SOCIO-TECHNICAL EVALUATION OF THE INTERACTIONS BETWEEN LARGE-SCALE (LSM) AND ARTISANAL AND SMALL-SCALE MINING (ASM), LATIN AMERICA.

by

Oscar Felipe Rodríguez-Novoa

A dissertation submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Geology)

Golden, Colorado

Date _____

Signed: _____

Oscar Felipe Rodríguez-Novoa

Signed: _____

Dr. Elizabeth A. Holley

Thesis Advisor

Golden, Colorado

Date _____

Signed: _____

Dr. Wendy Bohrson

Professor and Head

Department of Geology and Geological Engineering

ABSTRACT

In mineral-rich areas of the developing world, artisanal and small-scale mining (ASM) contributes significantly to production of commodities such as gold. As a result of economic and environmental pressures, this sector is expanding. As the demand for minerals and metal resources increases, large-scale mining (LSM) will also need to expand to meet the future needs. LSM and ASM are likely to have more contact as a result of these expansions. Coexistence between ASM and LSM is key in this scenario and should be viewed as a capacity to build synergies and work together.

The first chapter of this dissertation is a general introduction. The chapter explains the motivations for the study as well as the perspective used to approach the problem. This chapter also describes the importance of considering coexistence prospectivity and conflict risk when identifying and ranking exploration and mining targets. This chapter concludes by presenting the background and general aspects of the ASM sector in Peru and Colombia.

In the second chapter, this dissertation tests the hypothesis that there are particular technical and social characteristics that are more likely to lead to an ASM-LSM coexistence arrangement that benefits both parties. By examining coexistence from the perspectives of economic geology, mining engineering, economics, the legal framework, and the demographics and culture of the community, this dissertation aims to identify potential indicators of successful coexistence, as well as to examine the socio-technical intersections of these characteristics. The study shows examples of ASM coexistence with junior and senior LSM companies, during the exploration, development, production, and closure stages of the mining lifecycle. Coexistence scenarios are most common in gold projects but cover a wide variety of deposit types including epithermal, porphyry and volcanogenic massive sulfide ore deposits (VMS) among others. Governments have taken significant efforts to create tools for LSM companies and holders of mining titles to reach agreements with ASM

miners. Nevertheless, the success of these agreements largely depends on the willingness of the ASM and LSM parties to work together.

In the third chapter of this dissertation, success in coexistence is measured from the LSM perspective based on the cost of avoiding conflict using the decision-tree valuation model presented by Teschner and Holley (2020). The method is applied to a case study in Gramalote, Colombia where a coexistence agreement was developed between Gramalote Ltd (LSM) and small-scale mining companies referred to as La María. The study shows that application of ASM-LSM coexistence strategies can reduce the financial risk associated with social conflicts, add value to mining projects, and strongly impact the project´s net present value (NPV). Nevertheless, it is necessary for both parties to continue to manage the coexistence processes in the long run, in order to mitigate ongoing risk.

The Gramalote case study was also evaluated from the ASM community perspective, using the Sustainable Community Development framework of Bridger and Luloff (1999) and the United Nations Sustainable Development Goals (SDGs).

The study shows that coexistence with LSM contributes to the ASM community of La María by improving the conditions of Self-Reliance, Political Autonomy and Self Determination, Reduction of Materials and Energy, Protection of Local Ecosystems and Stewardship of Natural Resources, and Social Justice, defined as components of a sustainable community in the Bridger and Luloff Framework. Coexistence between LSM and ASM also can contribute to the fulfillment of the SDGs in parts of the Global South where the LSM mining industry is active, such as Colombia. The coexistence strategy of formalization subcontracts at La Maria have led to positive impacts on several SDGs including SDG6 *clean water and sanitation*, SDG8 *decent work and economic growth*, SDG14 *life below water*, SDG15 *life on land* and SDG17 *partnerships for the goals*, as well as potential medium- and long-term impacts on SDG1 *no poverty*, SDG2 *zero hunger*, SDG3 *good health and well-being*, SDG9 *industry innovation and infrastructure*, SDG10 *Reduce inequalities*, SDG11 *sustainable cities and communities*, SDG12 *responsible consumption and production* and SDG16 *peace justice and strong institutions*.

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ACKNOWLEDGMENTS

Foremost, I would like to express my deep and sincere gratitude to my research advisor, Dr. Elizabeth Holley for giving me the opportunity to be part of this project, for the continuous support, and providing invaluable guidance throughout this research. Her sincerity and motivation have deeply inspired me.

Besides my advisor, I would like to thank the rest of my thesis committee: Dr. Steve Enders, Dr. Nicole Smith, and Dr. Paul Santi, for their encouragement and insightful comments.

I am extremely grateful to my parents for their love, prayers, caring and sacrifices for educating and preparing me for my future. I am deeply grateful to my wife and daughter for their love and continuing support when the times got rough. Also, I express my thanks to my brothers for their support and valuable prayers.

Lastly, I thank my fellow mates in the Colorado School of Mines, Alejandro Delgado, Linda Jaramillo, Casey Gibson, Mateo Rojas and Isabel Casasbuenas for the stimulating discussions and the fun we have had in the last four years.

A mi padre…

CHAPTER 1.

GENERAL INTRODUCTION

1.1. Overview

Coexistence between large-scale mining (LSM) companies and artisanal or small-scale mining (ASM) communities has recently become more common in developing countries (World Bank, 2009; Holley et al., 2020). Coexistence agreements have been encouraged by government entities, LSM companies, and artisanal and small-scale miners. The reasons that lead governments to urge LSM coexistence with ASM are varied and range from the need to legalize or formalize ASM operations, or to reduce the use of mercury, deforestation, money laundering or child labor, or to facilitate foreign investment in the large-scale mining sector. LSM companies may pursue coexistence with ASM due to the need to obtain a Social License to Operate (SLO), manage reputational risk, minimize risk and security, and improve mine closure planning (Hilson et al., 2020). From the ASM perspective, coexistence is rarely the main objective but may be an acceptable alternative to conflict with governments or LSM operators or loss of access to traditional livelihoods and resources.

The perspective of this dissertation is that successful ASM-LSM coexistence should enable both parties to build synergies and operate peacefully together at the same ore deposit, at the same time, at different scales, while respecting the livelihoods of the people involved in ASM and the rights and obligations of the LSM company to its shareholders and the legal jurisdictions in which it operates. No prior work has systematically evaluated the impact of coexistence on either or both parties, and the characteristics which enable success remain undocumented.

Kemp and Owen (2019) demonstrate that geology exerts fundamental control on the interactions between ASM and LSM. In certain geological settings (e.g., Type 4), the two parties compete for the same resources in the same physical space (Figure 1.1). Conflict is

inevitable unless the two parties reach a coexistence agreement. Conversely, some geological settings are permissive of coexistence because the two parties operate in different physical spaces (e.g., Types 2 and 3). For example, at Marmato in Colombia, the shallow portions of epithermal veins are amenable to ASM, whereas the deeper disseminated resource is only accessible using LSM methods (Holley et al., 2020). At Bonanza in Nicaragua, both the LSM and ASM operators mine epithermal veins. However, some veins have greater thicknesses and lower grades, which allow them to be exploited profitably in the large-scale operation. The shallower expressions of the same veins are exploited by ASM (Holley et al, 2022). In addition, thin veins that are sub-economic for the LSM company due to their dilution factor or strip ratio factor are also given to groups of artisanal miners for their exploitation (Horan et al., 2020). The Bonanza area has traditionally been a mining zone, with few other job opportunities. Social factors critical to the success of the coexistence between ASM and LSM include the ability to organize and government support. This ability to organize has its roots in the “Revolución Sandinista,” a conflict won by the Nicaraguan people 1990 ending the dictatorship of the Somoza family. This capacity for social movements has enabled ASM miners to organize into cooperative groups to work and distribute the product of their work, while also maintaining a strong negotiation position with the LSM company. Such examples allude to the potential for particular factors to influence the success of coexistence between LSM and ASM. This dissertation seeks to explore how the technical factors intersect with the social context to facilitate or impede coexistence between ASM and LSM at similar sites across Latin America.

