Environment and Society: Long-Term Trends in Latin American Mining

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ABSTRACT

Drawing on historical and environmental research, this essay examines long-term trends in the ways that mining affected labour and the environment in Latin America. The article begins with a theoretical framework for analysing the changing conditions of labour and of the environment under capitalism. This is followed by a periodisation of Latin American mining, divided into six parts: pre-conquest, conquest, colony, neo-colony, capitalist modernisation and debt crisis. In each period (excepting the first) I assess the major social and environmental transformations associated with the industry. My central conclusion is that there has been an inverse relationship between two long-term trends: first, the brutality of labour conditions in the industry; second, the scope of environmental destruction linked to mining. The article concludes with a discussion of two more speculative issues: the impact this inverse relationship has had on contemporary political concerns, and whether the turn of the millennium marks the end of this inverse relationship.

KEYWORDS

Latin America, mining, labour, capitalism, marxist analysis

INTRODUCTION

Mining has given rise to major social and environmental transformations in Latin America since the Conquest. Drawing on historical and environmental research, this essay examines long-term trends in the ways that mining affected labour and the environment.[1] The article begins with a theoretical consideration of changing conditions of labour and environmental degradation under capitalism. This is

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followed by a periodisation of Latin American mining, divided into six parts: pre-conquest, conquest, colony, neo-colony, capitalist modernisation and debt crisis. In each period (excepting the first) I assess the major social and environmental transformations associated with the industry. My central conclusion is that there has been an inverse relationship between long-term trends in the brutality of labour conditions in the industry and the scope of ecological destruction linked to mining. The article concludes with a discussion of two more speculative issues: first, the impact this inverse relationship has had on contemporary political concerns; second, whether the turn of the millennium marks the end of this inverse relationship.

Before proceeding, three caveats are in order. First, as my purpose is to characterise long-term trends and major turning points in the social and ecological effects of mining, my analysis eschews detail. Second, the essay in its entirety should not be read as a history of how capitalism transformed labour and the environment in Latin American mining, since prior to the twentieth century the labour process in the Latin American industry was not, for the most part, capitalist. Third, while I argue that labour conditions in the industry tended to improve in the middle twentieth century, I am not suggesting that the exploitation of labour (in a Marxian sense) decreased, or that capitalism gave rise to prosperity, limited even to working miners. These are separate issues which are not treated in this article.

SOME THEORETICAL CONSIDERATIONS

It is widely agreed that as capitalism matures profitability comes to depend more on raising productivity through technological change than on expanding output by increasing the hours and pace of work. In the Marxian formulation, the first – productivity increases via technical change – raises relative surplus value, and the second – expanding output by increasing the time and pace of work – raises absolute surplus value.[2] As capitalism develops there is a tendency for the basis of production to shift from the latter to the former; this is part of the modernising dynamic of capitalism. Historically, technical change was forced on industries by two processes: first, workers' struggles to reduce the length and pace of work; second, competitive rivalry among firms. The result was that capitalist expansion came to depend primarily on increasing the exploitation of workers by revolutionising technology, and secondarily on intensifying the brutality associated with the appropriation of human labour in production.

This modernisation of production suggests the theoretical possibility that capitalist development might usher in more humane social conditions. However, in practice this largely depends on the character and outcome of labour struggles. While capitalist development historically has given rise to increased levels of consumption, this has characterised relatively few countries and in finite periods

of time. For example, in the post-war period from 1950 to 1970, improvements in the standard of living in the West depended on a number of contingent factors. These included: 1) rapid economic growth, 2) the relative strength of trades unions and the Left, particularly in Western Europe, and 3) the threat of an alternative way of organising society which, for all of their problems, was posed by the Soviet Union, China, Vietnam and Cuba.

Part of the dynamic of capitalism is that along with the possibility of raising the average level of consumption, the competitive drive for profits exerts a downward pressure on the condition of the working class. Historically, capitalist development has tended to be associated with a widening gap between the rich and the poor both in and between countries. This was especially evident at the end of the twentieth century, when the expansion and universalisation of capitalism, or 'globalisation', was accompanied by high levels of unemployment and insecurity of work, as well as by falling incomes and standards of living for the vast majority of people across the globe. In sum, tensions within capitalist development give rise to contradictory processes: on the one hand, a pressure to modernise production and raise productivity, and with this the possibility of improving labour conditions; on the other hand, a drive to expand profits by whatever means necessary, and with this a push to reduce labour costs which often results in deteriorating social conditions.

In apparent contrast to its modernising social potential, however restricted in time and scope, capitalist development, to date, has tended to intensify environmental degradation. The drive to accumulate, based on ever-expanding production, increased natural resource consumption. However, in a process analogous to the historic shift in exploitation from the production of absolute to relative surplus value, technological change within capitalism could, theoretically, reduce environmental degradation. This would involve the introduction and generalisation of 'nature-saving' technologies, profitmaking through resource recovery and environmental rehabilitation.[3] While there has been some movement towards such environmentally-motivated technological change, at the millennium's end this change did not represent a historic shift in the nature of capitalist production.

If environmental reform of capitalism could potentially reduce ecological destruction, the question remains how such a shift might be achieved? Echoing the earlier shift in the nature of capitalist production, which was forced on the system in large part by workers' struggles, significant change in the ways companies consume energy and resources will require concerted political action. But unlike the shift in the exploitation of labour, which responded in large part to workers' struggles, a shift to more sustainable production methods might depend more on concerted action by states than by workers' organisations.[4]

In so far as degradation of nature tends to destroy, in quality and quantity, raw materials and other means of production (including people), it poses a danger to the sustainability of capitalism as a whole. Although individual companies were

reluctant to adopt measures to reduce environmental degradation, especially if these jeopardised profits, political theory suggests that states might behave differently. In their role as guardians of the social order, as opposed to protectors of specific companies or economic groups, one might posit that states would enforce the use of environmentally sustainable production techniques. Notwithstanding that theoretical possibility, and the reality of strong pressure from the scientific and environmental lobbies, the scope and degree of state-sponsored environmental reform has remained modest. In the face of reasonable predictions as to the probable extent of environmental change in the short-term, in the late twentieth century most states remained largely resilient to pressure for environmental reform. This suggests that short-term profitability continued to take precedence over the longer term viability of states and societies in the political economy of the *fin du siècle*. Drawing on these theoretical considerations, this article examines how the development of the Latin American mining industry affected changes in the conditions of labour and the environment.

PRE-COLUMBIAN AMERICA, UNRAVELLING THE PRISTINE MYTH

The conquest of Latin America unleashed destruction of human life on a scale possibly unrivalled in history. Ironically, it may have been the single most important event of the past millennium to safeguard the plant and animal species of the New World. Notwithstanding the prevalence of scholarship and myth about a pristine pre-conquest America, there is increasing evidence that pre-Columbian peoples were systematically incapable of sustaining the ecosystems upon which their societies depended. Intense environmental degradation may have been a significant factor in the decline of pre-Columbian civilisations.

The collapse of the classical lowland Maya has long baffled scholars.[5] However, recently archaeologists uncovered evidence of acute over-cultivation and soil depletion surrounding the sites of Tikkal, Copan and Palenque dating from approximately 1000 AD, the period of the great collapse. Indications of a sharp decline in agricultural yields over a relatively short time-frame suggest that environmental unsustainability may have contributed to the Mayan crisis. These interpretations are not rooted in a Malthusian logic.[6] Rather, they propose that changing class relations were associated with the introduction of agricultural methods which proved incompatible with reproduction of the classical Mayan social order. Although Mayan belief systems enshrined the sanctity of nature, ideology may have diverged radically from social practices. If this interpretation is correct, it points to the conclusion that even though Mayans worshipped nature, their society was undermined by massive ecological change ultimately of their own making.[7]

New evidence also points to ecological unsustainability as a factor in the crisis of the Aztec Empire. Soil samples taken from Lake Pátzcuarco in Mexico

show that by the early sixteenth century the landscape of the highlands of Michoacán was seriously degraded.[8] Drawing on this evidence, archaeologists have proposed that severe soil erosion provoked a crisis of food security, which may have undermined the power of the indigenous ruling classes. If this hypothesis is correct, Aztec, Tarascan and other Mesoamerican people were especially vulnerable at the time Cortés and his army of six hundred men conquered Mexico. An explicit conclusion drawn from this research is that introduction by the Spaniards of the plough and of cattle grazing, long considered ecologically unsound, may not have been more unsustainable than indigenous agricultural practices.[9]

Clearly, the popularity of ecological explanations of pre-hispanic social instability reflected the rise of environmentalism and the emergence of ecology as an academic field. Nevertheless, those who continued to brush aside new research in order to perpetuate the pristine myth of pre-Columbian America were romanticists, as the notion of indigenous peoples living naturally in symbiosis with their environment, then as well as now, seemed increasingly untenable.[10] Rather than contributing to our understanding of the causes of ecological change, the pristine myth threatened to become a barrier to unravelling the complex dynamics of sustainable and unsustainable development.

CONQUEST OF PEOPLE, LIBERATION OF NATURE

Before Europeans 'discovered' the Americas, the Aztec and Inca Empires were weakened by internal warfare, as well as by environmental pressures, apparently. However, the catalyst of their demise was an exogenous force, the Spanish invasion. For the next three centuries, the search for precious metals was the driving force of European conquest and colonisation. In contrast to pre-Columbian people who worshipped nature, it would be fair to say that Spaniards worshipped silver and gold. As a consequence, the mining, processing and transport of metals was at the centre of the social and ecological transformation of colonial Latin America.

