Chapter 5
Indigenous Charcoal Production and Spanish Metal Mining Enterprises: Historical Archaeology of Extractive Activities and Ecological Degradation in Central and Northern Mexico

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Abstract The Iberian invasion of the New World resulted in land-degradation processes. Human agency associated with silver mining and the two methods involved in refining (smelting and amalgamation) had dramatic environmental consequences. The need for fuel used in one method led to the deforestation of vast areas where soils were further eroded. The use of mercury in the other produced toxic wastes and tailings in mining towns and regions, poisoning soils, sediments, and the water table. Based on the detailed analyses of historical records, surveys, and archaeological excavations, we discuss how the Otomí Indians of the Mezquital Valley in central Mexico became producers of charcoal required in the mines located in that valley, and show how mercury was introduced in the mining regions of northern Mexico using a case study from Zacatecas, in Pánuco, a mining town founded by the Oñate family.

5.1 Pre-Columbian and Post-Conquest Mining in Mexico

Simple metallurgy methods were implemented in pre-Columbian Mexico to collect surface- or river-metal nuggets and grains. Ornaments made of copper, gold, silver, and some of their alloys were produced by cold-working, hammering or sheeting, and casting, including soldering, welding, and inlaying. Moreover, some metal tools and weapons, predominantly copper items, had been manufactured probably since the seventh century A.D. in western Mexico. The use of metals objects was not widespread; indigenous societies gave them more symbolic meaning than economic

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or utilitarian importance, and metallurgy was practiced on a small scale (Bernstein 1964; Maldonado 2006).

Once Christopher Columbus landed in the New World in 1492 and precious metals were found in the newly discovered territories, the Spanish Crown became obsessed with finding gold, silver, and treasure. To that end, in 1519, Hernán Cortés set sail from Cuba to Mexico, a vast territory that became one of the most important and richest possessions of the Spanish Empire in the Americas.

Following the 1521 conquest of Mexico-Tenochtitlan, the Aztec capital and core of a thriving empire dominating most of central and southern Mexico, the indigenous population of these areas as well as those that were conquered to the north in the late sixteenth century and early seventeenth century were subjected to forced heavy labor and tribute and taxation systems. This labor included the growing of newly introduced, nonindigenous crops; raising livestock; and working in mining activities, which resulted in the deaths of many natives (Gibson 1964; Melville 1994). Moreover, diseases of European origin decimated the indigenous population to different degrees; in some places the population decreased, in others it remained stable, and in some it increased, which suggests that the impact of the epidemics was not a homogenous process and that it was definitely higher in regions with the highest population density (Fournier Garcia and López Aguilar 2015). This demographic catastrophe was exacerbated by environmental changes when a drastic drought affected North America in the mid-sixteenth century due to extreme climatic conditions resulting from irregular precipitation cycles. Also, an indigenous virus causing hemorrhagic fevers dramatically affected highland populations (Acuna Soto et al. 2002).

5.2 Mining and Selective Land Depredation in Mexico

Technology may be viewed as a means by which natural resources are transformed into raw materials, and such production may cause environmental damage and large-scale depredation of resources and land (e.g., Gruen 2001).

The quest for precious metals and treasure led to the conquest and control of territories located north, west, and south of the capital of New Spain. For economic reasons, the main goal was to mine gold, which turned out to be scarce, although silver and lead were abundant. Throughout the colonial period (1521–1821), metal extraction proliferated in different regions (Fig. 5.1); however, Zacatecas, Oaxaca, Taxco, and zones north of the Basin of Mexico located in contemporary Pachuca and the Mezquital Valley (Ixmiquilpan, Cardonal, and Zimapán) were among the most important mining districts (Bakewell 1971; Probert 1987).

Mining techniques introduced in the 1530s by the Spanish colonizers depended on the quantity of the veins and the quality of the ores discovered. By 1548, the Zacatecas mines to a lesser extent became the main source of silver in the viceroyalty, whereas the Mezquital Valley mostly provided lead and silver (e.g., Bakewell 1971, 1984).

Fig. 5.1 Map of Mexico showing the Royal or Silver road, and cities or towns mentioned in the text

Many mining settlements or *reales de mina* became important towns or cities as a result of their concentration of wealth, although many of the owners of the most prosperous mines lived in the capital of New Spain. The discovery of ores would give rise to the Royal Road or Silver Road that connected the capital to the northern provinces, the south, and through different branches to the Pacific and the Gulf of Mexico settlements and ports of call. These wagon trails opened as the Spanish conquest progressed and advances occurred in the northern areas. Eventually, the Silver Road extended to Fresnillo, Sombrerete, Nombre de Dios, Durango, and Valle de San Bartolomé, then deviated toward Chihuahua and up to the Paso del Norte, Albuquerque, and Santa Fe (Powell 1984).

All over New Spain mining villages proliferated, being nodes for the foundation of towns, cities, missions, agro-pastoral ranches, and smelting settlements, some of which were rich in precious metals, making them sources of huge wealth. Silver and gold were used, among other things, to finance expansionist incursions, to construct monumental civil and religious buildings, as well as to create a wealthy New Spain upper class and to guarantee full coffers for the Crown in the metropolis.

The distribution of precious metals passed through the capital, which was the center of all transactions (Fournier Garcia and Blackman 2010).

To supply the mining towns, agricultural and livestock ranches and haciendas[1] (agricultural estates) for grain and meat flourished in the mining regions. Hence, agricultural intensification and overgrazing resulted in further degradation of land and water resources.

Mines in New Spain were complex operations requiring significant human and natural resources. Once tunnels were opened by slaves, tribute Indians, and hired workers, wood was a necessity for beams and ladders for galleries and shafts. Containers to carry the extracted ores out of the mine were required, such as hide buckets, agave fiber baskets, and sacks. To extract precious metals from the ore, many raw materials and facilities were required: lead (litharge or lead monoxide) as a flux to refine the silver in furnaces; water, mercury, salt, copper, and iron sulphates (*magistral*); drag stones and horse mills; stables for mules and horses; tanks; paved yards; ore-refining facilities in general; store rooms; chapels; and living quarters for the administrators, accountants, and other company officers (e.g., Bakewell 1971; Bernstein 1964). A major raw material requirement was wood for the production of charcoal.