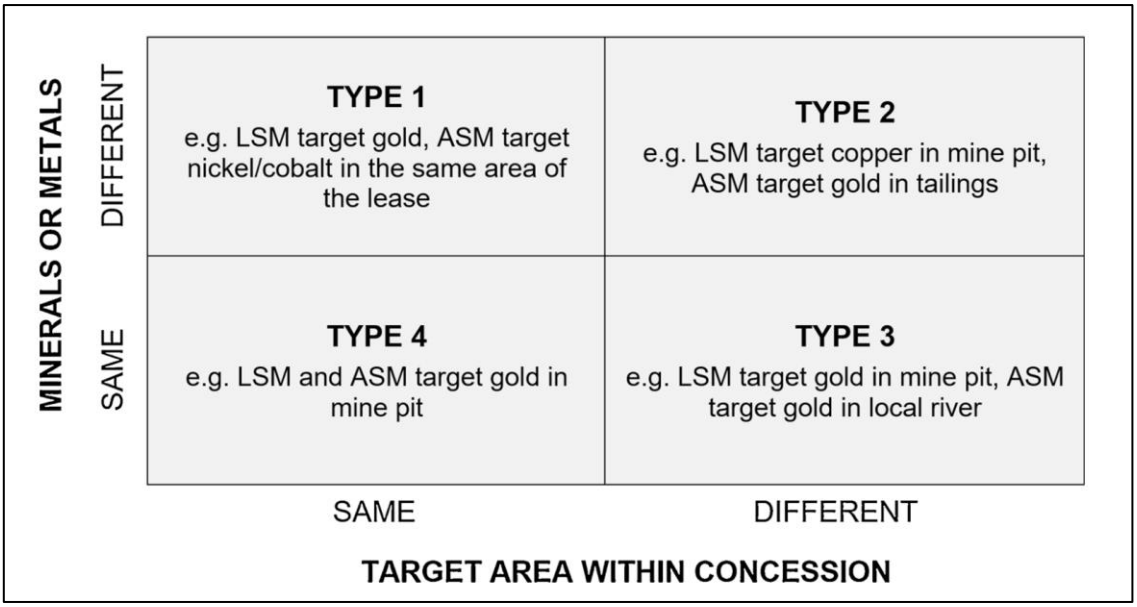

Figure 1.1 A base typology of LSM-ASM interface (Kemp and Owen, 2019).

This dissertation tests the hypothesis that there are particular technical and social characteristics that are more likely to lead to an ASM-LSM coexistence arrangement that is beneficial to both parties. By examining coexistence from the perspectives of economic geology, mining engineering, economics, the legal framework, and the demographics and culture of the community, this dissertation aims to identify potential indicators of successful coexistence, as well as to examine the socio-technical intersections of these characteristics. In this dissertation, success is measured based in the Sustainable Community Development framework of Bridger and Luloff (1999), and from the LSM perspective based on the cost of avoided conflict using the decision-tree valuation model presented by Teschner and Holley (2020).

This work is being undertaken by a geologist for a number of key reasons. First, the potential for conflict or coexistence with ASM should be considered a fundamental LSM exploration criterion in regions where the two groups converge. The role of the geologist is to identify, characterize, and rank exploration criteria, and to determine how “coexistence potential” should be integrated during exploration targeting. Secondly, geological evaluation is needed to assess the hypothesis that certain ore deposit styles and mining methods are more suited to coexistence. Third, geologists are the first “boots on the ground” during LSM

exploration (Mackenzie et al., 2020), and their interactions with ASM communities have the potential to make or break a project.

This study comprises a compilation and evaluation of LSM-ASM coexistence efforts in Latin America. The evaluated characteristics are listed in Table 1.1 The data on these characteristics at a range of sites in Latin America are used to test the hypothesis and identify the common social and technical characteristics among successful and unsuccessful processes. For example, are particular deposit styles or ore characteristics more amenable to coexistence? Do particular historical contexts or cultural aspects create insurmountable challenges? In addition, a comparative study was conducted at a case study site in Colombia, to examine the intersections among the social and technical characteristics. At the case study site, the following questions were addressed: What type of deposit is mined? What are the mining methods applied by the ASM and LSM operators? What is the percentage of recovery of the ASM plant versus the LSM plant? Which are the recovery methods applied and why? Which are the main dynamics involved in this type of agreements? How were these agreements reached? What was the role of the government agencies when these agreements were reached? Who else was involved, NGOs, community leaders, political leaders? What was gained or lost by ASM communities and LSM companies? This final question is examined by applying the framework of Sustainable Community Development (SCD) (Bridger and Luloff, 1999) to assess how the coexistence strategies are impacting the ASM communities, whether these impacts are positive or negative, and if there are opportunities to improve. The hypothesis raised here is that the coexistence between ASM and LSM facilitate Sustainable Community Development (SCD). The impacts on the LSM company are assessed by applying the decision-tree valuation model presented by Teschner and Holley (2020) to calculate the financial impact of stakeholders in the valuation of the projects. The modeling helps show how the investments in stakeholder engagement programs impacted (or could impact) the NPV of a project, based on the hypothesis that the coexistence processes between ASM and LSM reduce the risk associated with conflicts that lead to a delay or closure of the mining project.

The results of this research will be useful for geologists and other technical managers in the exploration and mining industry. The study results will enable geologists and other decision-makers to include coexistence prospectivity and conflict risk in the list of variables used to identify and rank exploration and mining targets. In addition, this research has the potential to boost the development of exploration and mining in Latin America, adding better practices, contributing to the reduction in the use of mercury, deforestation, and other illegal practices related to ASM such as money laundering and funding armed groups. The results will be also useful for governments and ASM communities interacting with LSM to make decisions that promote livelihoods, local economies, self-reliance, and social justice, and governments in the design of public policies.

Table 1.1 Summary of social and technical aspects related to coexistence of ASM and LSM

SUMMARY OF SOCIAL AND TECHNICAL ASPECTS RELATED TO COEXISTENCE OF ASM AND LSM			
TECHNICAL ASPECTS		**SOCIAL ASPECTS**	
GEOLOGY	Geology is the main technical aspect in the coexistence or conflict between LSM and ASM. The nature of the deposit determines if an ASM operator can exploit the deposit for profit. Usually, artisanal and small-scale miners are interested in deposits with low tonnage and high grade. LSM companies are able to exploit high tonnage and low-grade deposits. The interests of both, LSM and ASM intersect when both characteristics are available at the same deposit. e.g., porphyry type deposit with associated oxidized enriched zone or telescoped systems with epithermal veins in porphyry deposits.	**ETHNICITY**	ASM Communities in Latin America can be part of different ethnic groups, Indigenous people, Afro-American, or white settlers with long artisanal mining tradition that dates back from the pre-columbine times.
EXPLORATION	Exploration of mineral deposits usually involves high tech instruments, that are not generally affordable for ASM operators. LSM usually spends significant amounts of money on exploration activities before any exploitation.	**DEMOGRAPHICS**	The demographics of ASM communities vary by site.
MINING METHODS	The mining methods used in ASM are usually panning, dredging, underground, and washing soil or saprolite. ASM uses limited machinery and processes small amounts of tonnage per day. It is not common for ASM to mine hard rock with the open-pit method. LSM operators can employ open-pit mining, which is the most profitable option for shallow, low grade, bulk tonnage deposits. LSM also mine underground deposits with industrial methods, including machinery that helps to process large tonnages per day.	**CULTURAL/RELIGIOUS BELIEFS**	Some members of the ASM communities are marginalized due to cultural or religious beliefs. Identification and consideration of these characteristics could be decisive to the failure or success of the coexistence strategy.
MINE PLAN	ASM usually is not carried out according to a mine plan. Operators advance their workings on a day-by-day basis and lack certainty about future production. On the contrary, detailed knowledge allows LSM operators to have detailed mining plans for the short, middle, and large term.	**ECONOMIC ACTIVITIES AND VOCATION OF THE TERRITORY**	Some ASM communities are in areas where the only feasible economic activity is the gold mining. Sometimes there are other options, or the territory has the capacity to support diverse economic activities and ASM communities share different activities. The ASM activity in many cases is a traditional livelihood, and in some areas of Colombia and Perú, is the only option to provide an income.
RECOVERY PROCESS	The recovery process in ASM is rudimentary, the amount of ore processed is low, and the process can take a long time. Many operators in Latin America use mercury amalgamation for gold recovery, and the percentage of recovery is usually low. LSM does not use mercury and the recoveries of gold can be higher >80%	**UTILITIES, SANITARY SERVICES, HEALTH AND EDUCATION**	Many ASM Communities are in areas with poor infrastructure (lack of energy, water, sewer, internet), without access to good quality of health service or education.
ORE SALE AND PAYMENT PROCESS	Artisanal and small-scale miners usually sell their product to local traders at lower prices than in international markets. They do not have contracts or other kinds of commercial instruments to protect them against the fluctuation of the markets.	**TRANSPORTATION SYSTEM AND ACCESS ROADS**	Some ASM communities are in isolated areas where the contact with external people is limited, and this make it difficult for them to trust in people that come from outside of the community

Table 1.1 Continued

LEGAL FRAMEWORK	The legal framework could facilitate the process of giving rights to the ASM like in Nicaragua, where LSM is obligated by law to allow 1% of the mining rights area for the ASM community to mine. In Colombia, legalized ASM is required to fulfill several conditions that can be impossible to accomplish.	**SOCIAL AND POLITICAL ORGANIZATIONS**	The form of social organization of the ASM communities and the political, governmental, and nongovernmental organizations present in the territory are relevant to take into consideration in order to understand the power structures and focus the efforts, managing negative leadership and taking advance of positive leadership to build trust.
LOCATION	Location can be one of the most important factors in coexistence processes; for example, if the target commodities for ASM and LSM are located in the same part of the deposit or land claim.	**RELEVANT HISTORIC EVENTS / CONFLICTS**	In Latin America countries, especially in Colombia, people have suffered by long internal conflicts that have shaped their behaviors. Understanding historic and current events is important to know how to communicate with these communities.

