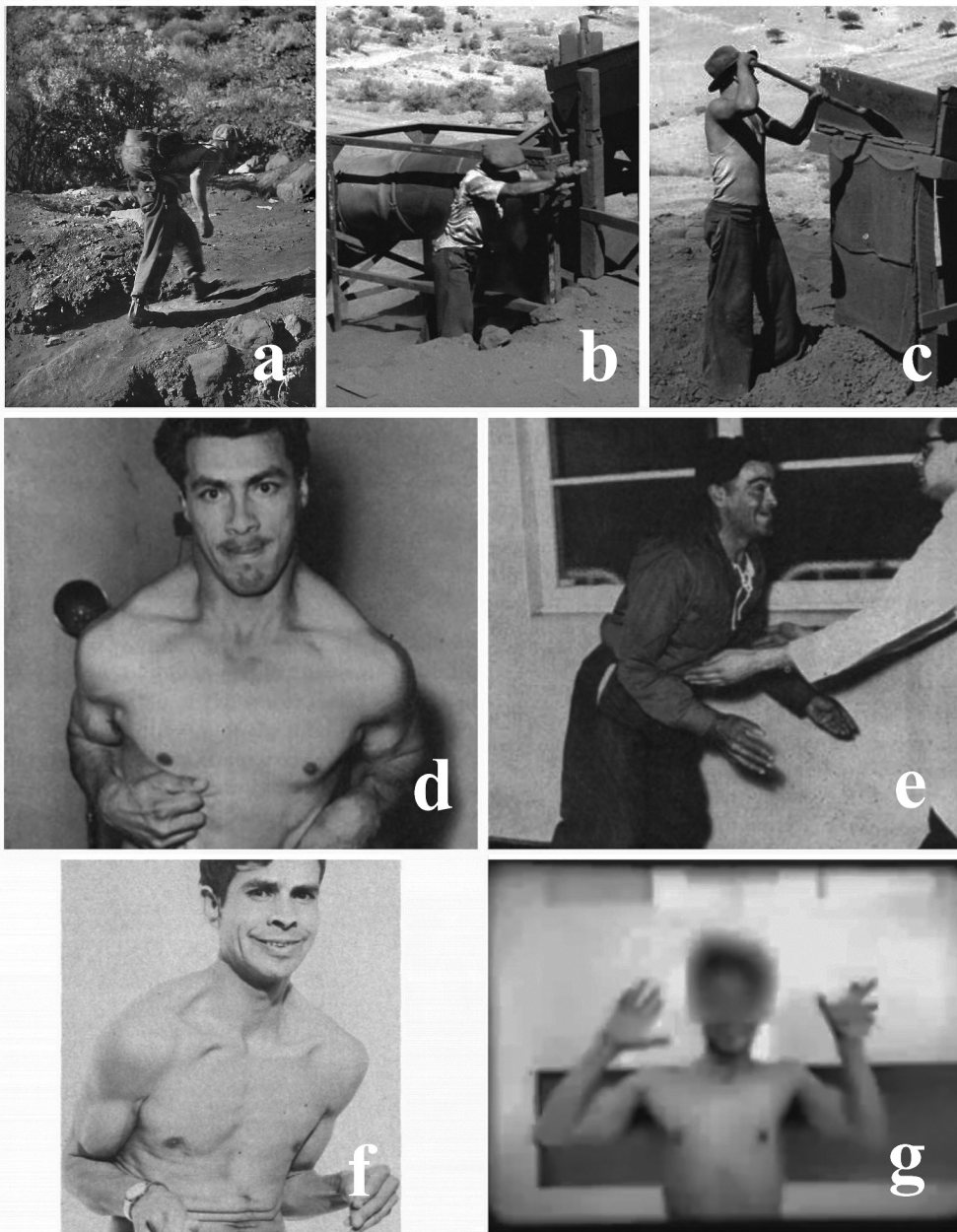


Figure 5. Different scenes derived sequentially from the manganese mine at Corral Quemado. (a) Manganese ore carrier, known as an *apir*, carrying a basket filled with manganese (ABCN, geography section, ECH3344, [Archivo Biblioteca Congreso Nacional \[National Congress Library Archive\]](#)); (b) and (c) Manganese miners working in the initial selection and milling process (ABCN, geography section, ECH3344, [Archivo Biblioteca Congreso Nacional \[National Congress Library Archive\]](#)); (d) A miner with dystonia; (e) A miner being examined at the Neurology Department of the Catholic University of Chile. The facial expression typical of manganism (manganese mask with pathological laughter) can be observed (Mena et al., 1967); (f) and (g) A miner with rigid extremities (claw hand; Mena et al., 1970). (Source: Own elaboration).