In the first stage of conquest the imperial enterprise was a campaign to extract precious metals as quickly as possible from the New World. This resulted in the extermination of the indigenous population of the Caribbean within several decades of contact. Extinction of the Tainos, Caribs and Arawaks – the people Europeans first encountered in the Caribbean – was caused by disease, hard labour, and social dislocation.[11] Isolated from contact with Europe, Asia and Africa, the native population of the Americas had little resistance to the bacteria and viruses that accompanied Europeans to the New World. When Spaniards enslaved the population of the islands, and forced them to pan rivers for alluvial gold, diseases spread rapidly and proved fatal.[12] The colonials terrorised indigenous people into submission by maiming and torturing those who resisted their

authority. Indifferent to the preservation of the native population, Spanish settlers worked their Indian slaves to death. When the native population of the Caribbean was extinct, Spaniards moved on to plunder the continent.

By the mid-sixteenth century it was evident that the Spanish American mainland was rich in silver. After advisers warned the Crown that mines without miners would produce no wealth, preservation of the native population become a priority of Royal policy. Although Crown and conquerors shared an overriding objective, to extract gold and silver from the New World, the immediate interests of the settlers clashed with the long-term viability of the colonial enterprise. In contrast to colonists, whose objective was to get rich quickly and return to Spain, the Crown endeavoured to safeguard the future prosperity of the Empire. To that end, the Crown enacted a number of decrees protecting the native population. These forbade enslavement of indigenous people, and all but abolished *encomiendas*, grants to privileged settlers of native communities which were obliged to pay tribute to their overlord.[13] Notwithstanding royal intention, decrees were notoriously difficult to enforce in the New World, and many of the first Indian labourers sent to the silver mines in Spanish America were enslaved in all but name.

After rich veins of silver were discovered at Guanajuato and Zacatecas in New Spain (Mexico), Potosí in Upper Peru (Bolivia), and a number of lesser sites, the locus of New World mining changed from looting and panning gold to underground silver mining. This ushered in a fundamental spatial and social reorganisation of the continent. Silver mining created a demand for draught animals to transport ore, food to feed miners, and timber to build shafts and tunnels. This, combined with forced recruitment of Indians, rapidly altered land use and social relations. The silver deposits were enormous, as were the logistical problems associated with extracting, processing and transporting ore. Cerro Rico at Potosí was particularly rich yet frustratingly inaccessible, located in the heart of the southern Andes at an altitude of 15,000 feet.

For thirty years following discovery of the great silver deposits on the continent, individual enterprise in mining continued virtually unrestrained. Notwithstanding Royal decrees, the age of conquest, from 1492 to 1570, was a period of almost unregulated violence against the native inhabitants of the Americas. History repeated itself as *encomenderos* imposed draconian working conditions to extract silver as quickly as possible. One might argue that if conquerors had sought to safeguard the health of the native population, it would have made relatively little difference to the spread of germs – the hidden conquest. Nevertheless, most epidemiologists agree that forced labour accentuated the mortal effects of disease, and exacerbated the population implosion. Although estimates vary, a majority of scholars concur that the population of Ibero-America declined from above 60 million on the eve of conquest to less than 10 million at its nadir in the seventeenth century.[14]

Ironically, demographic collapse safeguarded the ecosystems of the New World for centuries. Although diverting rivers to pan for gold, felling trees to construct mining shafts, and clearing land for grazing and agriculture all contributed to ecological change, their combined impact on the environment was relatively minor compared with the intensive cultivation, foraging and hunting which supported the large pre-conquest societies. The Latin American-Caribbean region was relatively under-populated for almost five hundred years, in comparison with Europe, Asia and Africa, and it did not recover its pre-1492 population until the nineteenth century.[15] As a result, there was considerably less human pressure on the region's natural resource base than in other parts of the world. This may explain, in part, why Amazonia and other great forests of the Americas survived into the twentieth century.

STATE-SPONSORED COLONIAL MINING

Soon after the rediscovery of abandoned Inca mines at Potosí in 1545, a 'silver rush' convulsed the Andean region. Spanish settlers, Indian labourers and fortune-seekers of all kinds flooded to the mining centre. However, by 1560 the silver boom was waning. Scarcity of labourers, exhaustion of the rich and easily extracted ores, and inefficient processing techniques threatened to close down the mines. When it was apparent that Peruvian silver production was in serious decline, the Crown reorganised the colonial state to counter the crisis.

From the 1570s onwards, expansion of the mining industry became the overriding objective of imperial rule.[16] To accomplish this, Viceroy Francisco de Toledo forged an absolutist state in Peru which directly appropriated and distributed Indians' labour. Prior to these reforms, Spanish mineowners corralled whatever labourers they could, by whatever means necessary, to extract and process ores. This resulted in chaotic use of labour, which, it was believed, exacerbated the decline of the indigenous population. Viceroy Toledo set out to increase the supply of Indians to work in the mines and at the same time to safeguard the health of the indigenous population. The instrument to achieve these two apparently incompatible objectives was a state labour draft, the *mita.* The state assumed responsibility for guaranteeing a regular supply of Indian labourers to Spanish mineowners. In the beginning the policy was successful, as Indian communities sent an estimated 14,000 men annually to Potosí alone in the late sixteenth century. In addition, the colonial administration attempted to prevent the worst excesses associated with exploitation of the indigenous population by regulating wages and working conditions. Finally, the state restricted the 'catchment' for the *mita* to highland communities where, it was hoped, men accustomed to hard labour at high altitudes would survive the work regime at Potosí.[17] However, despite its protective veneer, soon it became

apparent that state intervention did not significantly reduce the mortal effects of work in the mines.[18]

The introduction of mercury amalgamation, the newest technology in silver processing, accompanied the reorganisation of labour at Potosí.[19] Mill owners adopted the patio process, which was based on grinding silver to a fine dust and mixing it with mercury. As silver adheres to mercury, which was burned off, with the patio process it was economically viable to mine lower grade ores.[20] Soon the discovery of large mercury or 'quicksilver' deposits at Huancavelica in the central Andes sparked another upturn in the industry. The state established a monopoly to produce and sell mercury to ensure expansion of silver production because, in the words of Viceroy Toledo, 'Huancavelica and Potosí are the two poles which support this Kingdom and that of Spain'.[21]

State intervention resolved the immediate problems of the mining industry in Peru. With a regular labour supply and technological innovation, Peruvian silver production rose rapidly, peaking in the final decade of the sixteenth century. But the boom was short-lived; conditions which unleashed production undermined it as well.[22] As more Indian draft labourers, or *mitayos*, were sent to Potosí, more Indians came to know the horrors of life in the mines and mills. By the light of torches miners hammered at ore bodies in underground tunnels. In low, crowded and poorly ventilated vaults the temperatures soared. *Mitayos* spent hours climbing up fragile ladders with heavy sacks of ore, to emerge into snow and freezing temperatures at the surface. They immediately descended into the inferno below to cut and carry another load. Working alongside mules, men crushed silver and mercury with their bare feet in large vats. Some died quickly of mercury poisoning; others languished with fevers and sores.

In self-preservation, many *mita* labourers fled the mines. In addition, scores of Indians deserted their villages to escape the dragnet of the draft. Flight contributed to the devastation of Andean communities, which accelerated population decline and intensified the labour scarcity at the mines. Over the next century New World silver production declined. To expand output mineowners needed more workers, more accessible veins of higher grade ores and more quicksilver.

Silver mining dictated the social and spatial organisation of the Spanish colonial world. Mines became hubs of the largest urban centres in the Americas. With a constant flux of some 200,000 people coming and going to Potosí at the turn of the seventeenth century, it was one of the western world's largest cities. Lima, Panama, Vera Cruz and Havana, stops on the official trade route from the mines to Spain, all grew rapidly. The same was true of Buenos Aires, the nexus of the contraband silver trade. In addition, secondary towns sprang into existence along the mule trails which connected mines to the cities and ports of the New World.[23]

As well as giving rise to major urbanisation, mining changed the landscape of Latin America. Forests and fields were converted to pasture as demand for

mules to carry ore led to the creation of large ranches in areas surrounding the mines. Trees were cut to make shafts and tunnels for the mines. At Potosí, a network of dams formed twenty artificial lakes which ensured a regular supply of water to the mills. Caribbean islands were deforested to provide lumber to build the galleons which carried silver to Europe. The demand for food at the mining centres gave rise to commercial farming. All of this effected environmental change, but it did not threaten the sustainability of regional ecosystems because the population of Latin America had been declining precipitously since 1492. Throughout the continent large expanses of land were returning to wilderness.

Mercury, an adjunct of New World mining almost since its inception, was responsible for the greatest environmental damage.[24] Wrapped in leather bags, mercury was transported throughout the Americas and Spain. As a result, in addition to poisoning workers at the mines and mills, mercury contaminated large areas. Once rivers became saturated with mercury, the poison was passed to the humans, animals and birds which fed on toxic fish. In addition, plants were contaminated by irrigation waters, even in areas far from the mines. Because mercury accumulates in animal and plant tissue, it created long-lasting cycles of toxicity. Nevertheless, the damage caused by mining in the early colonial era was more social than ecological. Mining was associated with extermination of entire Caribbean civilisations and massive reorganisation and dislocation of indigenous society in Meso- and South America.