1.2. Background

1.2.1. Artisanal and Small-Scale Mining (ASM) Definition

In the literature, different definitions of ASM can be found; some of them are as follows: The term “artisanal miner” is used to encompass all small, medium, large, informal, legal, and illegal miners who use rudimentary processes to extract gold from secondary and primary ore bodies. Artisanal activity is "naturally" controlled by the type of ore deposit (Veiga 1997). Conversely, small-scale mining (SSM) produces less than 100,000 tons per year run of mine (ROM) for profit. Artisanal mining is a subset of small-scale mining, where operation does not follow the conventional ecological and engineering principles of mining and uses rudimentary, or basic, simple, techniques to extract minerals (Seccatore et al., 2014). Both artisanal and small-scale *gold* mining (ASGM) are conducted by individual miners or small enterprises with limited capital investment and production (Puluhulawa and Harun, 2019; Taux, et al, 2022).

In addition to providing jobs, ASM also generates significant financial flows. Millions of ASM operators worldwide produce an estimated 400 t of gold annually, representing 17–20% of officially recorded production (Seccatore et al., 2014) in (Salo et, al., 2016). The ASM sector is also commonly associated with high social and environmental costs, including precarious working conditions, poor living conditions, poor health, poor safety records, child labor, sexual exploitation, human trafficking, tax evasion, deforestation, and pollution (e.g., Hammond et al., 2007; Hilson, 2010; Elmes et al., 2014; Vallejo Rivera, 2014; Salo, et al, 2016). Artisanal and small-scale gold mining is responsible for over 30% of the world’s

mercury emissions, or about 1,400 tons of toxic mercury released per year (Seccatore et al., 2014).

This dissertation focuses specifically on artisanal and small-scale gold mining (ASGM), defined as encompassing various scales of labor-intensive gold mining operations that usually take place informally with minimal technologies (Hilson and Maconachie, 2019). ASGM sites are those small or large operations that use rudimentary techniques to extract gold, operating legally or illegally (Seccatore et al., 2014).

1.2.2. Artisanal and Small-Scale Gold Mining (ASGM) in Colombia

Colombia is the largest producer of gold from ASM in South America. In Colombia, the estimated gold production from ASM is between 41.4t and 50.8t per year. For comparison, In Perú the production is about 40t per year, and in Nicaragua is about 1.2t (Seccatore et al., 2014). In Colombia, 44% of the 1122 municipalities in the country have artisanal (informal) mining (Serrano et al., 2015), and 23% of those municipalities have artisanal gold mining. This is a result of poverty and lack of employment opportunities in rural areas.

Pantoja and Pantoja (2016) stressed that 74% of the Colombian population is living in poverty, and there is no evidence that conventional mining, through the return of royalties to the municipalities, is reducing poverty in rural municipalities. In 2013, informal employment in Colombia through all sectors represented 64% of the workforce (ILO, 2014), which continues to grow due to a large influx of informal immigrants, mainly from Venezuela (Veiga and Marshall, 2019). According to the Colombian Ministry of Mines and Energy (MME, 2014), It is estimated that artisanal gold production takes place in 261 municipalities and 19 departments (out of 32 departments in the country, which are equivalent to states). Most of them are using rudimentary processes to recover gold, such as mercury amalgamation. From the 543 units of ore processing investigated by the MME, approximately 70% did not have their legal papers in order (Veiga and Marshall, 2019).

In Colombia, ASM mainly exploits alluvial gold deposits, epithermal veins, and orogenic veins. The exploitation of disseminated gold deposits or oxidized zones in open pits is less common although still reasonably widespread in Colombia. The main alluvial gold deposits in Colombia are found along the Cauca River and the Atrato River. The second larger producer of gold in Colombia is the LSM company Mineros S.A, and their operations are 100% alluvial at an industrial scale in the lower basin of the Cauca River. Mineros S.A. maintains agreements with ASM to exploit portions of their mining titles at a lower production rate with smaller dredges.

ASM operators exploit epithermal veins in Antioquia (e.g., Segovia, Antioquia Batholith, and Cauca Belt), South of Bolivar, and orogenic gold veins in Nariño. The leading gold producer in Colombia is located in Segovia. There, the LSM company Gran Colombia Gold exploits epithermal veins via underground operations, in a conflict-ridden and contentious collaboration with ASM. The Segovia operations processed an average of 1200 tpd in the first quarter of 2021. In addition, the company processed 270 tpd of ore in the first quarter of 2021 from the small mines operating under contract with the Company in the brownfield areas within the Segovia mining title. To date, 56 small mines have been contracted by the company as part of its environmental, social, and governance initiatives.

The new Buriticá gold mine recently purchased by Zijin Mining is another example. Buriticá is located in the Cauca Belt in Antioquia. Large-scale operations started late in 2020, exploiting epithermal veins using underground methods. Buriticá is one of the major producers of gold in Colombia nowadays. A leak of proprietary maps showing vein locations led to an influx of ~5000 ASM miners and their families (Editorial La República, 2020), resulting in a humanitarian crisis and eviction by the military. An estimated 150 of ASM miners remain in Buriticá, mining the narrower portions of the veins via cooperatives that are formally recognized by the government and the company (Continental Gold, 2020).

There is also ASM open pit mining in oxidized zones of porphyry environments in the Antioquia Batholith, Cordoba (e.g., Cordoba Minerals) and Cauca departments, although there are currently no LSM operators mining via open pit in the country. However, in the

Antioquia Batholith, ASM workers used to produce gold from oxidized horizons in open pit operations in the same place where the LSM company Gramalote Ltd is planning a future mine. Gramalote Ltd (a joint venture between AngloGold Ashanti and B2Gold) and is pursuing coexistence with ASM. This operation would be the first LSM open-pit gold mine in Colombia, and the mechanism for ASM coexistence is still under negotiation. These preliminary data points suggest that epithermal gold deposits are the geological setting where there is most frequent convergence between ASM and LSM.

1.2.3. Artisanal and Small-Scale Gold Mining (ASGM) In Peru

Peru is the second largest producers of gold through ASM in South America (Valdivia and Ugaya, 2011). According to data from the Peruvian Society of Environmental Law (SPDA) it is estimated that the gold production of this sector represents approximately 20% of national production, that is, around 40 tons per year (Escobar et al., 2019). Artisanal and small-scale gold mining is an important livelihood in Peru, providing much-needed income for many impoverished communities. Currently, the prevailing method of ASGM in the country involves using mercury to extract gold. These activities result in the release of tons of mercury each year, causing significant air, soil, and water contamination and severe health impacts on local communities. Although there is a presence of this type of mining in 24 of the 25 departments of Peru, the greatest amount of ASM is located in eight departments: La Libertad, Ancash, Arequipa, Ayacucho, Apurimac, Cuzco, Madre de Dios, and Puno (Kuramoto, 2001).

Rather than discussing mining in every department, the study presents examples of divergence and convergence between ASM and LSM in Perú. In the Madre de Dios region, as in the Puno region in the Ananea district in the southeast of Peru, ASM operators work mainly in alluvial gold deposits. In these sectors, there are no LSM companies operating and therefore there are no ASM-LSM coexistence processes. What predominates in this sector are processes of formalization led by the state with the support of NGOs. On the other hand, Consorcio Minero Horizonte, which operates in the La Libertad region of northern Peru,

produces gold from a mesothermal or orogenic vein system, through underground mining in the Pataz Batholith. This vein system has a lateral extent of approximately 8km, giving the opportunity for artisanal miners to access the same resource from different locations at significant distance from the LSM infrastructure. This geologic characteristic has forced the LSM company to establish an agreement for the purchase of ore exploited by ASM. Like Parcoy, the LSM company Poderosa operates in the same district and in the same geological environment, applying the same strategy of coexistence. In the region of La Libertad, there are also epithermal vein gold deposits such as Cerro el Toro, a high sulfidation epithermal deposit where ASM began working in 2000. Suma Gold started LSM operations in Cerro el Toro in 2019 after negotiating coexistence with the ASM community. These examples suggest that convergence between ASM and LSM in Peru depends on the geological characteristics of the deposit and occurs mostly in orogenic or epithermal vein-type deposits.