Initially, smelting was employed to extract silver from high-yield ores: first the ore was crushed by hand or a mechanical mill and lead was added, then the particles of powder were packed into vertical Castilian furnaces made of rocks or adobe; and to that end, considerable amounts of charcoal were required. Since this process did not produce pure silver (because it contained lead impurities from the ores or as a result of adding this metal as a flux), further beneficiation was required, carried out in a reverberatory furnace, using charcoal as fuel inside the firebox (e.g., Bakewell 1984).

For silver-ore amalgamation, a process known as the yard or *patio* method or Medina's process— after the Sevillian Bartolomé de Medina who introduced it to New Spain in 1555—became widely. It was profitable since it was possible to refine most low-grade silver ores. Valerio Ortega (1902: 276–277) describes all the details of this method:

> The ore extracted from the mine is sorted by *pepenadores* [pickers] who break the large pieces with hammers, rejecting those which contain no ore, set aside the very rich to be smelted, and deliver the rest to be crushed and pulverized for direct amalgamation in the *patio* [yard]. The broken lumps, of about fist-size, are first ground in Chilean mills, and then reduced, in *arrastras* or *tahonas* [mills with cogwheels moved by horses or mules], to fine slime [sic slurry].
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> After the… [slurry] has acquired a suitable consistency by the evaporation, through the sun's heat, of a part of the water which it contained, it is spread upon the *patio* or amalgamating-floor, where it is mixed with 5% or 6%, of common salt. The next day a certain amount (depending upon the nature of the ore and the season of the year) of

[1] *Haciendas* were agro-pastoral or mining "… estates, operated by a dominant … owner and a dependent labor force, organized to supply a small-scale market by means of … capital, in which the factors of production are employed not only for capital accumulation but also to support the status aspirations of the owner" (Wolf and Mintz 1957: 380).

> Bluestone (cupric sulphate) is added; and, immediately afterward, mercury, in the proportion of eight units to one of silver contained in the mineral, squeezed through a piece of thick cloth or chamois skin, and spread over the pulp or *torta* [roughly equivalent to a cake]. These chemicals are thoroughly mixed with the [slurry] by means of horses or mules trampling the *torta* — an operation called the *repaso*, and repeated daily until the treatment is finished. The time required is from 2 to 5 weeks, depending upon the quality of the ore, the temperature of the locality, and the period of the year.
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> Samples are taken at intervals for assay by washing in a vanning-bowl; and when the tests show that amalgamation is too slow, more bluestone is added; if it be too active (from the presence of copper sulphate in excess, as indicated by gray color and floured mercury), it is retarded by the introduction of lime, cement-copper or wood-ashes. At the end of the process, it is usual in some places to make a final considerable addition of mercury, to collect the grains of amalgam.
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> Amalgamation being finished, the *torta* is transferred to deep circular stone vats, or settlers, through which water is passing, agitated by a revolving paddle. The amalgam and other heavy metalliferous materials collect in the bottom, while the light, earthy impurities are held in suspension and carried away.
>
> The fluid amalgam thus obtained is squeezed through canvas bags, whereby the excess of mercury is forced out, and there remains a solid or pasty argentiferous amalgam, containing about one-fifth of its weight of silver. This is compressed into triangular segments, which are transferred to the *quemaderas*, or retorting-houses, for the separation of the mercury by heat.

Bakewell (1984: 166) clarifies that for the cake, "Final separation of silver and mercury occurred by volatilization under a metal or clay hood, heat being applied… from below, causing the mercury to vaporize. The hood itself was cooled so that the vapor condensed on the inner surface and metallic mercury was recovered."

It is important to mention that the amalgamation process was applied exclusively to silver ores free of lead; therefore smelting was continuously used all over New Spain for low-scale mining, and by the late eighteenth century up to 36% of silver production depended on smelting (Guerrero 2016), with large amounts of charcoal being consumed in the process.

5.3 Indigenous Charcoal Production in Central Mexico: The Otomí Indians from the Mezquital Valley

The Mezquital Valley is part of the Central Mexican Highlands within the physiographic area of the neovolcanic axis of the central Mexican plateau. During the eighteenth century, the most important territorial jurisdictions of the region included Tula, Ixmiquilpan, Tetepango, and Huichapan (Fournier Garcia and Mondragón 2003). Most of this region has shallow soils, scarcity of permanent water sources, and low precipitation, except in zones with permanent rivers.

The Otomí Indians have inhabited the region at least since the seventh century A.D. based on DNA analyses. They had permanent settlements with monumental architecture. They were part of the multiethnic urban center of Tula, but scattered hamlets and villages were the main features throughout the pre-Columbian period.

Resource exploitation was apparently efficient enough to support a relatively large population, perhaps as many as half a million inhabitants in the sixteenth century. The region fell under the control of the Aztec Empire and was divided into a series of tributary provinces and independent states that paid tribute to their lords in the form of woven agave fiber, sandals, maize, beans, *Salvia hispanica*, amaranth, lime, and agave honey, among other items that reflect a level of specialized production as well as an emphasis on rainy-season agriculture and the specialized use of agave (Fournier Garcia and Mondragón 2003).

After the Conquest, Spanish forms of political, legal, ideological, and economic control affected the way of life of the Otomí. Indigenous communities experienced deep transformations in their basic subsistence and production patterns when the Spanish Crown granted European settlers most of the fertile lands of the region, dispossessing the indigenous towns of their most valuable resources by appropriating water supplies, the best irrigable fields, and the best grazing lands (Fournier Garcia and Mondragón 2003). New towns, ranches, and haciendas were founded, including mining settlements.

The landscape of the Mezquital Valley was reconfigured at different levels of local and regional specialization, depending on the presence of resources and the vision and interests of the Spanish settlers. Broadly speaking, the eastern zone was the center of mining and the raising of sheep and goats; and the western zone, where grasses and forests of oak and pine prevailed, was dedicated to livestock and horse breeding (Fournier Garcia and López Aguilar 2015).