Turning to the seventeenth-century, the historiography of this era traditionally focussed on the issue of economic depression. Historians writing before 1980 generally believed that New Spain and Peru suffered from a major depression, which originated in falling silver production and rising prices on both sides of the Atlantic. In contrast, later historians argued that there was little or no seventeenth-century depression in the New World. They maintained that the downturn in silver production and in transatlantic trade did not adversely affect the majority of inhabitants of Spanish America.[25] For example, because the colonial state was unable to impose the *mita* as effectively as it had in the Toledan era, Peruvian communities benefitted from the downturn in mining. In other words, they enjoyed a certain benign neglect.[26] Whichever position historians subscribed to, they tended to agree that the seventeenth-century was an era of commercial retreat in the New World. Whereas, in the sixteenth century an expanding mining sector had engendered production of mules, food and timber for exchange, in the seventeenth century a contracting industry caused a downturn in these activities.

It is noteworthy, however, that historians have not addressed the environmental consequences of the mining/population decline of the seventeenth century. While there is evidence that the forest cover in Spanish America was more extensive in the seventeenth century than it had been for some time before, or since, and that the mining/population crisis created conditions for the

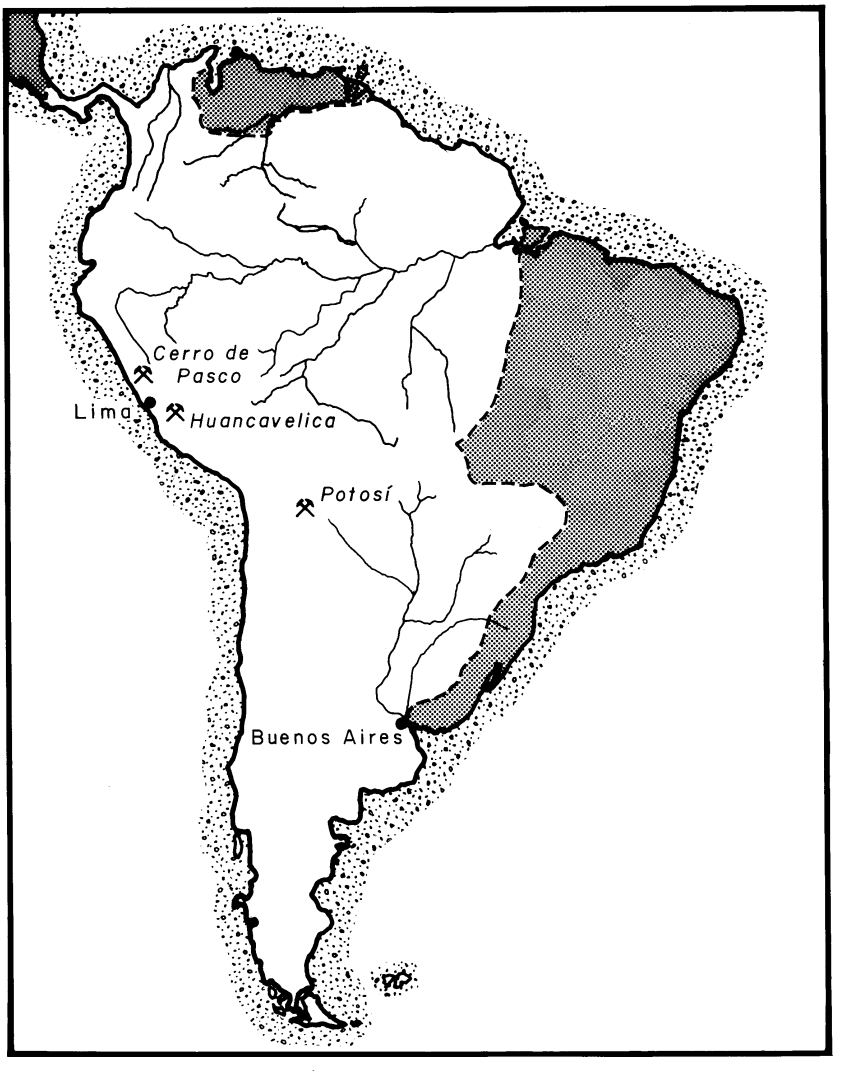

FIGURE 1. The major mining regions of the Viceroyalty of Peru, c. 1700

regeneration of vegetation and wildlife, more research is needed on the environmental consequences of seventeenth-century changes in the New World. With this in mind, it is significant that historians have come to agree that the notion of a land scarcity in the sixteenth and seventeenth centuries is largely fallacious. As

a number of recent studies have demonstrated, the land question in Latin America was not about shortage of land per se.[27] In the first two centuries of Spanish rule in the Americas, population pressure on land, or the 'person-land ratio', was probably lower than it had been for the preceding centuries.

Over the course of the seventeenth century, the use and abuse of mercury declined, particularly at Zacatecas. There, because of a mercury shortage, mill owners abandoned the amalgamation technique in favour of smelting, an older and less efficient method of processing silver. Consequently, the cycle of mercury poisoning which began in the Mexican mines a century earlier started to wind-down. However, this was in contrast to Potosí, where mill owners used relatively more mercury to process low grade ores in order to keep the mines operating.

In contrast to the preceding one hundred years, the eighteenth century was marked by gradual demographic growth and a revival of silver mining. It would be facile, however, to conclude that one caused the other. Notwithstanding an upturn in the Andean population after one hundred and fifty years of decline, the labour shortage intensified at Potosí.[28] In the first decades of the eighteenth century about 4,000 *mitayos* worked the mines and mills of Cerro Rico. By mid-century the number had fallen to 3,000 and it remained at that level for the next sixty years. This demonstrates that although the state undertook successive reorganisations of the *mita*, in order to expand the labour force, its efforts were largely futile. The rise in silver production at Potosí was achieved by increasing the exploitation of *mita* labourers and recruiting a growing number of nominally free workers. Mineowners appropriated more labour from *mitayos* by increasing production quotas. As a consequence, the average volume of silver ore each *mitayo* extracted doubled in the second half of the century. This was accomplished by intensifying the pace of work, lengthening working time and disregarding laws which set the maximum period *mitayos* worked at the mines. However, even with these measures, mine workers frequently fell short of their production quotas. Consequently, their wives and children often worked in the mines and mills to meet the tribute obligations.

By the nineteenth century the mining industries of Peru and Mexico were robust again.[29] It is significant, however, that throughout the era of Spanish rule, with the exception of the patio process, there was little technical innovation in extraction and processing. Although shafts and adits were deeper and longer than they had been two hundred years earlier, animal powered hoists were rare and steam power unknown.[30] Consequently, mineowners continued to rely predominantly on human labour to excavate and haul ores. In the absence of technical change, increased output in the mines was accomplished by prolonging labour time and intensifying work. In the last years of Empire fewer people worked in silver mining in Peru than in the boom years of the sixteenth century. Nevertheless, instead of working conditions improving in the mines, arguably over time the labour regime had become more brutal.

NEO-COLONIAL MINING AND THE RISE OF CAPITALISM

In colonial Latin America the ecological effects of mining were constrained by the nature of an economic system based on merchant capital. First, mining was largely limited to silver and gold, which were valued primarily as a means of exchange and a hoard of wealth. Second, technological innovation was slow, which itself tended to limit ecological change. However, in the nineteenth century, the development of capitalism in Europe and the United States dramatically increased ecological change associated with mining in Latin America. First, the industrial revolution expanded demand for an array of metals hitherto virtually ignored in Latin America. Second, the industry grew as a consequence of technological innovation in methods of production, processing and transport.

The initial phase of neocolonial mining began with British investment in Mexican silver mines. However, these early ventures foundered, largely as a consequence of the political and social turmoil which followed Latin America's independence wars.[31] When the industry revived in the late nineteenth century, after three quarters of a century of decline, expansion was based on non-precious metals and technological innovation. Although new mining enterprises in Latin America supplied minerals for the world capitalist market, force and indebtedness continued to prevail in the labour process. For example, in Peru, although the *mita* was abolished in 1812, for another one hundred years mining companies in the Andes relied on unfree labour.

Nitrate production was the first new mining sector to emerge in post-independence Latin America; its rise was directly linked to the development of agrarian capitalism in Europe. The transformation of land and labour systems in England, following the enclosures, created a demand for fertilisers to increase agricultural yields. The sodium nitrates mined in shallow seams in the Atacama desert were among the first 'natural' chemical fertilisers to be widely used in Europe.