1.2.4. The Minamata Convention

The Minamata Convention is a global legally binding instrument on mercury written by the United Nations Environment Assembly. Its text was adopted on 10 October 2013 in Japan and was opened for signature for one year until 9 October 2014. During this period, it was signed by 127 countries including Peru and Colombia. Also, one regional economic integration organization signed the document, resulting in a total of 128 total signatories (UN., 2019). The main objective of the Minamata Convention is to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds; it sets out a range of measures to meet that objective. These include measures to control the supply and trade of mercury, including setting limitations on specific sources of mercury, such as primary mining and controlling mercury-added products and manufacturing processes in which mercury or mercury compounds are used, as well as artisanal and small-scale gold mining (UN., 2019).

1.2.5. Coexistence

The term coexistence came into common usage during the Cold War, when in 1953 former Soviet premier Nikita Khrushchev promoted the concept of “peaceful coexistence” to ease tensions between the Soviet Union and the United States to avoid the possibility of nuclear war (Lipson,1964).

Coexistence takes place in situations where individuals and communities actively recognize and celebrate diversity (active coexistence) and where individuals and communities just tolerate other groups (passive coexistence). Passive coexistence is common when relationships are characterized by unequal power relationships, little inter-group contact, and little equity (Nyawira, 2003). In short, the principles of social justice are not apparent here. In active coexistence, relationships are characterized by a recognition and respect for diversity and an active embrace of difference, equal access to resources and opportunities, and equity in all aspects of life (Nyawira,2003). This type of coexistence fosters peace and social cohesion based on justice, equality, inclusion, and equity.

In the context of this study, coexistence between ASM and LSM is the capacity to build synergies and operate peacefully, in the same mineral deposit, at the same time, at different scales, while respecting the livelihood of the people involved in ASM as well as the rights and obligations acquired by the LSM companies according to the law of the country where it operates. The strategies already adopted by governments and LSM companies in Latin America are formalization (e.g., Mineros S.A, Royal Road Minerals), formalization subcontracts (e.g., Continental Gold, Gramalote Ltd), purchasing ore from ASM (e.g., HEMCO, Antioquia Gold, Grupo Minero Horizonte), and Contract Mining (e.g., Continental Gold, Gran Colombia Gold). In the Formalization model, the ASM workers may become owners of the mining rights when the area where they work is free or when the owner of the mining rights agrees to give up an area that later is titled to the ASM operators. Formalization Subcontracts describe the process through which the LSM company allocates an area for ASM but retains the mining title. In both cases the ASM is obligated to pay royalties and follow regulations, and the ASM operators are directly accountable for any

labor, environmental, or fiscal breach. In the ore purchasing model, the LSM company process the ASM ore in the LSM plant. The ore must be sampled and assayed, usually by the LSM company, so that the ASM operator can be paid according to a previously negotiated contract. In Contract Mining, the LSM company allocates an area or sector of its mine to be exploited by ASM. In this case, the ASM miners are not the owner of the mining rights, must follow the safety, environmental, and labor rules of the LSM Company, and are responsible to fulfill the commitments under a commercial services contract agreed with an LSM company.

The selection and application of any of these strategies will depend on the legal framework of the country, the stage in the mining cycle in which the LSM company is, the characteristics of the ASM community, and the nature of the deposit. For the latter, geological characteristics such as mineralogy, type of mineralization, shape, and location of the ore body, etc. are relevant. This combination of technical and social characteristics imply that the coexistence process is a sociotechnical system that needs to be evaluated using a sociotechnical approach.

1.2.6. Bridger & Luloff Dimensions of Sustainable Community Development (SCD)

The framework proposed by Bridger and Luloff (1999) for the ideal-typical sustainable community development is defined in five dimensions:

1. *Increasing Local Economic Diversity:* This dimension refers to creating or strengthening the local economies in a community so citizens are not dependent on imported goods and can create or produce the goods they need, also creating at the same time, job opportunities and different sources of income.

2. *Self-Reliance. Political Autonomy and Self Determination:* This is the capacity of a community to decide their destiny and take action on what they want to do and how they want to do it while maintaining their identity, traditions, and their livelihoods.

3. *Reduction of Materials and Energy:* This is the use of natural resources in such a way that what is used can decompose naturally and fast enough and that we use no more than the earth can provide.

4. *Protection of Local Ecosystems and Stewardship of Natural Resources:* This dimension aims to be friendly to the environment. Here we try to not contaminate or harm plant species or animals present in the area of influence of the Project. This dimension also aims to use natural resources appropriately in such a way that we do not consume them in full for a short period of time.

5. *Social Justice:* Equal distribution of opportunities and resources in order to enhance human capabilities while reducing the risk and harms among the citizens of a particular location.

1.2.7. Teschner and Holley Decision Tree Valuation Model

The Decision-Tree Valuation Model presented by Teschner and Holley (2020) translates stakeholders' concerns and priorities into an estimate of monetary risk to the investors. The model incorporates the risk associated with project suspension from social conflict into a mining projects' valuation and allows stakeholders´ perspectives to be considered alongside the other technical variables that inform a mining development decision.

The model proposed by Teschner and Holley (2020) suggests that financial value at the project level can be similarly improved by reducing the chance of company-community conflict (P_x). There are two approaches proposed to find P_x; the first one is the suspension likelihood as a function of project stage. It is based on the study of Davis and Frank (2014). The researchers examined 50 cases of prolonged company community conflict and noted both the mines´ stage and whether the company had been forced to suspend or abandon mining related activities due to the social conflict. The second approach is called uniform suspension likelihood, this approach is not stage dependent and applies to a uniform P_x value over the project´s life.

The model constructs a decision tree form the project´s cash flow, for this reason it is applicable to projects that count with at least a Preliminary Economic Assessment (PEA) or projects in pre-feasibility, feasibility, or more advanced stages.

The application of this model to the coexistence processes in early stages of the mining cycle is useful to quantitatively assess the impact of stakeholder influence in the valuation of the project (Teschner and Holley, 2020).

1.3. Dissertation Organization

Following the general introduction presented in this chapter, the bulk of the dissertation comprises three papers addressing the cases of coexistence between LSM and ASM found in Colombia and Peru, and two extended case studies: one to apply the decision-tree valuation model proposed by Teschner and Holley (2020) and the second to evaluate the coexistence process based on the sustainable community development (SCD) framework proposed by Bridger and Luloff (1999). Both case studies were conducted at the same location in Colombia.

Chapter 2 is a paper published in the journal Resources Policy. It documents the technical characteristics such as deposit and mineralization type, mining methods, recovery process and the social context including ethnicity, demographics, economic activities, and social organizations of sites in Colombia and Peru where an LSM-ASM coexistence has been attempted, to identify key characteristics that are permissive or indicative of success.

Chapter 3 is a paper submitted to the journal Resources Policy. The paper applies a previously published valuation model which incorporates the risk associated with project suspension from social conflict into a mining project's net present value of the project (NPV). We discuss that in contrast to investments needed to reduce technical risk, investments to reduce risks related to social conflicts are minimal. Our results suggest that LSM companies' investments in coexistence with ASM communities add value to the mining project and can be viewed as sustainable development investments that contribute to avoid conflict, enable

ASM livelihoods for communities, and reduce the social risk to exploration and mining projects.

Chapter 4 is a paper in preparation for submission to the Journal of The Extractive Industries and Society. The paper presents the case of LSM-ASM coexistence of Gramalote and evaluates it against the Sustainable Community Framework (SCD) (Bridger and Luloff, 1999), as well as evaluate whether this case of coexistence is aligned with the Sustainable Development Goals of the United Nations (SDG).

Chapter 5 is a global discussion of all three studies and provides recommendations and guidelines for future research on the topic.

1.4. Committee and Co-authors

This section clarifies the roles of the co-authors of the three papers presented in this dissertation. Together the co-authors form the dissertation committee.

Oscar Felipe Rodríguez-Novoa is the Ph.D. candidate, primary researcher, and first author of the papers. He conducted the work presented in the papers, analyzed the data, prepared the figures, and wrote the text incorporating edits from the committee.