By the mid-sixteenth century, Ixmiquilpan became part of a mining subregion where several mining towns were founded. The most important were Zimapán and Cardonal, where mainly lead was extracted as well as silver, gold, zinc, and arsenic-bearing minerals in low proportion (Gerhard 1986; Ongley et al. 2007). Minor mining centers included Cruz de los Alamos and La Pechuga that by the eighteenth century were integrated to the Zimapán district (Gerhard 1986; Tamayo 1943). Some of the owners of these companies had vast lands in the Mezquital Valley and nearby areas, dedicated to agriculture, and in addition, they had mines in Guanajuato and Zacatecas (e.g., González Dávila 2003; Vergara Hernández 2010). Extractive works at the mines required indigenous labor, which in the early days of exploitation meant that forced labor was used and even expanded (Fournier Garcia and López Aguilar 2015).

The intense construction activity in the northeast of the Mezquital Valley had negative effects on the ecosystem due to the demand for wood and stone to build churches, monasteries, and roads, as well as for mining in the habilitation of both open-pits and galleries as well as to build mills, winches, and diverse machinery and instruments (Studnicki-Gizbert and Schecter 2010). Wood was not only indispensable in the daily lives of residents of both European and indigenous origin; it was extremely important to the production of charcoal. Charcoal was essential to the furnaces that were used for continuously in the silver-refining process (Lacueva Muñoz 2010). This was the only viable method that could be used in the Zimapán, Ixmiquilpan, and Cardonal mines since the ores contained considerable amounts of lead, which ruled out the use of the mercury process (Mendizábal 1941).

The production and sale of charcoal by the Indians allowed them to count on income that they could use for the payment of taxes and tithes, to support their families, and to buy corn when required, so that those who managed to learn Iberian techniques for charcoal production, had a source of income at hand if crops failed (e.g., Ayala 2007), even if it was only seasonal.

By the eighteenth century, the extractive activities in the mining centers of Zimapán and Cardonal were combined with agriculture, especially in the haciendas and ranches producing the grains and fodder required to feed the miners and draft animals required to work both inside the mines or to process the ores for metal beneficiation. In these mining zones, there were villages and minor settlements, mainly of Otomi Indians as well as some Spaniards and mestizos who lived in small rural settlements. These individuals carried out commercial activities; produced agave-fiber textiles, cords, sandals, and other items; fermented agave sap (*pulque*, a mildly alcoholic beverage widely consumed by Indians and mestizos); or worked as muleteers (Fournier Garcia 2007; Molina del Villar and Navarrete Gómez 2007).

Charcoal production in the Mezquital Valley for use in refining metals started early in the colonial period. According to a chronicle about Zimapán dating to 1579, deforestation of the neighboring mountainous zones was a problem since pines, oaks, and poplars were continuously cut to produce charcoal, and mesquites were threatened by overexploitation of forest resources (e.g., Acuña 1985). Even though local authorities issued ordinances to protect mesquites, in semi-arid areas of New Spain mesquite wood was favored for charcoal production because of its high thermal performance compared to other species, and because both the tree and its roots could be transformed into charcoal (Fournier Garcia and López Aguilar 2015; Studnicki-Gizbert and David Schecter 2010). In the Zipamán subregion, in 1795 there were more than 100 refining furnaces (Sonneschmid 1983: 62); hence tons of charcoal were used.

Historical and ethnographic information for Mexico and Europe (e.g., Argueta Spínola 2006; Biringucci 1540) provides the basis for understanding traditional, non-industrial, small-scale charcoal production. Charcoal-makers build earth-mound kilns of different sizes and forms—round, oval, or square —directly on the ground. A cone is formed with piles of firewood covered with dry leaves, sticks, or straw, and then completely covered with a layer of earth except for a few holes that function as chimneys. Firing depends on the amount of firewood: for example, for 4 tons of wood fired between 400 and 600 °C, the process lasts about 12 days, and it may take up to 9 days to cool the kiln. The earth employed to cover the kiln can be used multiple times, and it gets darker in color each time it is used. Charcoal production usually is a seasonal activity. Firewood must be dry, and if there are no special facilities to store it indoors until it dries completely, it is not feasible to produce this fuel during the rainy and cold seasons.

Based on historical information for different mining regions of New Spain, although the activities of charcoal-makers were not continuous, this craft was part of the diversified domestic economy of indigenous and European-descent peasants. They combined agricultural activities and small-scale livestock-raising with charcoal-making as collective endeavors, with men, women, and children working