In the 1840s Chilean entrepreneurs set up nitrate mines in the coastal desert strip which straddled the borders separating Chile, Peru and Bolivia. They brought tens of thousands of people to work in a region which hitherto had been considered uninhabitable. In the next decades, companies, most of them British, built railroads, set up banks, and bought mines in the area. Soon British firms dominated the Chilean nitrate industry. In 1879 Chile, Peru and Bolivia went to war over the deposits in the Atacama, the first of many wars fought over mineral rights in Latin America. With British support, in 1883 Chile won and appropriated Peruvian and Bolivian territory in the desert. But nitrates were soon replaced by new petroleum-based fertilisers. By the end of the century, mining in the Atacama was all but abandoned, along with the railroads and scattered towns it spawned.[32]

Latin American petroleum production followed close on the heels of the collapsing nitrate sector. In 1872 petroleum was discovered at Talara, where the Humbolt and El Niño currents converge off the north coast of Peru. In what was

considered one of the world's richest areas of sea life, the International Petroleum Company (IPC), a subsidiary of Rockefeller's Standard Oil of New Jersey, drilled Latin America's first wells.[33] With wooden oil rigs and primitive technology, there were many accidents in IPC's first decades of production. Oil spills killed fish, animal and plant life along the Pacific, which forced a number of fishing communities to abandon the zone.[34]

By the end of the century, proliferation of electrical instruments, of railroads, and the mass production of tools, machines and armaments created markets in Europe and the United States for new industrial metals. To satisfy that demand, domestic capitalists in Peru, Mexico and Chile developed small-scale copper-lead-zinc mines. Within a decade, however, most of them sold out to foreign firms, which had more capital with which to expand and modernise the industry.[35]

Around the turn of the twentieth century many Latin American governments implemented Liberal reforms which extended rights of private property to mineral deposits. These reforms hastened denationalisation of the mining industry. In Peru, for example, prior to the twentieth century mineral deposits were state owned. On a number of occasions, foreign firms had declared they would not invest in the industry because of the precarious nature of leaseholds. In 1901, responding to pressure from U.S. capitalists, the Peruvian government enacted a new mining code which altered the property regime: mineral deposits could be privately owned. Almost immediately, a New York company purchased 80 per cent of the mines in the Cerro de Pasco region of the central Andes.[36] Many of the deposits were virtually inaccessible, situated at altitudes between 9,000 and 12,000 feet above sea level. They were in regions without roads, bridges or other infrastructure, which were subject to seasonal flooding and mud slides. Despite these climatic obstacles, the Cerro de Pasco Corporation soon dominated the economy and society of the central highlands of Peru.

Within a decade, the large-scale mining, processing and livestock operations of the Cerro de Pasco Corporation altered the ecosystem of the Andes. The company constructed networks of roads, railroads, smelters, mining camps, dams and hydro-electric plants to serve its chain of underground copper-lead-zinc mines. First the company modernised refining by introducing the Bessemer process, the most up-to-date technology of the period. Because its smelter, inaugurated in 1905, had a capacity more than five times that of the next largest processing plant in Peru, it created a seemingly insatiable demand for ore and fuel. To supply the smelter, the Corporation modernised haulage and transport systems by installing a system of carts on rails, propelled by electric and horse power. This replaced the men who had for centuries climbed up and down ladders in the mines hauling bags of ore. Finally, the company built a network of lifts, cars and railways to transport ore from their mines to the centralised smelter.

The Cerro de Pasco Corporation purchased large quantities of timber to build its infrastructure, greatly increasing deforestation and erosion in the region. The

series of dams to generate electricity for its chain of mining complexes also contributed to ecological and social change. Although the steep terrain of the Andes limited the size of dams, their sheer number flooded highland valleys far from the mines. In addition, railroads altered land. Responding to the availability of transport and the demand for foodstuffs at the mines, commercial grazing and farming began to push out subsistence agriculture, especially in areas close to the tracks.

In 1922 the company inaugurated a large smelter-refinery at La Oroya, which in short order dramatically altered the environment of an area of approximately one hundred square miles. The new smelter polluted the region's air, soil and rivers with arsenic, sulphuric acid and iron-zinc residues. Vegetation withered, animals and fish died, and people developed new diseases. Thirty peasant communities and twenty-eight hacienda owners as far as 75 miles from La Oroya filed legal claims against the Corporation for acute environmental damages. After years of litigation the people whose land and livelihood had been destroyed won a pyrrhic victory: the courts ordered the company to purchase their land. In one stroke the Cerro de Pasco Company became the largest landowner in Peru.

In an example of ecological modernisation, once the company owned the barren lands it increased profits by means of reducing environmental damage. Over the next decade the company installed flues to capture lead, zinc and bismuth particles, as well as arsenic and sulphuric acid emissions. These measures gradually increased the smelters' productivity. The company sold the recovered metals, which contributed to its expanding output of lead-zinc ores. Environmental controls had another benefit: the soil of the Andean *puna* slowly regained its fertility. On the cold, dry lands at altitudes of 12,000 feet, which the courts had ordered the company to purchase, the Company developed Peru's largest cattle ranch. Nevertheless, those environmental measures did little to regenerate the flora and fauna of the La Oroya valley, closer to the refinery. There soil and rock remained bleached by sulphuric acid, and rivers and underground water continued to be toxic and lifeless.[37] More than eighty years after the Corporation opened the refinery, the Oroya valley remained a sort of lunar landscape.

Although the Corporation modernised mineral processing and transport, for over forty years its methods of labour recruitment looked to the past more than to the future. From its inception, the Cerro de Pasco Corporation found it difficult to attract workers. The Company's North American staff regularly complained that of all the difficulties associated with mining in the Peruvian Andes, worst was the shortage of labour. The root of their problem lay in the vitality of communal and household production in the Andes. Although peasant communities were changing, households remained largely self-sufficient. Consequently, rather than accepting that work in the mines was a permanent feature of life, Andeans sought wage labour in the mines only occasionally, to solve an immediate cash crisis.

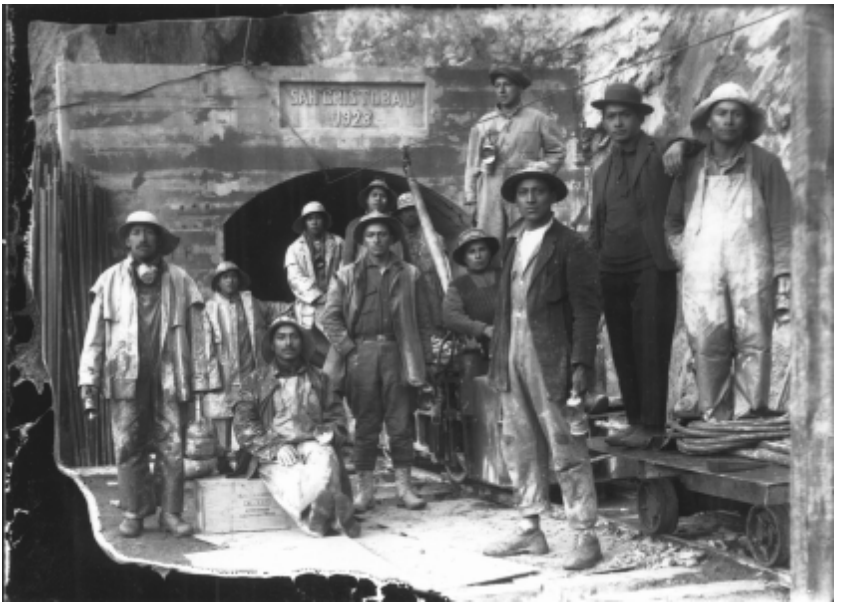

FIGURE 2. The entrance to the San Cristóbal Mine of the Cerro de Pasco Mining Corporation. The mine was inaugurated in 1928; this photograph was taken soon after by the Peruvian photographer Sebastían Rodríguez.

Occasional labour was incompatible with the Corporation's labour requirements. The company needed permanent workers it could train in the skills of mining and metallurgy, not men who worked for short stints, then returned to their villages. To resolve this problem, the Corporation adopted an Andean tradition called *enganche* (the hook), another name for debt peonage. It sent labour recruiters into highland villages, giving cash advances to men who promised to work off their debt in the mines. In this system, peasants became tied to the company, often for long periods because not infrequently their debts mounted, rather than declined, the longer they remained at the mines.

Within a decade, environmental damage caused by the Oroya refinery contributed to resolving the labour shortage. After inauguration of the refinery at La Oroya, peasants could no longer harvest crops in the area surrounding La Oroya. Further away, yields declined and animals died. In addition, paid labour on haciendas was harder to come by as many of the region's estates were also affected by contamination. Consequently, as the viability of peasant production declined, more families came to depend on wage labour in the mines for survival. In this period, proletarianisation of the peasantry facilitated modernisation of the mining industry.

REVOLUTION IN MINING

In the 1960s, underground mining was fast becoming a relic of the past as technological innovations transformed the industry. The exploitation of high-grade subterranean veins gave way to extraction of low-grade ores from vast disseminated mineral bodies. The new open-cast techniques transformed all stages of metals mining. First, modern excavation equipment was used to remove the earth's 'overburden', or surface layer, which covered shallow mineral deposits. Second, conveyer belts and pipelines facilitated the movement of large quantities of soil, sludge and rock. Third, new mechanical and chemical techniques were employed to process low-grade ores. Fourth, super-tankers and large port facilities were used in the transport of metals. All in all, open-pit techniques revolutionised copper, iron and bauxite mining, in particular. The result was a leap in the scale of production, but at tremendous environmental cost. Mountains *were* moved and valleys obliterated. Fertile soil that had supported plant and animal life was covered by toxic tailings. Often these residues were recklessly discarded, initiating a chain of soil, water and air contamination that altered the ecosystems of large areas.

Chile, among the world's leading copper-producing countries, was in the forefront of open-pit mining. The decline of its nitrate industry in the early twentieth century paralleled the rise of copper. Copper production in Chile was based on low-grade porphyry ores, which required large investments. Following the opening of the Panama Canal, which lowered transportation costs, and technological innovations in mining and refining low-grade ores, U.S. companies rapidly bought out Chilean mining firms. By 1920 the Chilean copper industry was dominated by three U.S. companies. To give some sense of the scale of production, one open-cast mine, Chuquicamata, the largest copper mine in the world, produced half of Chile's copper exports throughout most of the twentieth century.