Dr. Elizabeth Holley is an Associate Professor in the Mining Engineering department at the Colorado School of Mines. She is the student's advisor and provided guidance on experimental design, data interpretation, and presentation of the results in the papers. She is a co-PI on the NSF grant that funded this project and provided the financial support for the work.

Dr. Steve Enders is the department head and Professor of Practice in the Mining Engineering department at the Colorado School of Mines.

Dr. Nicole Smith is an Associate Professor in the Mining Engineering department at the Colorado School of Mines.

Dr. Paul Santi is a Professor in the Geology and Geological Engineering department at the Colorado School of Mines.

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CHAPTER 2.

COEXISTENCE BETWEEN LARGE-SCALE MINING (LSM) AND ARTISANAL AND SMALL-SCALE MINING (ASM) IN PERÚ AND COLOMBIA

A paper published in the Resources Policy Journal

Felipe Rodríguez-Novoa[1][2], Elizabeth Holley[2]

2.1. Abstract

Artisanal and small-scale mining (ASM) is common in mineral-rich locations in the developing world, generating a significant share of production for commodities such as gold. This sector is expanding due to economic and environmental pressures. Large-scale mining (LSM) will also need to expand to meet future demand for minerals and metal resources. The likelihood that these expansions will result in further points of contact between the LSM and ASM sectors is high. In this scenario, coexistence between ASM and LSM is key and should be seen as the capacity to build synergies and operate together. Our aim is to document the characteristics of sites where a LSM-ASM coexistence has been attempted, to identify key characteristics that are permissive or indicative of success. We built a database of sites in Colombia and Peru where ASM and LSM both occur, documenting the technical characteristics such as deposit and mineralization type, mining methods, recovery process and the social context including ethnicity, demographics, economic activities, and social organizations. We observed that coexistence occurs between ASM and both junior and senior LSM companies, covering all the stages of the mining cycle. Coexistence scenarios are most common in gold projects but cover a wide variety of deposit types including epithermal, porphyry and VMS among others. We observed differences in the mining laws between Colombia and Perú which result in contrasting approaches to ASM formalization, leading to variation in the observed coexistence scenarios. We conclude that governments

[1] Department of Geology and Geological Engineering, Colorado School of Mines, 1600 Illinois Street, Golden, Colorado 80401, USA
[2] Primary researcher and author , corresponding author

have taken significant efforts to create tools for LSM companies and holders of mining titles to reach agreements with ASM miners. However, governments have failed to give ancestral ASM miners who do not belong to an ethnic minority the tools to defend their livelihoods, resulting in power-imbalanced negotiations. Nevertheless, the success of these agreements largely depends on the willingness of the parties to collaborate.

Keywords: Artisanal and small-scale mining, Large Scale Mining, Coexistence. Perú, Colombia, Formalization, Contract Mining, Ore purchase.

2.2. Introduction

Artisanal and small-scale mining (ASM) is common in mineral-rich locations in the developing world, generating a significant share of production for some commodities such as gold, colored gemstones, diamonds, tantalum and tin (Harlow, et al., 2019; Villegas et al., 2012; World Bank, 2013). The term ASM is broadly used to refer to small or large labor-intensive operations that use rudimentary techniques to process and extract minerals, operating legally or illegally (Hilson and Maconachie, 2020, Seccatore et al., 2014).

ASM alternately contributes to and impedes sustainable development. For example, the use of mercury, deforestation and child labor pose grave challenges to sustainable development, while simultaneously ASM creates jobs and alleviates poverty (Hilson and Maconachie, 2020). Careful management of ASM is essential to achieve Sustainable Development Goals (UN, 2018). ASM is typically practiced in poor rural locations such as Peruvian and Colombian Amazon, and Chocó rainforest in Colombia, where it is an economically and culturally important livelihood (Sidorenko et al., 2020; World Bank, 2013). Approximately 80% of ASM mines operate outside of legal and regulatory frameworks (IGF, 2017), and such operations can generate environmental and safety hazards, including unsafe working conditions, discharge of tailings into waterways, and mercury contamination during gold processing (Aubynn, 2009). ASM is an important source of employment and generates significant financial flows. Millions of ASM operators worldwide produce an

estimated 400 tonnes of gold annually, representing 17-20% of officially recorded production (Seccatore et al., 2014, Salo et, al., 2016).

According to the International Institute for Environment and Development (IIED), 20% of the world's gold is produced by the ASM sector; 40 million people in the world are directly employed by the activity, and 150 million people in the global south depend on it (IIED, 2018). The ASM sector is also commonly associated with high social and environmental costs, including precarious working conditions, and poor living conditions, poor health, poor safety records, child labor, sexual exploitation, human trafficking, tax evasion, deforestation, and pollution (Salo, et al, 2016). Worldwide, artisanal gold mining is conducted by individual miners or small enterprises with limited capital investment and production where there are not necessarily salary payments, but distribution of income according to the amount of contribution of each individual (UN, 2019), and is responsible for over 30% of the world's mercury emissions, or about 1,400 tonnes of toxic mercury released per year (Seccatore et al., 2014).

In contrast, Large Scale Mining (LSM) refers to capital-intensive, legal mineral extraction usually performed by companies or associations with cleaner, more efficient, and higher rates of production; LSM is also characterized by steadier rates of production usually following financial production guidance. LSM mining companies are often divided into three categories according to size: majors, mid-tier, and juniors. The structure of the global mining sector is heavily weighted towards a relatively small number of *majors* which control the most active production sites in the world (GHGm, 2008; Sidorenko et al., 2020). According to some estimates, the top 150 mining companies make up less than 4% of the number of industry players but produce 80% of global metals (GHGm, 2008; Sidorenko et al., 2020). *Mid-tier* mining companies are usually defined as those which operate one or more small mines (Thomson and MacDonald, 2001; Sidorenko et al., 2020). The term *junior* is used to denote those companies that are involved in exploration or those mining companies that exclusively extract a single commodity, such as gold. Junior mining companies account for less than 1% of global metal production (GHGm, 2008). Junior exploration companies are

considered part of the LSM industry because most of the global spending on exploration, which has increased five times over the past 20 years, was raised by junior companies (Dougherty, 2013).

As resource extraction intensifies across the globe, ASM and LSM are increasingly intersecting. This can trigger a conflict between LSM companies arriving in a territory and ASM communities present in the territory. When the conflict spreads and becomes violent, it can end up destroying one or both parties economically, socially or politically. Coexistence prevents conflicts from spreading and becoming violent. In the context of this study, we envision coexistence between ASM and LSM as the capacity to build synergies and operate peacefully together at the same ore deposit, at the same time, at different scales, while respecting the livelihoods of the people involved in ASM and the rights and obligations of the LSM company to its shareholders and the legal jurisdictions in which it operates. In this study, we operationalize successful coexistence as *evidence of operating together at the same ore deposit, without documented conflict.*

The main objective of this research is to examine the socio-technical characteristics of sites where LSM-ASM coexistence has been attempted, in order to identify key characteristics that are permissive or indicative of success. The hypothesis tested in this paper is that particular coexistence models rely on specific technical and social criteria. Examples of such technical criteria include the ore deposit type, morphology of ore zones, geometallurgical characteristics and mining methods. Key social criteria include the demographics of the community, the legal framework and the cultural context.

2.3. Background

2.3.1. LSM in Perú and Colombia

In 2020, Perú ranked 13th among the world's gold-producing countries, and Colombia ranked 20th. At the Latin American level, Perú ranks third after Mexico and Brazil, and Colombia ranked number four (PlanetGOLD, 2021*)*. In 2021 the total production of gold from Perú was 127.3 tonnes and Colombia produced 61.0 tonnes of gold the same year

(Table 2.1). Both countries have huge potential to increase production, with a pipeline of projects enroute to production and with great exploration potential for new discoveries.

In Perú, the mining sector is responsible for 10% of gross domestic product (GDP), 60% of exports, 16% of private investment and 19% of taxes paid by companies, according to the National Society of Mining, Oil and Energy (IPE, 2018). According to the country's Ministry of Mines, during the first half of 2021, Newmont produced 4 tonnes of gold, becoming the largest producer in Perú, followed by Compañía Minera Poderosa with a production of 3.7 tonnes of gold. The third largest producer of gold in Perú that year was Aurífera Retamas with 3.69 tonnes the fourth was Compañía Minera Ares with a production of 2.7 tonnes and the fifth was Consorcio Minero Horizonte (CMH) with a production of 2.7 tonnes (MINEM, 2021). It is expected that, starting in 2023, gold production in Perú will increase with the entry of new projects such as the Santa María Expansion (Compañía Minera Poderosa) and the optimization of the Inmaculada (Compañía Minera Ares) and the San Gabriel mine (Compañía. de Minas Buenaventura) (MINEM, 2019).