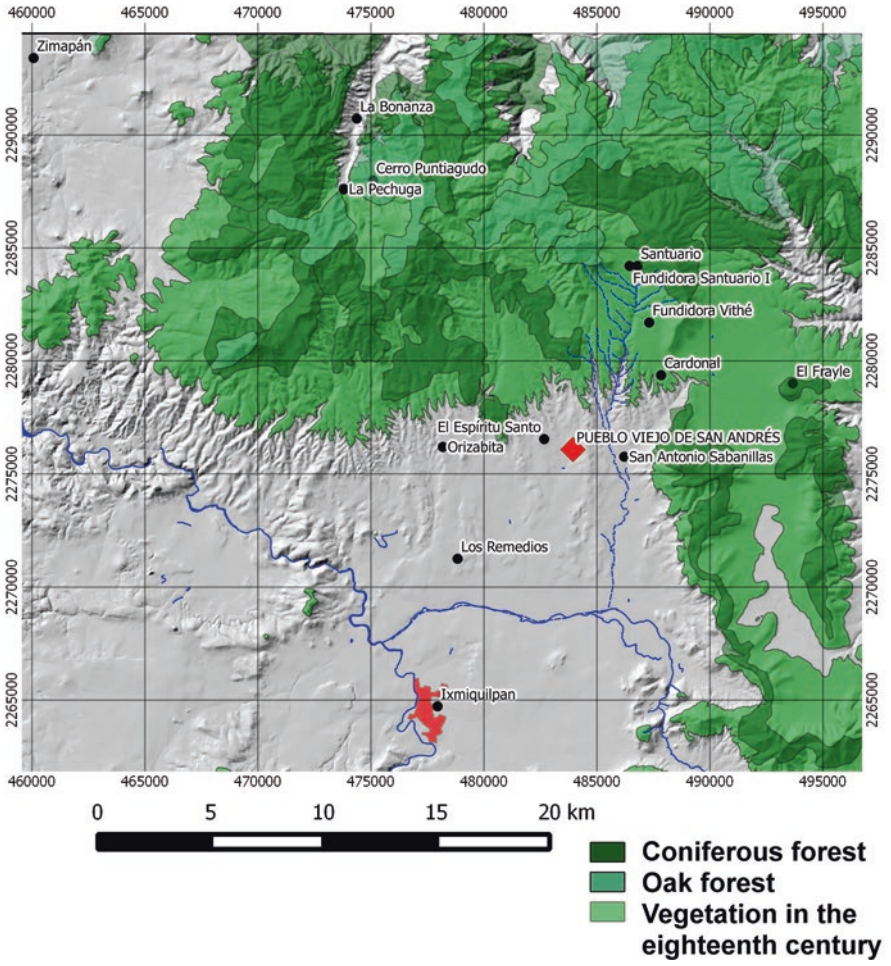

Fig. 5.2 Location of Pueblo Viejo San Andrés and major mining centers in the eighteenth century. (Adapted from Fournier Garcia and López Aguilar 2015)

to make a living (e.g., Studnicki-Gizbert and Schecter 2010). This was the typical extended-family organization of the Otomí Indians in the Mezquital Valley during post-conquest times.

To date, there is only one report on the archaeological visibility of charcoal production sites in Mexico—the study carried out in the Mezquital Valley based on surveys and excavations at the ruins of a hamlet (Fournier Garcia and López Aguilar 2015).

Pueblo Viejo San Andrés (Fig. 5.2), as the locals name the ruins of an old settlement, is located in the Ixmiquilpan district. The site is composed of 11 structures, the remains of another and five mounds (Fig. 5.3). This hamlet is located on a small and eroded hill with shallow soils, bordered by alluvial fans where xerophytic

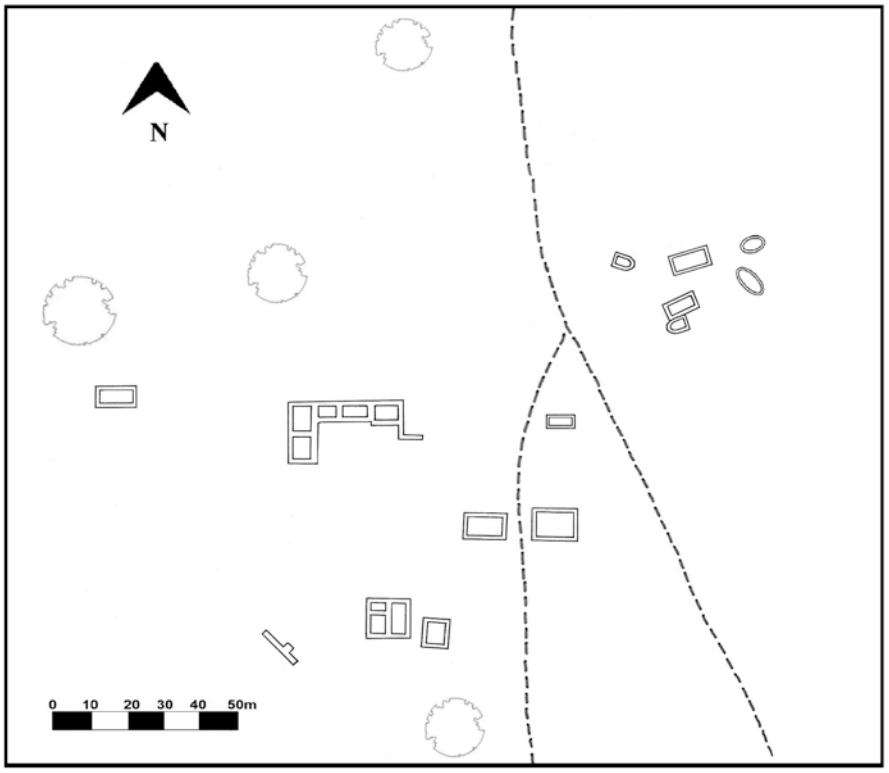

Fig. 5.3 Ruins of Pueblo Viejo San Andrés

shrubs and cacti grow. Toward the center of the site, there are four structures with several rooms, forming a small square covering 35.0 m (east-west) by 15.0 m (north-south). A displaced engraved stone was found with the legend "May 28, 1791," in addition to a carved cross. These elements may have been part of an eighteenth-century chapel, common in this region since the Otomí mixed Catholic and traditional ideas dedicating these buildings to their ancestors.

To the east of this square, there is a rectangular structure, the largest of the site, 25.0 m (east-west) by 8.0 m (north-south). To the south of the square, there are two structures. One is an irregular pentagonal, 10.0 m in the longest axis and 7.0 m in the shortest. The other structure is rectangular, oriented to the north and composed of five rooms. To the southwest of the square, there are alignments of a possible structure that together with the two previous constitute the southern limits of the square.

The rest of the buildings are located around the latter architectural complex. To the northwest is a set of five structures. Two of them are oval, two are rectangular, and the last one is quadrangular, comprising two rooms. Between this set of structures and the structure located to the east of the square, there is another rectangular building, 8.0 m long (east-west) by 4.0 m wide (north-south). To the west of the

chapel, there is another structure measuring 10.0 m (east-west) by 6.0 m (north-south).

Four ash mounds were found, whose dimensions are on the average 15 by 10 m, and from 1.50 m to 3.0 m in height. Based on archaeological excavations, these mounds consist of silty-clay material, ash, lime, and many fragments of charcoal. These are the remains of earth-mound kilns used to produce charcoal, evidence that the inhabitants of this hamlet were charcoal-makers, who probably sold to the Cardonal, Ixmiquilpan, or Zimapán mines.

The ceramic collections include majolica sherds of types that date from the early seventeenth century to the mid-nineteenth century and a few fragments of British nineteenth-century transfer-printed whitewares. These ceramics were associated with status in New Spain but tended to be more affordable during the Republican period (post-1821); hence the inhabitants of this hamlet had the purchasing power to consume expensive ceramics since charcoal production might have been a profitable business.