In Peru, technological revolution rendered obsolete Cerro de Pasco's empire of underground mines. After the 1960s, when the Corporation's profits declined, the bulk of Peru's mineral exports, predominantly copper and iron ore, came from Cuajone, Toquepala and Cerro Verde, open-pit mines in the south. These were an extension of the rich deposits in northern Chile. In Bolivia, from the early twentieth century, tin was extracted from abandoned silver mines at Potosí, as well as from Siglo XX and Catavi, underground mines on the *altiplano*.[38] However, the development of open-cast mining in other countries contributed to the virtual collapse of Bolivia's tin industry in the 1980s. In particular, open-cast tin mining in Brazil, and the substitution of other metals, such as aluminium, for tin in a number of industrial uses undermined profitability in the Bolivian industry. Nevertheless, if environmental sustainability had been calculated in estimating the costs of open-cast mining ventures, the Bolivian tin industry might not have been written off as uncompetitive.

The open-pit mining revolution was partially responsible for the widespread substitution of aluminium for tin. In general, it was cheaper to mine bauxite, from which aluminium is derived, from surface deposits using open-pit techniques, than to extract tin from underground mines. However, this ignored the fact that aluminium production often was associated with acute environmental degradation. First, it required massive amounts of electricity; in fact, electricity was the major input in aluminium production, not bauxite. As a consequence, bauxite-aluminium production gave rise to the construction of large hydro-electric dams. For example, in Jamacia, as part of the development of bauxite mines, companies built large dams. These flooded agricultural valleys and forced farmers off their land. A second highly damaging side effect of aluminium production was the residue of vast quantities of toxic waste. So-called 'red mud', discarded by aluminium processing plants, is a highly alkaline caustic waste that frequently contaminated ground water and soil in areas surrounding bauxite mines. In Jamaica, Venezuela and Brazil companies disposed of red mud by spreading it over large areas.

While the technological revolution in mining had direct negative ecological consequences, these were intensified by national development strategies which promoted the construction of industrial complexes as spin-offs from the mines. In Latin America, petroleum and iron ore deposits in formerly inaccessible and relatively unspoiled regions frequently formed the hub of 'development poles'. Politicians, bankers and lending agencies coordinated efforts to create these new centres of industrial production.[39]

This was the case with the massive oil deposits developed in Tabasco and Chiapas in Mexico in the 1970s, where the government expropriated agricultural land for mining operations. In ten years Villahermosa, once a small river town, had refineries, ports, pipelines and almost a million people.[40] Air pollution combined with filtration of contaminated water reduced fertility of the remaining farmland. In addition, after a few years vegetation had been damaged by nitric acid rain which originated in the sulphur and nitrate emissions from the refinery.[41] By 1980 one of the few remnants of Villahermosa's past was its ironic name, 'beautiful town'. Its pollution problem was so extreme that residents of Mexico City derived consolation from comparing the toxicity of the two regions.

One of the first development poles to be established in conjunction with metal mining in Latin America was in the remote Orinoquia rainforest in Venezuela. In the 1960s the Venezuelan government nationalised U.S.-owned iron mines in the state of Bolívar to build a large iron-steel complex at Ciudad Guayana.[42] The massive infrastructure at Ciudad Guayana, where the Orinoco and Caroní Rivers converge, included open-pit mines, steel plants, a hydro-electric power plant, and as an after-thought an aluminium refinery. The aluminium refinery was put there to take advantage of electricity generated by the Guri hydro-electric dam, one of the largest in the world. In its early years of

operation all the bauxite the plant processed was imported. Only later were bauxite deposits discovered at Los Pijiqüaos, about 800 kilometres from Ciudad Guyana. This discovery spread environmental dislocation into a new region, inhabited by indigenous peoples and unique varieties of birds, animals, reptiles and plants. Bauxite excavated at the giant open-cast mine at Los Pijiqüaos was floated up the Orinoco to the refinery at Ciudad Guayana. This initiated a chain of pollution carried by the rivers and extending from the mining-industrial complex into the surrounding rainforest.

The development of Ciudad Guayana involved careful economic planning, but little consideration for the project's impact on the tropical ecosystem. The entire river network was altered to meet the needs of the complex. The Guri Dam changed the flow of an extensive river system and flooded large areas of tropical soil. The construction of super-ports on the Orinoco, and widening the river to accommodate ocean-going tankers, aggravated the environmental transformation of the river system. In addition, the mining-metallurgical complex generated a sociopathic process of urbanisation that would be repeated at other development poles. As population growth outpaced the provision of basic urban services, the combination of human waste, debris from the mines, and airborne pollutants from the metallurgical plants turned Ciudad Guayana and the surrounding zone into an environmental disaster area.

Notwithstanding their size, Ciudad Guayana, Villahermosa, and other mega-mining projects were dwarfed by Brazil's *Programa Grande Carajás*. Begun in the 1980s, Carajás was the largest mining project in the world. Everything about Carajás was mammoth, including its threat to the global ecosystem. The project converted one quarter of the planet's largest tropical rainforest into its largest agro-industrial center.[43] At the hub of the enterprise was an iron ore deposit which reputedly enjoyed the lowest production costs in the world. It was calculated that Carajás alone would produce ten per cent of the world's iron.

The Carajás iron mine became the heart of a vast 'integrated development project' that included a string of open-cast mines producing bauxite, copper, chrome, nickel, tungsten, cassiterite and gold. Processing plants, steel and aluminium factories, agro-livestock enterprises, hydro-electric dams, railroads and deep-water river ports all radiated out from the mines. These formed an archipelago that covered an area of 900,000 square kilometres, the size of France and Britain combined. In addition, the project was like a giant magnet, drawing farmers, gold prospectors, and enterprises of all kinds into the Amazon.[44] Like earlier mining booms in Brazil, mining in Amazonia altered the locus of the country's economy.[45] Along with ranching, it transformed Amazonia from a vast natural preserve to one of Brazil's most dynamic centres of economic growth.

Before Carajás was completed its effect on the environment was apparent, particularly repercussions from deforestation. Besides clearing the forest to make way for mines, farms, and cattle ranches, 1.6 million acres of timber was

cut annually to stoke pig iron smelters and provide lumber for construction. The project included plans for reforestation; nevertheless, large areas of the forest were reduced to scrub. This contributed to climate change in and beyond Amazonia. Less rainfall, combined with soil erosion, siltation and flooding were early warning signs of desertification. Research showed that certain plant and animal species were becoming extinct. In total, the construction and operation of Carajás set in motion overwhelming negative changes in the ecosystem.[46]

Large as they were, Carajás and other industrial ventures did not monopolise mining in Amazonia. After the rise in the price of gold in 1979, an estimated one million *garimpeiros*, or prospectors, invaded the region in a gold rush of unprecedented proportions. In the 1980s, the gold which *garimpeiros* extracted from the rivers of Amazonia accounted for approximately 90 per cent of Brazil's annual output. The roads, railroads and services installed for Carajás facilitated the gold rush.[47] In contrast to the scale and technology of integrated development projects, *garimpeiros* were mining's 'informal sector'. Relying on simple machinery and artisanal methods, prospectors worked alone or for small-scale contractors.

Garimpeiros have been blamed for much of the erosion in Amazonia because their techniques involved excavating the banks of the region's waterways.[48] This activity disturbed the ecology of the river system, in particular causing siltation that choked out shallow-rooted trees and plants which had stabilised the terrain.[49] Most destructive of the environment and of *garimpeiros* themselves was their abuse of mercury. To separate gold from ore prospectors used an amalgamation technique not unlike the one developed in the sixteenth century to process silver.

Some specialists argued that small-scale prospecting caused extreme environmental degradation because it was unregulated and unplanned. In their view, prospectors' profligate use and careless disposal of mercury contaminated rivers, soil and the atmosphere more than large mining companies would have done. They argued that the scale of silt, sewage and other kinds of river contamination was an inevitable by-product of the sheer numbers of gold prospectors; this could have been avoided if the sector were dominated by large firms. Finally, critics of small-scale mining held that random logging caused more serious erosion than did projects, such as Carajás, with programmed deforestation/reforestation.[50]

Other specialists disagreed. Faced with massive industrial mining, they viewed *garimpeiros* as the lesser of two evils. Despite the damage they caused, together with indigenous tribes and small farmers, *garimpeiros* helped to resist the advance of ranchers, speculators, and mega-mining companies which were relentlessly transforming Amazonia.[51] However, the ecological damage that resulted from informal gold mining caused conflicts between *garimpeiros*, farmers and indigenous peoples of the region.[52] Indian tribes, in particular, attempted to keep prospectors out of the forest because their survival depended

on hunting, gathering and fishing, all of which were jeopardised by small, unregulated mining.[53]

Environmental destruction caused by mining in Latin America increased significantly in the twentieth century, particularly following the introduction of open-cast techniques. This was in contrast to a general reduction in the brutality of working conditions in the industry. The technology of open-cast, non-selective mining transformed the labour process in metals extraction. Modern mining no longer required men to work underground in dangerous, unhealthy conditions. Men (and some women) who extracted ore from open-cast mines operated construction equipment. They drove cranes, shovels and dredgers which scraped away the earth's mantle. The mechanisation and division of labour which came to characterise industrial mining has been associated with rapid increases in productivity. For example, in 1970 on average more than ten times more metal was produced per day in Peru's open-cast copper mines than would have been possible in underground mining.[54]

In Latin America, the open-cast revolution in mining marked a turning point for the human condition of miners and the environmental sustainability of the industry. While the first tended to improve, the second tended to deteriorate. In so far as profitability came to depend on the pace of technical innovation in extraction, processing and transport, more than on prolonging and intensifying labour, it was associated with two tendencies: first, the *relative* reduction in the number of workers employed by large mining companies; second, some scope for improvement in working conditions for those in work.