Although in Colombia the precious metals mining industry is not well developed, the country is dependent on export earnings from extractive activities such as emeralds, coal, nickel, oil and gas. External mining sales have contributed one-fifth of the country's sales abroad: 20.8% in 2019. In Colombia, gold production accounts for 21.4% of mining sales (Martinez et al., 2021). At the end of 2020, the main LSM gold miners in Colombia were Gran Colombia Gold, Mineros S.A., Continental Gold (which started production from its Buriticá mine in the fourth quarter of 2020) and Antioquia Gold. In 2020, Gran Colombia Gold produced 6.11 tonnes of gold in its Segovia operations and 0.74 tonnes at its Marmato operation. Mineros S.A.'s total production was 2.4 tonnes from its alluvial operations in Bajo Cauca. Continental Gold's total production during 2020 (from October) was 2.2 tonnes from its Buriticá operation, and Antioquia Gold at its Cisneros operation produced 0.63 tonnes (ANM, 2021).

The Colombian Ministry of Mines and Energy foresees an increase in gold production in Colombia mainly due to the possible commencement of production at the Gramalote gold

project owned by AngloGold Ashanti and B2gold Corp, the Quebradona project owned 94.9% by AngloGold and the remaining by B2Gold Corp, and the Soto Norte project owned 80% by Mubadala investments and 20% by Aris Gold (ANM, 2022). In terms of exploration, there are various multinational senior and junior companies from South Africa, Canada, the United States, China and Australia, among others, that operate in Colombia.

The Fraser Institute's 2020 annual survey of mining and exploration companies assessed how mineral endowments and public policy factors such as taxation and regulatory uncertainty affect exploration investment. Their overall Investment Attractiveness Index was constructed by combining the Best Practices Mineral Potential index, which rates regions based on their geologic attractiveness, and the Policy Perception Index, a composite index that measures the effects of government policy on attitudes toward exploration investment. According to the 2020 Investment Attractiveness Index, Colombia is ranked 28 out of 77 jurisdictions and Perú is ranked 34 (Yunis and Aliakbari, 2021).

The positive perception published by the Fraser Institute for these countries in recent years, combined with their high mining potential (and in the case of Colombia, the minimal amount the country has been explored and the nominal level the LSM industry has developed there), sets up a scenario for increased investment and presence of LSM in these two countries, accompanied by a potentially consequential increase in the interactions between LSM and ASM.

2.3.2. ASM in Colombia

In Colombia, 44% of the 1,122 municipalities in the country have a tradition of artisanal (informal) mining (Serrano et al., 2015), and 23% of those municipalities have artisanal gold mining. Colombia is the largest producer of ASM gold in South America. In Colombia, the estimated gold production from ASM is between 41.4 tonnes and 50.8 tonnes per year (Seccatore et al., 2014). In contrast, the National Mining Agency of Colombia (ANM) reported that legal gold production in Colombia during the last five years averaged 48.1 tonnes (Figure 2.1).

In 2019, 42.96% of Colombia gold production originated in subsistence mining, including *barequeros* (gold panners) and *chatarreros* (ASM miners, usually women, who process tailings and/or waste rock) ASM producers. The Colombian Mining Association (ACM) estimates that only 30% of the gold produced in Colombia comes from legal (ASM and LSM) sources, (ACM, 2020). Legal ASM gold production in Colombia rises to 47% when production is added in from the beneficiaries of Special Reserve Areas (AREs) (Martinez et al, 2021). The previous numbers indicate that about 85% of the gold produced in Colombia is coming from legal and illegal ASM. In any case, ASM production is very difficult to quantify accurately due to the illegal status of this sector.

In Colombia, illegal mining is strongly fought by the authorities. Some ASM miners have achieved formalization and operate legally. However, other ASM communities work under the yoke of groups outside of the law. ASM miners are often extorted by illegal armed groups, who finance their criminal activities, mainly related to the production and export of illegal drugs, by extorting non-formalized (illegal) ASM miners or communities. Despite the low mechanization of ASM operations and the use of rudimentary techniques compared to those used by LSM, ASM mining in Colombia generates more gold production than LSM due to the high number of ASM miners involved, the high grade of the deposits they mine, and the immaturity of LSM development in the country.

Table 2.1 Comparative table of legal gold production in tonnes reported to authorities of Colombia and Perú since 2015. Modified from (World Gold Council, 2021). *Escobar et al., 2019 **ACM, 2020.

COUNTRY	YEAR							Illegal production %
	2015	2016	2017	2018	2019	2020	2021	
Peru	170.5	166.0	166.6	162.6	143.3	101.6	127.3	~20%*
Colombia	49.6	53.2	53.2	43.9	45.5	53.6	61.0	~70%**

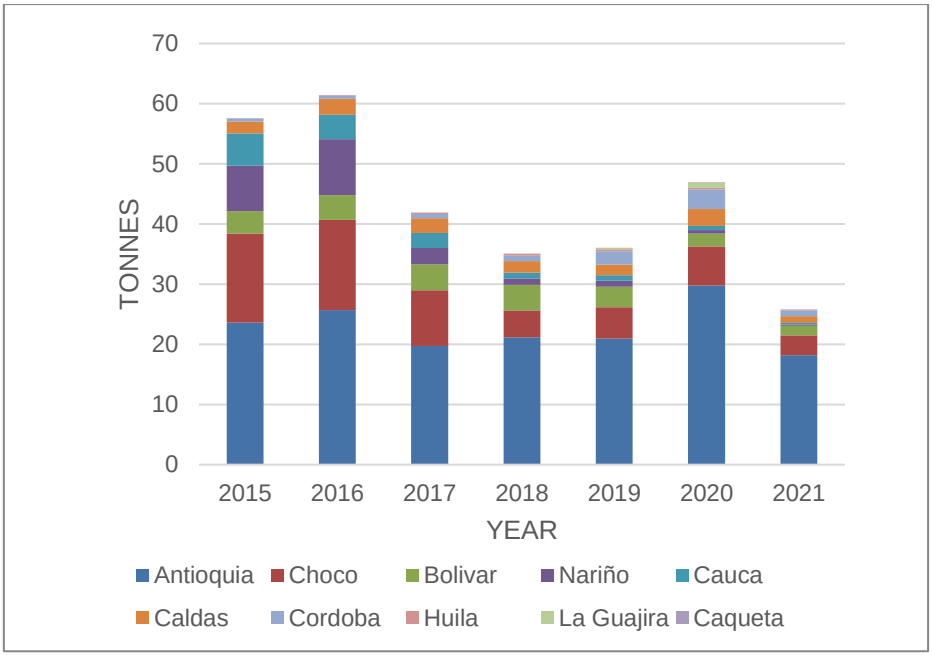

Figure 2.1 Gold production reported to the National Mining Agency (ANM) in Colombia. The information for 2021 corresponds to the first six months of the year. Adapted from National Mining Agency of Colombia, 1 Sept. 2021.

2.3.3. ASM in Perú

Artisanal and small-scale miners (ASMs) is relatively common in Perú, especially at or near LSM mines, with some estimates of ASM ore production reaching 15,000 tonnes per day (Inca one, 2021). Estimates on mining production and producers in Peru are still quite rough. The figures of informal and illegal miners that are handled are in a range of 100,000 to 500,000 ASM miners throughout the country (Nueva Sociedad, 2016; Cano and Kunz, 2022), and that one million people's livelihoods depend on ASGM (PlanetGold, 2021; Cano and Kunz, 2022).

Perú is the second largest producer of ASM gold in South America (Valdivia and Ugaya, 2011). According to the Peruvian Society of Environmental Law (SPDA), it is estimated that gold production in this sector represents approximately 20% of national production -- that is, around 40 tonnes per year (Escobar et al., 2019). Although ASM has a presence in 24 of the 25 departments of Perú, the greatest concentration of ASM is located in eight departments: La Libertad, Ancash, Arequipa, Ayacucho, Apurimac, Cuzco, Madre de Dios and Puno (Kuramoto, 2001).

2.3.4. Coexistence

The term *coexistence* came into general usage during the Cold War, when former Soviet premier Nikita Khrushchev promoted the concept of “peaceful coexistence” in 1953 to ease tensions between the Soviet Union and the United States, which had both considered the possibility of nuclear war (Darity, 2008). In this context, coexistence is the capacity to live in the same place at the same time, living peacefully with other nations, religions, etc., despite fundamental disagreements.