According to the information registered in archival sources (Fournier Garcia and López Aguilar 2015), during the eighteenth century in the Ixmiquilpan district legal disputes were common among the vice-regal authorities; several Indian towns and Otomí caciques (heads of Indian towns, villages, and hamlets) vied for the right to cut oak trees to make charcoal. However, Otomí charcoal-makers depended on the prosperity of the regional mines, so the fluctuations in mining production would have had a negative effect on the development of their craft and, therefore, on their ability to have economic resources that would allow them to prosper. Perhaps the abandonment of Pueblo Viejo San Andrés was a result of the decline in extractive activities toward the mid-nineteenth century; hence the inhabitants of the hamlet were forced to seek other alternatives to survive in another site. The archaeological evidence shows that the occupation of the site seems to have been truncated in the second half of the nineteenth century, although ceramic types and wares are not sufficiently diagnostic to determine exactly when.

5.4 Spanish Silver Mining in Zacatecas

The discovery and exploitation of silver ores led to a significant expansion to the north and the emergence of major population centers. The Zacatecan silver veins was the result of Cristóbal de Oñate's efforts, who was Nueva Galicia's vice-governor; and in 1546 he sent an expedition from Guadalajara composed of Indians and black slaves as well as Spanish troops that were captained by Juan de Tolosa, accompanied by Miguel Ibarra to do some exploration. This invasion resulted in the location of important veins, including one that was found in 1548 by Diego de Ibarra, Miguel's nephew, about 4 km northeast of Zacatecas, the same year, on the Day of All Saints, when the Pánuco vein was also discovered (Rivera Bernardez 1883). Miguel Ibarra's nephew, Francisco de Ibarra, explored vast northern regions, and founded the province of Nueva Vizcaya, where he discovered rich veins leading

to the establishment of more mining towns (San Martín 1989). Durango became the capital of Nueva Vizcaya, the northern frontier of New Spain in the 1530s, and with time it became an important urban center, eclipsed in the seventeenth century by the thriving mining center of Parral that had a large region rich in precious metals, including the San Bernabé and San Bartolomé mines.

Regarding the Oñate family, in 1623 (Bloom 1939) Juan de Oñate wrote a letter to the king where he describes many aspects about his father's merits, Cristóbal de Oñate, who apparently was born in 1504 in the heart of a noble family from Biscay in the Basque region; and in 1524, when he was still very young he became one of the conquerors along with Hernán Cortés (Zumalde 1998).

In 1531, while being subordinated to Nuño de Guzman, Cristobal de Oñate founded the city of Guadalajara, the capital of Nueva Galicia. As cavalry captain, from 1539 to 1542 Cristobal de Oñate led the conquest of the hostile indigenous tribes living in the Mixtón area along with 300 soldiers, including Aztec and Tlaxcalan allies from central Mexico; later, as captain general, he led more than 80,000 men in the war that took place in Jalisco. His title was ratified by the Viceroy Antonio de Mendoza, and he carried out the conquest of Nueva Galicia, bringing peace to this kingdom and eventually becoming its vice-governor (Bakewell 1971; Bloom 1939; Mota Padilla 1973).

Along with Juan de Tolosa, he was one of the first settlers in the Zacatecas' mines once the Spanish conquered the region and managed to repel hostile Indians. Cristóbal de Oñate basically settled in Pánuco, although he lived on horseback between that place, Zacatecas, and the vice-royalty capital. He died in 1567 at his home, "Los asientos de Oñate" in Pánuco, where he was buried in the church (Zumalde 1998).

According to the aforementioned letter (Bloom 1939), Juan de Oñate (who was born around 1552 in Pánuco) married Isabel Cortés Tolosa, daughter of the aforementioned Juan de Tolosa and Leonor Cortés Moctezuma (granddaughter of one of the last Aztec emperors), who was Hernán Cortés's natural child. As soon as he could, while still a very young man, he took up arms and participated in the pacification of hostile Indians along with the Viceroy Luis de Velasco. He was ordered by that viceroy to discover and take over the mines of San Luis, Chicu, and Charcas, using his own resources. In 1592 he was ordered by the King Philip II to go to the provinces and kingdoms of New Mexico, which he conquered over the course of 13 years, spending a considerable amount of his own money. Moreover, he discovered many other provinces, and he reached the Pacific shores, in spite of the fact that he did not get the support of men and capital that he requested from the king in 1602. When he was asked to return to New Spain, he was accused of several charges, and he was given a considerable fine, which had to be paid immediately, and sentenced to perpetual exile in New Mexico (Zumalde 1998).

Once he got back to Zacatecas in 1613, he found that during his absence and due to mismanagement, the mines that belonged to his family as week as metal extraction and beneficiation were about to be abandoned, so he set in motion several machines to revitalize the exploitation of ores, producing between that year and

1623 more than 137,000 ingots, that yielded the Crown nearly 130,000 pesos in gold because of the royal tax (Bloom 1939; Zumalde 1998).

Regarding the mines of the mining settlement of Pánuco, which Juan de Oñate inherited from his mother, Catalina de Salazar, from December 1614 to late 1622, for the royal tax to the Crown alone he paid more than 51,000 silver ingots. Thus, he was able to gain back the favor of the king, and he was granted titles, prestige, and authority as mine inspector of the whole kingdom but without any pay; besides this he was honored with the habit of the order of St. James of the Sword, a knighthood usually conferred to Catholic noblemen in Spain. Unfortunately, the Governor of New Mexico died in 1627 in Spain when he was inside a mine that collapsed (Bloom 1939; Zumalde 1998).

On the other hand, two sons of Francisco Perez de Ibarra, who was Castile's Constable Judge, and Maria Perez Marquiegui, moved to New Spain. The first one to arrive there was Miguel de Ibarra, who was Nuño de Guzman's captain. The second son, Diego de Ibarra, was born in Éibar, Guipuzcoa, in the Basque region, probably in 1520 or 1521. In 1540 he arrived in New Spain, and he joined his brother; in 1556 he married Ana de Castilla, Luis de Velasco's daughter, who was the Viceroy at that time, and then he went to the north. Diego de Ibarra and Oñate lived in the mining town of Pánuco (Mechan 2005; Porras Muñoz 1968).

Diego de Ibarra became mayor of Zacatecas; and, thanks to this position, he attracted Basque settlers who took an active part in mining (Azcona Pastor 2004: 36). He was a promoter of the worship to the Holy Virgin Mary in Zacatecas, and he was also known for his generosity to charities to and several religious institutions, such as the parish church at Pánuco, which he built and endowed (Porras Muñoz 1968).