In the middle twentieth century, the militancy of miners' trades unions in several Latin American countries, in the context of mechanisation associated with new techniques, brought improvements in miners' working and living conditions.[55] In general, the horrors of heavy physical labour in appalling conditions underground gave way in advanced sectors of the industry to a more 'modern' labour process. As the character of the exploitation of labour in the mines changed, work at the mines became more like that in other industries. As a consequence, by the 1960s miners' collective struggles derived less from their conditions of work than from the increasing numbers of miners who had no work at all. With underground mines closing down, unemployment became the scourge of the industry.

Transformations in the labour process, which provided the possibility for improving conditions of work, also generated massive environmental destruction. The same mechanisation and open-cast techniques which lightened the labour of working miners brought ecological disaster to large regions of Latin America. Leaps in productivity ushered in alterations of the environment on what seemed like an ever-expanding scale. The direct and indirect effects of the mining revolution degraded large expanses of the earth's surface, the impact of which was felt far beyond the continent.

DEBT DISASTER

Environmental destruction and debt were among the major global concerns of the late twentieth century. Although apparently separate issues, their causes and effects were linked because finance capital imposed a solution to the debt crisis which almost inevitably resulted in large scale ecological degradation.

The Third World debt crisis originated in an escalation in the price of oil in the 1970s. Flush with petro-dollars and anxious to extend credit wherever they could, banks in Europe and the US pressed loans on Latin American governments. These funds financed the construction of roads, dams, ports, pipelines and mines. The result was growth in production, in particular of petroleum and metal mining; however, income growth was not as rapid as economists had expected. Construction of some of these projects dragged on for decades, others were never completed. In many cases mega-mining projects proved to be less profitable than they appeared on paper. Instead of generating income, a number of these projects generated debt. For example, in Peru debt servicing for the mining sector alone was US$ 663 million in 1984.[56]

The North's solution to the debt crisis accentuated environmental and social dislocation throughout the Third World. The bankers' response to indebtedness was coordinated by the International Monetary Fund, which imposed structural adjustment policies on governments. The aim of these policies was to ensure that countries did not default on their debts to private banks and multilateral lending agencies. Structural adjustment, or conditionality, involved economic deregulation, denationalisation and, above all, export promotion. In Latin America, to satisfy conditionality, governments encouraged exports, almost regardless of their environmental or social impact.[57]

In the context of debt, export promotion and environmental degradation became intertwined. Petroleum was Latin America's leading export in the 1980s. Although prior to the 1970s, Mexico and Venezuela had been the only significant producers in the region, in the 1980s petroleum companies initiated ambitious exploration programmes in Amazonia as well as in offshore fields. The expansion of petroleum exploration was directly related to the debt crisis. Faced with large service payments and contracting economies, governments were anxious to exploit their petroleum reserves. Consequently, they offered companies favourable terms to develop their deposits. While these governments sometimes paid lip service to issues about the environmental impact of these programmes, in practice they were unwilling to take actions which might discourage companies from operating in the region.

In the 1980s Brazil had the largest debt of any country in the world. Although the capitalist development of the rainforest preceded the debt crisis, Brazilian politicians resolved to hasten exploitation of the resources of Amazonia to service its loans. For instance, notwithstanding low metals prices in the 1980s,

Carajás and other large open-pit mines were inaugurated and enlarged. These contributed to the fastest and most ruthless enclosure movement in history. It is estimated that in twenty years, between 1970 and 1990, 50 million hectares of common lands in Amazonia were appropriated as private property. The rush to the Amazon unleashed environmental destruction and violent conflicts over natural resources on a scale few had anticipated.[58]

As I have described, Amazonian gold prospectors represented an extreme and well publicised case of environmental depredation. While less well known, the spread of an informal sector in mining occurred in other countries of Latin America, and with similar effects. Neo-liberal economics engendered widespread poverty, unemployment and deregulation, which encouraged artisanal mining to flourish in the shadows of industrial enterprises. As small scale, 'informal' mining ventures easily circumvented regulations controlling the disposal of toxic tailings and chemical pollutants, the environmental consequences of these activities rapidly became apparent. This suggests that in mining, small is not necessarily more sustainable than large-scale ventures.[59] I propose that with regard to mining, the salient factors which condition environmental impact are the form of property relations and the political will to regulate production, not enterprise size. When capital accumulation drives production and choice of technology, ecological considerations tend to be disregarded, whatever the size of firm. This would support the conclusion that where production is consciously and collectively designed to enhance social needs, there is more possibility that choice of technique, including scale, might reflect environmental considerations. However, writing in a time when socialism seems remote, realism leads me to suggest that the nationalisation of mining activities might be a more pragmatic political agenda. And, unlike in the past, environmentalists would endeavour to ensure that the politics of nationalisation was based on environmental as well as class objectives.

ENVIRONMENTAL DESTRUCTION AND HUMAN IMMISERATION: INVERSE OR MERGING TENDENCIES?

Analysis of historical trends in Latin American mining suggests a tendency towards decline in human immiseration coupled with a rise in environmental destruction. These processes intensified with the expansion of capitalism in Latin America. Capitalism has the potential to free human beings and productive resources from limitations which characterised previous economic systems. At the same time it subordinates workers and resource use to the competitive drive to accumulate capital. The combination of 'liberation' and subjugation creates

a power that is productive as well as destructive. Production expands rapidly, but in the process of accumulation capital consumes resources on an ever expanding scale.[60] This creates a tendency within capitalism to erode ecological sustainability: however, it also contains counter-tendencies. The development of technologies which economise in the use of resources is one; another is that when profitability is constrained by environmental degradation, firms may take measures to overcome impediments to the expansion of capital, such as at La Oroya in the 1920s.[61] However, the most important force for ecological preservation stands outside capital and potentially opposes its expansion. That force is the power of people who in an organised way resist the destruction of natural resources which are crucial to their lives.

With the expansion of capitalism, exploitation of the working class tends to increase, as capitalists appropriate more unpaid labour time in the process of production. Yet inherent in capitalism is the possibility that the standard of living and working conditions of the labouring class may improve. Rising productivity provides the possibility that capitalists can increase profits and also accede to some demands by workers for improvements in their conditions of existence. That two-fold process occurred in industrial countries in the twentieth century: trade unions fought for improvements in the lives of workers, and the standard of living of the working classes rose. To a lesser extent that process characterised the mining industry in Latin America.

One might conclude that these long-term inverse tendencies – improvement in the conditions of existence of the masses of people in contrast to increased ecological deterioration – gave impetus to environmental movements which flourished in the industrialised countries in the late twentieth century. In Europe and the US, where human suffering seemed to be on the wane, people became increasingly alarmed by the devastation of the natural world. However, the experience of the 1990s underlined the fact that with the expansion of capital, improvements in the standard of living of the working class is only a possibility, not an inherent characteristic of capitalist development.

Events of the *fin du siècle* in the developing world, specifically the social consequences of the debt crisis, of neo-liberal economics and of globalisation, suggested that in so far as an inverse relationship between human and natural degradation existed, it might be drawing to an end. One could project that in the future the two tendencies will fuse into a common trend.[62] This possibility stems from trends apparent in the final decades of the twentieth century. These include: first, falling incomes and standards of living of the vast bottoms of the social pyramid in Latin America, Africa and parts of Asia; second, chronic environmental decay and acute environmental crises which eroded the quality of life of broad sections of the population throughout the developing world.

NOTES

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[1] For historical analysis see: Elizabeth Dore, *The Peruvian Mining Industry: Growth, Stagnation and Crisis* (Boulder, CO: Westview Press, 1988); John Fisher, *Silver Mines and Silver Miners in Colonial Peru, 1776-1824* (Liverpool: Centre for Latin American Studies, University of Liverpool, 1977) and 'Silver Production in the Viceroyalty of Peru, 1776-1824', *Hispanic American Historical Review* 55:1 (February 1985); Peter Bakewell, 'Mining in Colonial Spanish America', and A.J. R. Russell-Wood, 'Colonial Brazil: the gold cycle', in Leslie Bethell, ed., *The Cambridge History of Latin America: Colonial Latin America*, Vol. II, (Cambridge: Cambridge University Press, 1984); Brooke Larson, *Colonialism and Agrarian Transformation in Bolivia: Cochabamba, 1550-1900* (Princeton: Princeton University Press, 1988); Florencia Mallon, *In Defense of Community in Peru's Central Highlands* (Princeton: Princeton University Press, 1983); Richard L. Garner, 'Long-Term Silver Mining Trends in Spanish America: A Comparative Analysis of Peru and Mexico', *American Historical Review* 93:4 (October 1988): 898-935.