Coexistence occurs in situations where individuals and communities actively accept and embrace diversity (active coexistence), and also where individuals and communities merely tolerate other groups (passive coexistence). *Passive coexistence* occurs when relationships are characterized by unequal power relationships with little inter-group contact and little equity. In short, the principles of social justice are not apparent here. In *active coexistence*, relationships are characterized by a recognition and respect for diversity and an active embrace of differences, equal access to resources and opportunities, and equity in all aspects of life. This type of coexistence fosters peace and social cohesion based on justice, equality, inclusion, and equity (Nyawira, 2003).

The likelihood that mining expansions and new developments will result in further points of contact between the LSM and ASM sectors is high (Verbrugge, 2017; Holley et al., 2020; World Bank, 2009). Most industry analysts agree the global demand for minerals and metal resources will increase during the next decades (Valenta et al., 2019). To meet future demand, LSM companies will need to either expand existing operations or bring new projects into development. In recent decades (90s and 2000s) ASM has expanded due to economic and environmental pressures. Governments in developing countries commonly do not have the capacity to take charge and operate efficiently in remote areas of their jurisdictions, so they have delegated to the companies present in the territories the task of providing technical and financial support to the ASM communities settled in active areas of the LSM.

There is no known public policy that explicitly encourages ASM-LSM coexistence, but in both Perú and Colombia there exist policies to support formalization. Coexistence therefore depends on the ASM miners agreeing to work with the LSM companies. The Peruvian and Colombian governments do not incentivize coexistence for LSM companies, nor do they intervene to balance the power differences between LSM and ASM. The coexistence strategies already adopted in Latin America include formalization (e.g., Mineros S.A, Royal Road Minerals), formalization subcontracts (e.g., Continental Gold, Gramalote Ltd.), purchasing ore from ASM (e.g., HEMCO, Antioquia Gold, Grupo Minero Horizonte, Dynacor) and contract mining (e.g., Continental Gold, Gran Colombia Gold). Each of these strategies will be discussed in Section 4.

Regardless, the current extent of the LSM-ASM interface is undefined. Rates of public disclosure by companies are low. Other interested parties, including governments and finance institutions, have not prioritized the collection and release of information about interactions between the two sectors. Governments may be hesitant to divulge the extent of ASM workings due to the fear it will discourage investors from the LSM market. Likewise, large companies may not want to alarm investors who may view the presence of ASM as presenting an investment risk (Kemp and Owen, 2019).

2.4. Methods

This paper comprises a compilation and evaluation of LSM-ASM coexistence efforts in Latin America. The characteristics that will be evaluated are listed in Table 2.2. This information was gathered to identify social and technical characteristics common among successful and unsuccessful processes.

We conducted a bibliographic review of academic articles published in indexed journals, geodatabases, and other sources such as web pages, videography, press releases, news and other gray literature. We drew most of the geology, mining, social and legal information from technical reports (NI 43-101s) published by LSM companies. We collected information from geodatabases via the free, public GeoServices service using open

software Qgis (Version 3.1.2), an open-source application to view and edit geographic data. The software has the option to connect demographic, statistical and geological databases, among other geodatabases from different governmental offices in Colombia and Perú and overlay different layers of information. A list of the geodatabases accessed are summarized in Appendix B. For background information and context, we held seven semi-structured interviews with LSM representatives and artisanal and small-scale miners to gather additional details on the social, technical, legal and financial context of the coexistence cases[3]. These people were identified from the first author's contacts, as well as snowball sampling methods (Bernard 2017).

The data were tabulated and are presented in four different tables for each country, Perú, and Colombia: location (Table 2.3 for Colombia and 2.9 for Perú), geology (Table 2.4 for Colombia and 2.10 for Perú), mining (Table 2.5 for Colombia and 2.11 for Perú), social aspects including demographics (Table 2.6 for Colombia and 2.12 for Perú), and access to utilities and poverty levels (Table 2.7 for Colombia and 2.13 for Perú). The location table presents the information related to the geographic location of the site, its coordinates, and location information for the LSM companies involved. In the geology table, the lithology, alteration, mineralization and type of deposit are described. The mining table describes the type of mining performed at each site, and the processing capacity and the machinery used. The social table describes the demographic aspects of the community where the mining project is located. Lastly, the coexistence strategies table (Table 2.8 for Colombia and 2.14 for Perú), summarizes the aspects related to the strategy adopted during coexistence.

Data were analyzed using qualitative comparative analysis (QCA), an approach to examine the relationship of conditions to outcome. To display relations between conditions and indicate which descriptive accounts apply to specific cases, or group of cases, the

[3] This study took place using protocols that were approved by an Institutional Review Board for Human Subjects Research at the University of Colorado.

notions of logical necessity and sufficiency are key. A condition is necessary when the outcome is never present without it, and sufficiency does imply the presence of the condition will accompany the event´s occurrence (Halperin and Heath, 2020). Using this approach, we evaluated our database to determine which conditions are necessary and sufficient to enable coexistence.

Part of this research uses qualitative data as empirical material. In order to analyze the qualitative data collected, the qualitative comparative analysis (QCA) technique was chosen. QCA is a technique that consistently and systematically addresses the analytical stage of qualitative data. This technique uses boolean algebra as a formal tool to identify which of a series of factors (or independent variables) identified are associated with the presence of a given outcome. QCA is not intended to replace other forms of qualitative analysis applied in this study. As the name suggests, QCA assumes that both the research question and the analysis strategy have a comparative objective, in other words. This method seeks to establish links between the cases under study, without the need to carry out very deep descriptions of them. Charles Ragin formalized this methodological proposal in the late 1980s (Ragin, 1987). The application of QAC aims to overcome some of the difficulties that qualitative data analysis often faces: 1) the problem of generalization; 2) the descriptive and particularistic tendency in relation to the phenomenon studied and 3) the lack of systematicity and replicability in the treatment of empirical information (Rosati & Chazarreta, 2017). The analysis was carried out with the support of the free software fsQCA, following the instructions of its operating manual and following the step by step guide on how to employ the software and best practices published by Pappas and Woodside (2021).

2.5. ASM-LSM Coexistence, Strategies and Regulation

Here we briefly summarize the legal context of ASM-LSM coexistence in Colombia and Perú, so that the characteristics of the individual case studies are clear. Our data compilation shows that there are three main mechanisms for coexistence in these countries: ore purchasing, contract mining, and formalization.

2.5.1. Ore Purchasing

In the ore purchasing model, the LSM company processes the ASM's ore in the LSM's plant, (e.g., Chala Plants in Perú and Antioquia Gold in Colombia; Holley et al., 2022). The ore must be sampled and assayed, usually by the LSM company, so the ASM operator can be paid according to a previously negotiated contract.

This type of contract is ruled by the commercial law of each country, independent from the Mining law. The benefit offered to the ASM miner is that they receive income from their production faster, because they do not have to wait until the ore is processed, and they avoid the risk of gold transport and price negotiation. This contract also offers the potential benefit of higher profit, because when ASM miners process their ore in an ASM plant the recovery can be as low as 20% to 30%, whereas the purchase agreements offer payments based on 50% to 55% recovery. The LSM plant profits from this model because their recovery usually is more than 90%.

This coexistence model also helps reduce the use of mercury. When ASM miners sell their ore to the LSM company instead of processing the ore in the ASM plant, the LSM company process the ore with the highest industry standards avoiding the use of mercury. When ASM miners stop using mercury the process of formalization becomes easier for them; in Colombia, the use of mercury in mining is illegal and in Perú is highly regulated. The LSM companies involved in ore purchasing support the process of formalization of the ASM miners, because the legal origin of the gold is of fundamental importance to the company. Formalization of the ASM operation helps the LSM company maintain a legal supply chain and obtain permits to sell gold to the international market.