With 200,000 pesos, he financed the conquest of Nueva Vizcaya—undertaken by his nephew, Francisco de Ibarra (ca. 1539–1575), which started in 1554—and departed from Zacatecas. This man from Éibar earned the lifetime designation of governor and captain general; he died from tuberculosis, childless, without paying his the debts to his uncle, who actually succeeded him in 1576 in his position as governor of the provinces of Copala, Nueva Vizcaya, and Chiametla. It was detailed in his will that among his assets there were two water mills and mines in Pánuco. These smelters and mines, like many others in San Martín, Zacatecas, and Sombrerete, and several properties in Nueva Vizcaya, including ranches, along with substantial capital, were kept by the Ibarra family until 1610, when their primogeniture decreased dramatically, and the Pánuco mines, as well as other assets, were sold (Mechan 2005; Porras Muñoz 1968).

5.5 Silver Mining in Pánuco

Nowadays Pánuco, located less than 18 km from Zacatecas, is a small agricultural town, but there are still some remnants of its old mining boom, and small amounts of silver are still extracted from the tailings. Pánuco is located in the Zacatecan

mining district at 2125 m above sea level, in a semiarid zone. In Pánuco the Buen Suceso Creek is a temporary stream fed by low precipitation (Echavarría Cháirez et al. 2004; Ponce 1985).

Pánuco's downtown is still standing, with many nineteenth and twentieth-century modifications; the church is still in use and part of the eighteenth- to nineteenth-century style living quarters for the priests have been preserved. As modest as it might look today, this was the See of the first Zacatecan parish, which was founded in the seventeenth century. The modifications in the central square and its surroundings have wiped out the few vestiges of the colonial period, although the locals believe that some of the houses belonged to the conquerors. The temple tells us a lot about the origins of the Real de Minas de los Tajos del Nervión de Pánuco, since it was dedicated to the Biscay Virgin of the Rosary or of the Victory, which refers to the Christian victory at the Battle of Lepanto against the Turks in 1571.

Pánuco was the place where on All Saints Day, November 1rst, 1548, Cristóbal de Oñate among others discovered the silver veins which made Zacatecas famous due to its high productivity for smelting and amalgamation during the colonial period.

Since the most important mines that were discovered were located several miles away—"one and two leagues"—from Zacatecas, the mining town of Pánuco was founded so that the mine owners would not have to travel between the small mining towns and the city. In fact, Pánuco and Zacatecas constituted a political unit integrated into a single judicial and administrative district (Enciso Contreras 1994; Mota y Escobar 1940).

The aforementioned Cristobal de Oñate was one of the rich miners who settled in Pánuco, where he had 13 grinding and refining mills, 101 slave houses, and a two-story residence. He also constructed within his property a church, and he covered the cost of supporting a priest so that all the miners could attend mass (Sescosse Lejeune 1985). In 1552, his wife, Catalina de Salazar, gave birth to twins. One of them was named after his father; and the second one, Juan de Oñate (Etulain 1999), became famous due to his unsuccessful search in 1598 for the fabled cities of gold (Cibola) and the beginning of the colonization of New Mexico; these adventures were financed with the silver extracted in Pánuco.

By 1562, in the Zacatecan mining district, there were 35 amalgamation mines and about the same number of smelting mines exploiting veins like the one in Pánuco (Langue 1993). The operations were definitely profitable for people such as the Spaniard Gregorio Quintana, who in 1575 was a mine manager of one of the Oñates' mines that was worth 200,000 pesos, and earned an annual salary of 1000 pesos, while the foreman at his orders made 200 pesos. By that time he had bought a hacienda which was worth 5000 pesos (Otte 1985).

We must point out that in 1598, the more than 1000 individuals who worked in the Zacatecan mines created a colorful ethnic mosaic comprising 11% black slaves, and more than 88% free Indians (Martínez López Cano 2001).

In the sixteenth century, the wholesale merchants of the Zacatecan mines had no direct negotiations with Castile (Enciso Contreras 1994) due to the monopoly of the merchants in the capital of New Spain. Consequently, it was common to trade con-

sumer goods from the motherland, China, and Mexico City to the mining towns in order to exchange them for silver (Martínez López Cano 2001). In Pánuco, as well as in the city of Zacatecas, there was a street market; there were also a large number of supply stores, although trading was less significant in Pánuco than in the jurisdiction (Enciso Contreras 1994).

Until the late seventeenth century mining in the Sierra de la Bufa and the area around Zacatecas such as Vetagrande surpassed the metal yields of Pánuco, with 29 million pesos paid to the Crown in 1643 (Brading 1970; Mechan 1927).

From 1620 to 1630 there was a prosperous period in the Zacatecan silver production which was not equaled again until the early eighteenth century, but it was followed by a depression sharpened by tragedies such as the flooding of the Vetagrande mine from 1619 to 1620; epidemics that decimated black workers, mulattoes, and Indians; and the depopulation caused by the migration to the Nueva Vizcaya Parral mining district (Alberro 1985). By the eighteenth century, from 1740 to 1763, there was also decline in the Zacatecan mining sector, followed by a recovery in the last third of the eighteenth century, which was the golden age for the companies or "mining capitalists" (Lange 1991).

By the mid-seventeenth century, despite Pánuco's prosperous economy and the fact that its discoverers were among the wealthiest men living in the Spanish possessions in the Americas, the mismanagement of their fortunes as well as their unsuccessful investments in other enterprises, conquests, and the wars they took part in ruined them. Like Juan de Oñate, who was New Mexico's conqueror, their descendants inherited illustrious names but more debts than capital.

According to a population and housing census that probably dates from the seventeenth century, the town of Pánuco was prosperous; and there were five churches, 72 residences, 235 slave houses, 27 grinding mills, 41 smelting mills, 14 amalgamation mills, 39 owners of mines and mills, two or three priests, two traders, three merchants, one blacksmith, one butcher, and one carpenter (Acosta López 2013: 7).