For environmental analysis see: Anthony Hall, *Developing Amazonia: Deforestation and Social Conflict in Brazil's Carajás Programme* (Manchester: Manchester University Press, 1989); David Cleary, *Anatomy of the Amazon Gold Rush* (Oxford: Macmillan, 1990); Elizabeth Dore, 'Open Wounds', *NACLA's Report on the Americas* 25: 2 (September 1991): 14-21; Joan Martinez-Alier, *Ecological Economics: Energy, Environment and Society* (Oxford: Blackwell, 1991) and 'Ecology of the Poor: A Neglected Dimension of Latin American History', *Journal of Latin American Studies*, 23:3 (October 1991); Alejandro Toledo, 'Destruir el paraiso: energéticos y media ambiente en el sureste mexicano', *Ecología: Politica/ Cultura* (Mexico), 2 (Summer 1987): 15 ff. and 'The Ecological Crisis of Latin America', a special issue of *Latin American Perspectives* 19:1 (Winter 1992).

[2] John Weeks, *Capital and Exploitation* (Princeton: Princeton University Press, 1981), 10-49.

[3] Contributions to 'Green Marxism' include Peter Dickens, *Society and Nature: Towards a Green Social Theory* (Hemel Hempstead: Harvester, 1992) and *Reconstructing Nature: Alienation, Emancipation and the Division of Nature* (London and New York: Routledge, 1996); John Foster, 'The Absolute General Law of Environmental Degradation Under Capitalism', *Capitalism, Nature, Socialism* 3:3 (1992): 77-82; James O'Connor, 'Capitalism, Nature, Socialism: A Theoretical Introduction', *Capitalism, Nature, Socialism* 1:1 (Fall 1988): 11-37; Daniel Faber, 'The Ecological Crisis of Latin America: A Theoretical Introduction', *Latin American Perspectives* 19:1 (Winter 1992): 3-16; Jean Paul Deleage, *Historia de la Ecología: Una ciencia del hombre y la naturaleza* (Barcelona: ICARIA, 1992); Tim Allmark, 'Environment and Society in Latin America', in M.R. Redclift and G. R. Woodgate, eds, *The International Handbook of Environmental Sociology* (Cheltenham and Northampton, MA: Edward Elgar, 1997) and Enrique Leff, *Ecología y capital: hacía una perspectiva ambiental del desarrollo* (Mexico, DF: Universidad Nacional Autónoma de México, 1986).

[4] This was demonstrated by the limited nature of international accords, for instance the Kyoto Agreement of 1997 and the Buenos Aires Agreement of 1998.

[5] Theories range from military defeat, internal insurrection, spiritual convulsion, natural disaster such as earthquakes etc. T. Patrick Culbert, ed., *The Classic Maya Collapse* (Albuquerque, NM: University of New Mexico Press, 1973).

[6] Malthus argued that population tends to increase at a faster rate than its means of subsistence and that unless it is checked by a moral restraint or by disease, famine, war or other disaster, widespread poverty and degradation inevitably result.

[7] For analysis of the sustainability of Mayan resource use see Mary Pohl, ed., *Prehistoric Lowland Maya Environment and Subsistence Economy* (Cambridge, MA: Peabody Museum, 1985); Elizabeth A. Graham, *The Highlands of the Lowlands: Environment and Archeology in the Stann Creek District, Belize, Central America* (Madison, WI: Prehistory Press, 1994); Ursula M. Cowgill, *Soil Fertility and the Ancient Maya* (New Haven, Conn: Transactions of the Connecticut Academcy of Arts and Sciences, 42 (Oct 1961), 1-56; Helmuth O. Wagner, 'Subsistence Potential and Population Density of the Maya on the Yucatan Peninsula and Causes for the Decline in Population in the Fifteenth Century', International Congress of Americanistas, XXXVIII, Stuttgart-Munchen, Germany, 1968, v. 1, 179-196.

[8] Michael Harner, 'The Ecological Basis for Aztec Sacrifice', *American Ethnologist* 4:1 (1977): 117-133; Sarah L. O'Hara, F. Alayne Street-Perrott and Timothy P. Burt, 'Accelerated Soil Erosion around a Mexican Highland Lake Caused by Prehispanic Agriculture', *Nature* 362:6415 (4 March 1993): 48-51; and Karl W. Butzer, 'No Eden in the New World', *Nature* 362:6415 (4 March 1993): 15-17.

[9] O'Hara, et al., 'Accelerated Soil Erosion'.

[10] William Denevan, 'The Pristine Myth: the Landscape of the Americas in 1492', *Annals of the Association of American Geographers*, 82:3 (1986), 369-85. For arguments about the unsustainability of the pre-hispanic Amazon see B. Meggers, 'Amazonia: Real or Counterfeit Paradise?' *Review of Archeology* 13 (1992): 25-40, and 'The Prehistory of Amazonia', in J. Denslow and C. Padoch, eds., *Peoples of the Tropical Rain Forest* (Berkeley: University of California Press, 1988). For an interpretation of pristine America see Raphael Girard, *Historia de las Civilizaciones Antiguas de America* (Madrid: Ediciones Istmo, 1976), 3 vols.

[11] Irving Rouse, *The Tainos: Rise and Decline of the People Who Greeted Columbus*, (New Haven: Yale University Press, 1992).

[12] Alfred W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, CT: Greenwood Press, 1987) and *Ecological Imperialism: biological expansion of Europe, 900-1900* (Cambridge: Cambridge University Press, 1986).

[13] The first royal measures to protect the Indians were decreed in 1542 and called The New Laws. Africans brought to the colonies as slaves were less fortunate than the Indians: the New Laws ratified their enslavement. Their financial cost to their owners would serve, in theory, as protection. Henry Stevens, trans. and ed., *The New Laws of the Indies* (London: The Chiswick Press, 1893), iii-xvii.

[14] This mid-range estimate is from William M. Denevan, ed., *The Native Population of the Americas in 1492*, 2nd ed. (Madison: University of Wisconsin Press, 1992). For contributions to the debate on the demographic collapse see, Nicolás Sanchez Albornoz, *The Population of Latin America*, translated by W.A.R. Richardson, (Berkeley: University of California Press, 1974), 37-66; Sherburne F. Cook and Woodrow Borah, *Essays in Population History: Mexico and the Caribbean* (Berkeley: University of California Press, 1971), Vol. 1, and 'The Rate of Population Change in Central Mexico, 1550-1570',

Hispanic American Historical Review 37:4 (Nov 1957): 463-470; Linda A. Feinman et al. 'Long-term Demographic Change: A Perspective from the Valley of Oaxaca', *Journal of Field Archaeology* 12:3 (1985): 333-362; Thomas M. Whitmore, *Disease and Death in Early Colonial Mexico: Simulating Amerindian Depopulation* (Boulder, CO: Westview Press, 1992).

[15] Joan Martinez-Alier, Conference 'Worlds in Collision', University of Portsmouth, November 1992.

[16] On reorganisation of the colonial state in Peru see Steve J. Stern, *Peru's Indian Peoples and the Challenge of Spanish Conquest* (Madison: University of Wisconsin Press, 1982); Larson, *Colonialism and Agrarian Transformation*, 51-91; and Karen Spalding, *Huarochirí: An Andean Society under Inca and Spanish Rule* (Stanford: Stanford University Press, 1984).

[17] The labour system in the Mexican mines was substantially different from that in Peru. The standard interpretation of the labour force at Zacatecas and other Mexican mines emphasises the preponderance of wage workers who were attracted to the mines by high pay. P. J. Bakewell, *Silver Mining and Society in Colonial Mexico: Zacatecas 1546-1700* (Cambridge: Cambridge University Press, 1971).

[18] Stern, *Peru's Indian Peoples*, 51-113; Larson, *Colonialism and Agrarian Transformation*, 51-91.

[19] Mercury amalgamation developed in New Spain (Mexico) in the 1550s.

[20] D. A. Brading and Harry E. Cross, 'Colonial Silver Mining: Mexico and Peru', *Hispanic American Historical Review* 52: 4 (November 1972): 567.

[21] G. Lohmann Villena, *Los Minas de Huancavelica en los siglos XVI y XVII* (Sevila, 1949), 169-177.

[22] This is a case of O'Connor's second contradiction of capitalism. 'On the Two Contradictions of Capitalism', *Capitalism, Nature and Socialism*, 107-109.

[23] For the ways mining altered the spatial organisation of colonial society see Carlos Sempat Assadourian, *El sistema de la economia colonial: mercado interno, regiones y espacio económico* (Lima: Instituto de Estudios Peruanos, 1982).

[24] For estimates of quantities of mercury used in New Spain and in Peru see Brading and Cross, 'Colonial Silver Mining', 572; and Garner, 'Long-Term Silver Mining'.

[25] For the orthodox view see: Earl J. Hamilton, *American Treasure and the Price Revolution in Spain 1506-1650* (Cambridge: Cambridge University Press, 1934); Woodrow Borah, *New Spain's Century of Depression* (Berkeley: University of California Press, 1951); J. I. Israel, 'Mexico and the 'General Crisis' of the Seventeenth Century', *Past and Present* 63 (1974): 33-57. For revisionist interpretations see: John Lynch, *Spain Under the Hapsburgs* (Oxford: Oxford University Press, 1964-69) 2 vols., II,195; Herbert S. Klein and John J. Tepaske, 'The Seventeenth-Century Crisis in the Spanish Empire: Myth or Reality?' *Past and Present* 90 (1981): 116-135; and J. I. Israel and Henry Kamen, 'Debate- The Decline of Spain: A Historical Myth?' *Past and Present* 81 (1981): 170-185.