the mine, there were no traces left', the article stated. 'The miners, who before the treatment could not even walk without falling, began to move with confidence'. They also claimed that 12 miners, 'ranging from patients with three to twenty-five years of illness' had participated in the experiment (Ercilla, 1969, p. 54, translated by the authors). John Pennington (1969), wrote in *The Atlanta Constitution* newspaper the successful use of L-dopa in the treatment of manganese poisoning at the Catholic University of Santiago:

Dr. Ismael Mena has directed the treatment in Chile as the result of research cooperation with the Brookhaven National Laboratory beginning in 1963. Results in treatment of manganese poisoning, which causes frozen muscles and a grotesque configuration of the body, have been dramatic. In one group, seven of the eight patients responded "most favorably." The eighth responded to another drug. (*The Atlanta Constitution*, 28 September 1968, p. 12)

Due to the visibility gained by the workers, the Chilean Parliament stated in 1972 that a modification to the law on occupational diseases was necessary because there were instances where issues had not been resolved. Senator Montes noted that while in Corral Quemado, he observed cases of manganism, which, 'when deepened (. . .) produces delirium, madness, and severe mental deficiency in those who suffer from it (. . .). An irreversible damage to these workers' (ABCN, Senate of Chile, Session 60, 23 February 1972, p. 2388; translated by the authors).

Conclusion

The development of extractivist capitalism has been diachronically based on prevalent expropriation methods. This includes dominant labor-relations organizational structures as well as a systematic form of dispossession. This extractivism and economic view has normalized the expropriation from several perspectives, including resources, time, energy, and the biology of the communities employed for the benefit and consumption of others. Manganese mining, examined in this study, was an extractivist process with a strong allocation of systemic damage to the miners. Workers, paradoxically, assumed subsidiarity not only with their labor in the expansion of capitalism, but also with their own bodies and health to contribute relentlessly to a type of extractivism rooted in pre-capitalist practices.

Thus, the manganese mining in Coquimbo demonstrates not only the environmental and biological configuration of a sacrificial zone, but also the emergence of a sovereign region in which a certain state of exception was normal. A perplexing and violent environment was created between the right to health, extractivism, and the legal system, giving rise to a territory with its own right through the state of exception, which was presented as the legal arrangement of what could not have a legal base (Agamben, 2004, p. 10). It was an autonomous business space that adversely affected the workers as there was no law to protect them. Miners became affected by severe chronic manganese poisoning in this labor and marginal working space, and the labor laws failed to protect them once they contracted the manganese disease. This type of mining capitalism, in fact, was the experience of power as a demolition of beings (Mbembe, 2021), through a logic of worker exhaustion. Strikes, however became a way of protesting for change, but they were met with a lack of government support and adequate legal protection for the workers.

Manganese mining was hostile to labor justice to grow and survive various market crises. Unfortunately, this discord was necessary for manganese mining to exist. In this sense, manganese extractivism necessitated not only resource exploitation but also biological appropriation. In other words, acceptance of a fatalistic outcome in which a local population received the worst part of the labor deal by not having more job options. Manganese workers had a dual status in this scenario. While they were undervalued, mistreated, abused, and even treated as disposable commodity, they were also indispensable and essential for the development of the mining industry. Between this dual statuses, fateful passages intertwined, leaving a memory that was not always visible in the mining cycles of the Norte Chico articulated by global capitalism. Community subsidiarity modes were



Figure 6. The Manganese Sport Club, established on 18 July 1936 at the Corral Quemado mine (El Día, 21 July 2021. p. 28). This club is still active in Andacollo city. (a)–(c) Soccer teams and their leaders; (d) the club house in Andacollo; (e) The badge of the club depicting a miner, a soccer ball, leaves, the name of the club, place, and the foundation date. The bottom line reads: ‘Our people, our history’ (Source: Own archive and elaboration).

critical in those peripheral geographies for the development of a mining industry that was not only feeble and barely competitive, but also profoundly toxic and a source of ailments and delusions for its workers.

The Corral Quemado mine was closed owing to economic ups and downs, as well as various difficulties associated with manganese extraction. However, the memory and cultural identity of its mining history has been preserved by the Manganese Sports Club, founded on 18 July 1936 (Figure 6). This institution in the city of Andacollo is still in operation today. With almost 100 members (70 men and 30 women), it was able to earn a spot in the 1993 National Amateur Soccer Championship. Today, it serves as a social institution for agglutination, remembrance, long-standing work, social memory, and miner pride, where the extracted mineral works as a form of association and a knowledge of its harsh and fatal health effects.

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Data availability statement

Archival documentation available upon reasonable request. https://www.bcn.cl/historiapolitica/corporaciones/periodos_legislativos?periodo=1925-1973; <http://www.bibliotecanacionaldigital.gob.cl/visor/BND:353134>

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