Frédérique Langue's (1991) stories of great and wealthy miners are more mythical than real. Pánuco's history shows that wealth rarely remained in its owner's hands; these men often financed other enterprises and thus squandered their fortunes and capital. Furthermore, due to the fluctuations in the quality and quantity of silver that was obtained, they could barely afford the mercury required for the smelting process and paying taxes to the Crown. Consequently, the Pánuco mines passed from one owner to another.

Bartolomé Bravo de Acuña, a descendant of the Oñates and Temiño de Bañuelos, who were Zacatecas' first conquerors, bought the Real de Pánuco mines by the mid-seventeenth century. He was succeeded by his son Juan Bravo de Medrano, who was a peacemaker in Colotlan and Sierra de Nayarit. He was also Lieutenant General of Nueva Galicia; and thanks to his success in mining, he became the first Zacatecan to buy a noble title, becoming the count of Santa Rosa in 1691; however, his son inherited his debts and flooded mines, and he was not able to keep the precarious family business, so his goods were auctioned after his death due to his insolvency (Rivera Bernardez 1883).

When the second Count of Santa Rosa died in 1706, notarial records listing his properties include the Pánuco smelters and amalgamation facilities (Archivo Histórico de Zacatecas, Fondo Poder Judicial, Serie Civil, Caja 5). At the hacienda, the chapel had a tower with three bells; inside there were two altars, but it had to be remodeled because the ceiling collapsed. Religious sculptures represented Our Lady of the Immaculate Conception, with a silver crown; St. John the Evangelist; St. John the Baptist; St. Bartholomew, with silver crown and two angels; Our Lord Jesus Praying in the Garden; and Jesus of Nazareth. Other elements included two large crucifixes with silver aureoles and other ornaments, and for the liturgy, objects in silver like a cruet, a paten, a chalice, a thurible, an incense boat, and small bells.

The house was in good condition and was presented to the new owner with all the accessories (doors, keys, etc.). It contained 40 canvas paintings of all sizes; a Mexican crucifix with a baldachin made of red damask; five oil paintings of landscapes and three portraits; , four wooden benches, a table, and a tablecloth; three Mexican-style desks; two baskets, two beds, a cedar chest, three tables, and one iron chest; a chair and a stool; and a wooden wardrobe.

On the other hand, the buildings at the smelter had roofs, walls, and doors with padlocks; and at a stable there were six mills stored inside. All the mills had four pitchforks, horse blankets, and blinkers. There were two stables with managers, stone-water tanks with plaster coating, and in front a water-wheel with four pillars and a water tank embedded in a wall to provide water through channels to the stables. There were also warehouses made of stone with plaster coating to store salt . The stone horizontal cog-wheel and shaft and the sieves required for the amalgamation process were also stored there.

The hacienda also had an amalgamation yard and two horse powered-treadmills, one close to the creek as well as a room to store mercury adjoining the yard and washing vats with wood channels and a water-wheel. The multiple iron and wood instruments required in the different phases of the amalgamation and smelting processes are also listed in the inventory. The list includes a female black slave; three adult and two infant mulattoes; a herd of 24 mules; 34 pack donkeys; harnesses, sacks, and ropes; and 300 mules and 82 horses used to power the mills.

Juan Alonso Díaz de la Campa, Knight of the order of Alcántara, bought this property and became the most important silver producer in Zacatecas between 1725 and 1750. He owned several mines as well as Pánuco's smelting facilities and used his own capital to lead an expedition first to Mazapil and then to the province of Texas. When he died his company was dismantled, and his smelters were sold. Then Manuel Flores Correa became the new owner of the mine of Nuestra Señora del Buen Suceso in Pánuco. By 1781 he had 55 workers, 5 Spaniards and 50 mixed-race individuals. Eventually he sold his smelters to the Vetagrande Company, which was formed in 1783 (e.g., Bakewell 1971; Brading 1975; Garner 1970; Langue 1987, 1988): the era of the private owners of mines gradually made way for shareholders and partners that formed companies.

In the second half of the nineteenth century several mines as well as the smelting facilities in Pánuco were sold to Mexicans; but during the late 1800s several foreign companies were in charge of mining. In this context, national companies such as

Negociación Minera Azogueros were overwhelmed by losses and taxes, and were forced to sell all their properties in 1893, including the Juárez mine in Pánuco (Gámez Rodríguez 2004).

In Panuco silver production gradually decreased from the late seventeenth century on due to the mineral's scarcity, although the poor exploitation of metal in Pánuco continued through the twentieth century.

Among the smelting facilities that the Bishop of Guadalajara, Alfonso de la Mota y Escobar (1940: 154–155) refers to in the early seventeenth century, four haciendas in Pánuco are listed, one with eight mills. Pánuco had a mild climate, good land where fruit trees were grown, and many water sources; however, the Bishop noticed that mining activities were not as intensive as before. The buildings are partly preserved but terribly affected by the extraction of mercury and stone since the 1940s, according to our informants. The facility has undergone few changes since it was declared common land in 1965 as an elementary school garden.

5.6 The Hacienda del Buen Suceso in Pánuco

The Hacienda del Buen Suceso in Pánuco evidences the development of mining headed by the Oñate family, with its fortunes and misfortunes; it was part of a major population center, with a labor pool and farming land that developed because of metal extraction.

Based on our surveys, the distribution of spaces and some architectural features part of activity areas and buildings with specific functions in mining can be distinguished on the surface (Fig. 5.4). The chapel's plan is defined, including its access and apse, with its tower attached to the front and a side ramp, and there are a few steps in good condition at the bottom. One of the vats used to separate the amalgamated ore from waste rock after it had aged in the sun is intact, and some of its internal walls have been recently cemented in order to take advantage of the water that accumulates; so most of the channels that took the fluid from the aqueduct, whose beginning is unknown, have been blocked up.

The smelting and amalgamation yard, which is next to the vats, adjoins a large area where there are several retaining walls that according to the archaeological materials on the surface and the regularity of the alignments of the stone foundations formed platforms for rooms, which must have been some of the rooms with different functions listed in the second Count of Santa Rosa's inventories.

The main house, which has been severely plundered in order to recover building materials and as a result of treasure hunting, is located in the north part of the complex; and to the east toward the stream, there are broad segments of the smelter's battlemented rampart still standing (Fig. 5.5); this wall probably dates to the nineteenth century, considering it was not mentioned in the inventories from the eighteenth century. This channel must have been used for discarding tailings, which overstock the eastern margin of the creek, looking like gray mounds since no vegetation grows because of the abundance of toxic substances such as mercury and arsenic, by-products of the amalgamation process.