[26] While the fall in the number of *mitayos* sent to the Peruvian mines may reflect the continued population decline, of more importance was the declining power of the colonial state. Larson, *Colonialism and Agrarian Transformation*, 92-115.

[27] William Taylor, *Landlord and Peasant in Colonial Oaxaca* (Stanford: Stanford University Press, 1972); Eric Van Young, 'Mexican Rural History since Chevalier: The Historiography of the Colonial Hacienda', *Latin American Research Review* 18 (1983): 5-61.

[28] This discussion is based on Enrique Tandeter, *Coercion and Market: Silver Mining in Colonial Potosí, 1692-1826* (Albuquerque, NM: University of New Mexico Press, 1993), and 'Forced and Free Labour in Late Colonial Potosí', *Past and Present* 93 (November 1981): 98-136. See Dore, *Peruvian Mining*,. 71-76, for discussion of the nature of forced and free labour.

[29] D.A. Brading, *Miners and Merchants in Bourbon Mexico, 1763-1810* (Cambridge: Cambridge University Press, 1971); Fisher, 'Silver Production in the Viceroyalty of Peru, 1776-1824'.

[30] Brading and Cross, 'Colonial Silver Mining', 548-556.

[31] Arthur C. Todd, *The Search for Silver: Cornish Miners in Mexico 1824-1947* (Padstow: Lodenek Press, 1977).

[32] In 1991 it was proposed that Chile should import toxic waste and store it in these abandoned mines.

[33] William Bollinger, 'The Rise of United States Influence in the Peruvian Economy, 1869-1921', M.A. thesis, University of California at Los Angeles, 1972; I. G. Bertram, 'Development Problems in an Export Economy: A Study of Domestic Capitalists, Foreign Firms and Government in Peru, 1919-1930', Ph.D diss. Linacre College, University of Oxford, 1974.

[34] On oil exploration and indigenous peoples see J. Kimerling, 'Oil, Lawlessness and Indigenous Struggles in Ecuador's Oriente', in H. Collinson, ed., *Green Guerrillas* (London: Latin American Bureau, 1986).

[35] For analysis of this process in Peru see Dore, *Peruvian Mining,* 78-111; and Adrian DeWind, *Peasants Become Miners: The Evolution of Industrial Mining Systems in Peru, 1902-1974* (New York: Garland, 1987). For Chile, Maurice Zeitlin, *The Civil Wars in Chile: or, The Bourgeois Revolutions that Never Were* (Princeton: Princeton University Press, 1984). For Mexico, Marvin D. Bernstein, *The Mexican Mining Industry 1890-1950: A Study of the Interaction of Politics, Economics and Technology* (Albany, NY: University Press of the State University of New York, 1965); Robert Randall, *Real del Monte: A British Mining Venture in Mexico* (Austin, TX: University of Texas Press, 1972); and Todd, *The Search for Silver*.

[36] For the denationalisation of mines and the Peruvian Mining Code of 1901 see Dore, *Peruvian Mining,* 89-91.

[37] Joan Martinez-Alier, 'La Interpretación ecologista de la historia socio-económica: algunos ejemplos andinos', *Revista Andina* 15 (1990). For the 'smoke controversy' see Mallon, *In Defense of Community*, 226-31.

[38] On Bolivian tin mining see James Dunkerley, *Rebellion in the Veins* (London: Verso, 1984); June Nash, *We Eat the Mines and the Mines Eat Us: Dependency and Exploitation in Bolivian Tin Mines* (New York: Columbia University Press, 1979); *The Great Tin Crash: Bolivia and the World Tin Market* (London: Latin American Bureau, 1987); and Manuel Contreras, *The Bolivian Tin Mining Industry in the First Half of the Twentieth Century,* (London: Institute of Latin American Studies, 1993) Research Paper No. 32.

[39] F. Neto, 'Development Planning and Mineral Mega-Projects: Some Global Considerations', in D. Goodman and A Hall, eds., *The Future of Amazonia* (Basingstoke: Macmillan, 1990). For the petroleum industry see Frank Tugwell, *The Politics of Oil in Venezuela* (Stanford: Stanford University Press, 1975); George Phillip, *Oil and Politics in Latin America* (Cambridge: Cambridge University Press, 1982); and George W. Grayson, *The Politics of Mexican Oil* (Pittsburgh: University of Pittsburgh Press, 1980).

[40] Toledo, 'Destruir el paraíso',15.
[41] Joel Simon, *Endangered Mexico: An Environment on the Edge* (London: Latin American Bureau, 1998).
[42] For Ciudad Guayana see María Pilar García, 'Actores y movimientos sociales en los grandes proyectos de inversión minero-industriales en América Latina', *Revista Interamericana de Planificación*, XXIII: 89 (enero-marzo 1990): 223-252. García compares the ecological impact of Ciudad Guayana to the Lázaro Cárdenas-Las Truchas iron-steel complex in Michoacán, Mexico.
[43] Hall, *Developing Amazonia*, and 'Agrarian Crisis in Brazilian Amazonia: the Grande Carajás Programme', *Journal of Development Studies* 23:4 (July 1987): 522-552; Philip M. Fearnside and Anthony Hall, 'Agricultural Plans for Brazil's Grande Carajás Program: Lost Opportunity or Sustainable Local Development?' *World Development* 14 (March 1986): 385-409; J. Timmons Roberts, 'Trickling Down and Scrambling Up: the Informal Sector, Food Provisioning and Local Benefits of the Carajás Mining 'Growth Pole' in the Brazilian Amazon', *World Development* 23:3 (March 1995): 385-400.
[44] Charles F. Bennett, 'The Carajás Project, Brazil: Ecological Impacts of Mineral Development in the Amazon Basin', (San Diego: *Proceedings, Pacific Coast Council on Latin American Studies,* 1987), 91-100.
[45] In early colonial Brazil economic life centered around sugar exports, produced on slave plantations in the North East. The discovery of gold at the end of the 18th century in Minas Gerais began a major shift from the North East to the South. Fortunes made in gold mining built the coffee estates around Rio de Janiero, which became the fulcrum of the economy.
[46] Hall, *Developing Amazonia*.
[47] Marianne Schmink and Charles H. Wood, *Contested Frontiers in Amazonia* (New York: Columbia University Press, 1992).
[48] D. Biller, 'Informal Gold Mining and Mercury Pollution in Brazil', Policy Research Working Paper no. 1304 (Washington, DC: World Bank, 1994).
[49] For analysis of similar processes in Guyana see Marcus Colchester, *Guyana: Fragile Frontier* (London: Latin American Bureau, 1997).
[50] Cleary, *Anatomy of the Amazon Gold Rush.*
[51] *Ibid*.
[52] Schmink and Wood, *Contested Frontiers*; G. Macmillan, *At the End of the Rainbow? Gold, Land and People in the Brazilian Amazon* (London: Earthscan, 1995).
[53] On peasant agriculture and sustainability see Evaldice Eve and Christopher Eve, 'Resource Base of Peasants in the Brazilian Amazon: Planning Solutions for Current Problems of Sustainability', *Bulletin of Latin American Research* 17:3 (1988): 387-407. For effects of mining on the Yanomami see *Bound in Misery and Iron: The Impact of the Grande Carajás Programme on the Indians of Brazil* (London: Survival International, 1987).
[54] This is a conservative estimate calculated from a historical series on productivity in Peruvian mining. Dore, *Peruvian Mining*, 87-159.
[55] Notwithstanding these tendencies, in some countries of Latin America, particularly Chile and Peru, technologies that facilitated rising productivity were introduced in the 1980s, when trades unions suffered extreme repression. As a consequence, in this period technical change was accompanied by deteriorating working conditions and by an absolute and relative reduction in the level of employment in open-pit mining.

[56] For indebtedness in Peruvian mining see Oscar Ugarteche, *El Estado Deudor: Economía Política de la Deuda: Perú y Bolivia 1968-1984* (Lima: Instituto de Estudios Peruanos, 1986).
[57] For debt and ecological destruction see Elizabeth Dore, 'Debt and Ecological Disaster in Latin America', *Race and Class* 34, 1(1992): 73-87. For causes of the debt crisis, John Weeks, 'Losers Pay Reparations, or how the Third World Lost the Lending War', in John Weeks, ed., *Debt Disaster: Banks, Governments and Multinationals Confront the Crisis* (New York: New York University Press, 1989), 41-63.
[58] Susana Hecht and Alexander Cockburn, *The Fate of the Forest* (London: Pengiun Books, 1990) 2nd edition.
[59] On sustainabilility of small-scale mining ventures see G. Burke, 'Policies for Small-scale Mining: the need for integration', *Journal of Minerals Policy, Business and Environment- Raw Materials Report,* 12:3 (1997); Mamadou Barry, ed., *Regularising Informal Mining: a summary of the proceedings of the International Round Table on Artisanal Mining* (1995); and World Bank, Industry and Energy Development. Occasional Paper no. 6 (Washington, DC, 1996).
[60] O'Connor, 'On the Two Contradictions of Capitalism.'
[61] This is an example of 'ecological modernisation'. G. Spaargaren, *The Ecological Modernisation of Production and Consumption: Essays in Environmental Sociology* (Wageningen, The Netherlands: Wageningen University, 1997).
[62] This view is developed in the 'Green Marxism' school. See, for instance, Dickens, *Reconstructing Nature;* and Tim Allmark, 'Environment and Society in Latin America'.