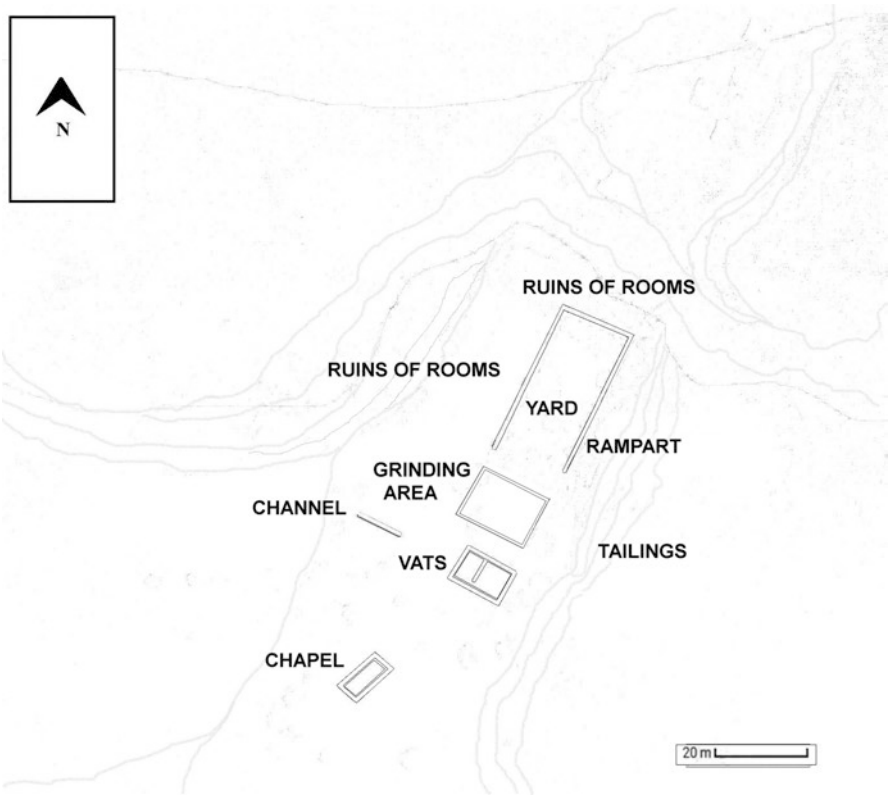

Fig. 5.4 Ruins of the Hacienda de Pánuco

The archaeological materials that clearly show the smelter's opulence include fine pieces of Chinese porcelain of the Ming and Ching dynasties, some fragments of fine burnished pottery from Guadalajara, colonial period majolica from Puebla and Republican period majolica from Guanajuato and Aguascalientes, nineteenth-century British transfer-printed whitewares, a few French porcelain sherds from the nineteenth century, as well as monochrome and black-on-orange glazed pottery dating from the seventeenth to the twentieth century.

5.7 Conclusions

In New Spain, the new conquests to the north and west employing natives as part of the Spanish armies working as porters, servants, or slaves, resulted in a movement of different indigenous ethnic groups that originated in the central valleys and ended with their settling elsewhere, often as members of the lower classes. Together with the Spanish settlers, they introduced Old World crops, agricultural techniques such

Fig. 5.5 Hacienda de Pánuco, ruins of amalgamation yard and section of the battlemented rampart

as the use of the plough, livestock, and strategies for exploiting natural resources not suitable for dryer climates and thin soils, contributing to land degradation and desertification.

Before the Spanish invasion, most of Mexico sustained high- or low-intensive agriculture, and the exploitation of forest resources was limited; hence, the human impact on the environment was not significant in the Mezquital Valley and Zacatecas. Except for a few zones, the landscape was green, almost lush, and water was not scarce; but the post-conquest introduction of domestic animals and overgrazing brought changes in the vegetation and an increase in xerophytic shrubs.

Moreover, large-scale mining caused great damage to forests, often leading to the deforestation of mining regions (e.g., Bakewell 1971; Elliot et al. 2010; Melville 1994).

Because of the method used to process precious metals from the ores, toxic wastes formed tailings, and over time these mine dumps became an environmental liability since toxic elements impacted on soils and sediments and saturated the water table and groundwater (e.g., Gutiérrez Ruiz et al. 2007; Yarto Ramírez et al. 2004).

All over New Spain, miners made fortunes extracting silver while employing methods that polluted the environment; and the Otomí charcoal-makers, found a way to earn some money with their craft, ravaged forest resources intact before the Spanish conquest.

Silver mining in Mexico and South America fueled the global economy, the development of capitalism in Europe, and a new system of monetary economy in Asia where silver coined in New Spain became the most important currency in late imperial China. But the legacy of silver exploitation is complex and goes beyond economics. As a consequence of human agency in metal mining and metal smelting, toxins remain in soils, sediments, and aquatic systems. Since post-conquest times and for centuries, chemical pollutants and metals such as lead, mercury, and arsenic have contaminated thousands of square kilometers of arable and grazing lands all over Mexico. Moreover, mining degraded large areas of forest resources, leading to the deforestation and soil erosion exacerbated by over-intensive grazing of cattle, sheep, and goats in central and northern Mexico. Studnicki-Gizbert and Schecter (2010: 111) explain, "Deforestation and the associated development of a colonial agroecology profoundly transformed existing ecologies and the human communities that interacted with them."

In Mexico, recently constitutional amendments and the energy reforms of 2013 implemented by the most corrupt government the country has had in years resulted in lax environmental regulations, and permits to exploit metals have been continuously issued. Hence, powerful foreign companies—including Canadian enterprises (e.g., Olvera 2017)—have been taking advantage of this new scenario. While peasants can barely make a living and many try to migrate north of the border, these companies continue to deplete natural resources, polluting soils and the water table.

Colonialism has many forms and variations, and from the Spanish invasion until today a once mighty, rich area has been continuously exploited over and over. As a result, even today most of the nation's wealth ends up in the hands of those who do not care for the Mexicans' well-being.

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