Table 2.2 Summary of Social and Technical Aspects Related to Coexistence of ASM and LSM

TECHNICAL ASPECTS		SOCIAL ASPECTS	
GEOLOGY	Geology is the main technical aspect in the coexistence or conflict between LSM and ASM. The nature of the deposits determines if an ASM operator can exploit the deposit for profit. Usually, ASM is interested in deposits of low tonnage and high grade, when the geology of the deposit does not fit this characteristic the ASM cannot exploit it at a profit, but LSM companies are able to exploit high tonnage and low-grade deposits. The interests of both LSM and ASM intersect when both characteristics are available at the same deposit. E.g., porphyry type deposit with associated oxidized enriched zone or telescoped systems with epithermal veins in porphyry deposits.	**ETHNICITY**	ASM Communities in Latin America can include members of various ethnic groups, including Indigenous people, Afro-American people, or the ethnic majority *Mestizo* population *(*mixed race descendants of both European settlers and Indigenous people).
EXPLORATION	Exploration of mineral deposits usually involves high tech instruments that usually are not affordable for ASM. The ASM does not spend much time nor money in exploration, instead, they prefer to advance their workings hoping to make a finding while exploiting. LSM usually spends significant amounts of money on exploration activities before any exploitation.	**DEMOGRAPHICS**	The demographics of ASM communities vary by site.
MINING METHODS	The mining methods used by ASM are usually panning, dredging, underground, and washing soil or saprolite. ASM uses limited machinery and processes small amounts of tonnage per day. It is not usual for ASM to mine hard rock with the open-pit method. LSM operators can employ open-pit mining, which is the most profitable option for shallow, low grade, bulk tonnage deposits. LSM also mines underground deposits with industrial methods, including machinery that helps to process large tonnages per day.	**CULTURAL / RELIGIOUS BELIEFS**	Some members of the ASM communities are marginalized due to cultural or religious beliefs. Identification and consideration of these characteristics could be decisive to the failure or success of the coexistence strategy.
MINE PLAN	ASM usually does not have a mine plan. Operators advance their workings on a day-by-day basis and do not have certainty about their future production. On the contrary, detailed knowledge allows LSM operators to have a detailed Mining Plan in the short, middle, and large term.	**ECONOMIC ACTIVITIES AND VOCATION OF THE TERRITORY**	Some ASM communities are in areas where the only feasible economic activity is the gold mining. Sometimes there are other options, or the territory has the capacity to support diverse economic activities and ASM communities share different activities. The ASM activity in many cases is a traditional livelihood, and in some areas of Colombia and Perú, is the only option to provide an income.
RECOVERY PROCESS	The recovery process in ASM workings is rudimentary, the amount of ore processed is low, the process takes a long time. Many operators in Latin America use mercury amalgamation for gold recovery, and the percentage of recovery is usually low. LSM does not use mercury the amount of ore processed per day is significantly higher and the recoveries of gold can be higher >80%	**UTILITIES, SANITARY SERVICES, HEALTH AND EDUCATION**	Many ASM Communities are in areas with poor infrastructure (lack of energy, water, sewer, internet), without access to good quality of health service or education.
ORE SALE AND PAYMENT PROCESS	ASM usually sell their product to local traders, at lower prices than the international markets, and they are at the mercy of local traders and sell at spot prices. They do not have future contracts, or any other kind of complicated commercial instruments as used by LSM companies to protect them against the fluctuation of the markets. LSM companies process the ore in their own facilities.	**TRANSPORTATION SYSTEM AND ACCESS ROADS**	Some ASM communities are in isolated areas where the contact with external people is limited, and this make it difficult for them to trust in people that come from outside of the community
LEGAL FRAMEWORK	The legal framework could facilitate the process of giving rights to the ASM like in Nicaragua, where LSM is obligated by law to allow 1% of the mining rights area for the ASM community to mine. In Colombia, legalized ASM is required to fulfill several conditions that can be impossible to accomplish.	**SOCIAL AND POLITICAL ORGANIZATIONS**	The form of social organization of the ASM communities and the Political, governmental, and nongovernmental organizations present in the territory are relevant to take into consideration to understand the power structures and focus the efforts, managing negative leaderships and taking advance of positive leaderships to build trust.
LOCATION	Location can be one of the most important factors in coexistence processes; for example, if the target commodities for ASM and LSM are located in the same part of the deposit or land claim.	**RELEVANT HISTORIC EVENTS / CONFLICTS**	In Latin America countries, especially in Colombia, people have suffered by long internal conflicts that had shape their behaviors. Understanding historic and current events is important to know how to communicate with these communities.

2.5.2. Contract Mining

In contract mining, the LSM company allocates an area or sector of its mine to be exploited by ASM (e.g., Mineros S.A. and GCG in Colombia; Holley et al., 2022). In this case, the ASM miners are not the owner of the mining rights, must follow the safety, environmental and labor rules of the LSM company and are responsible to fulfill the commitments under a commercial services contract agreed to with an LSM company. It is a private agreement of operation that ASM miners reach with LSM companies to operate portions of the LSM mine. The contract mining agreement must comply with the commercial law and with the labor law.

Usually, the ASM miners are organized either in a cooperative, company or commercial organization. The LSM company sign an agreement with the ASM association which in turn, distributes the payments to the ASM miners. This payment may be determined according to the work contributed by each ASM miner, or the payment may be distributed evenly among the ASM miners. The contract mining coexistence strategy helps to maintain the livelihood of the ASM miner, enabling them to continue working as miners with the potential to improve their salary and workplace safety conditions.

2.5.3. Formalization

This style of coexistence between LSM and ASM is based on both parties working within the law. Large Scale Mining (LSM) companies comply with the rules and laws and if the other party (ASM) is in an extralegal condition, the coexistence process becomes difficult. This legal status can be achieved by ASM miners in various ways, depending on the respective country's legal framework and on the will of the LSM company that owns the mining rights.

A series of legislative acts implemented since the 2000s in both Colombia and Perú have sought to offer tools to legalize or formalize ASM mining activity (Appendix A). However, in many cases, even when miners want to pursue formal licensing, they cannot afford the amount of the location license or they distrust the government's intentions and prefer to remain

anonymous and illegal (Siegel and Veiga, 2009). Conversely, the distinction between “informal” and “illegal” mining are diverse and sometimes confusing and unclear, even within state legislation (Echavarría, 2014; Vélez-Torres, 2014). One of the main barriers to formalization is caused by disputes between owners of mineral titles (individuals or mining companies) and artisanal miners. Artisanal miners are often the discoverers of the deposits and the first to work them, but they are typically deemed to be invading the land, as they do not possess the mineral titles and necessary permits to operate (Veiga and Marshall, 2019).

2.5.3.1. Formalization in Colombia

The legal framework in Colombia that was designed to promote the formalization and legalization of ASM miners has been modified several times since its inception with Law 1658 of 2013. In the past, this process had been very complicated. As explained by Veiga and Marshall, (2019), more than 380 different documents were required and, along with associated costs and high technical standards, the formalization of artisanal miners has been very difficult. However, recent legislation established different requirements for the granting of concession contracts to small-scale miners and beneficiaries of return areas for mining formalization through Decree No. 1378 of 2020. The most common forms of formalization established in Colombian legislation are “Return Areas for Formalization” and “Formalization subcontracts.”

Formalization subcontracts describe the process through which LSM companies can allocate an area for ASM but retain its mining title (Law 1658 of 2013, in Article 11). In terms of the coexistence between LSM and ASM, Formalization subcontracts is a tool for LSM companies to allow the exploitation of a granted mineral or another mineral to a group of ASM miners who are doing exploitation work within the same area of the LSM mining concession. In this case, the LSM company retains rights to the mining title and continues to be responsible for the activities that occur there. ASM miners must comply with health and safety regulations,

environmental regulations and others indicated by law, and the LSM company is obliged to verify this compliance.

Return areas for mining formalization are governed by the Decree 933 of 2013 Chapter IV. This process is carried out by the titleholder after a mediation process or by direct decision of the latter to contribute to the formalization of small mining. This return can be made to (i) formalize ASM miners who are carrying out exploitation activities around the mining title, or (ii) for those ASM miners who are carrying out exploitation tasks in an area other than that of the mining title and that require relocation.

Special Reserve Areas (AREs) The Mining Code Law No. 685 of 2001, modified by Article 147 of Decree 019 of 2012, indicates that the Mining Authority would delimit zones where there were ASM communities and where there were no current mining titles. In these areas the concession would only be granted to the same ASM communities that carried out traditional mining operations. According to the National Mining Agency of Colombia (ANM), there are 167 AREs declared in Colombia where LSM is excluded (ANM, 2018).

2.5.3.2. Formalization in Perú

According to Peruvian law under Legislative Decree 1105 of 2012, *illegal ASM mining* is a mining activity carried out by a person or group of people, using equipment and machinery that does not correspond to the characteristics of the ASM, or without complying with the requirements of the administrative, technical, social and environmental standards that govern such activities, or that are carried out in areas where their exercise is prohibited. Moreover, the *informal ASM miner* is the person or group of people who carries out this activity under similar conditions to the illegal ASM miner, but who does so in a non-prohibited area and who has started a formalization process.

Ordinary mining formalization process: On January 24, 2002, Law No. 27651: “Law of Formalization of small and artisanal mining” and its regulation approved by Supreme Decree

013-2002-EM, granting for the first time, a specific legal framework to mining on a small scale in Perú. This legal framework was created for a miner who wanted to start an ASM project. First, he/she ask for the required permits, then after the permits are obtained, the ASM miner receives the authorization and after that he/she start working.

Comprehensive Mining Formalization Process: In 2012, a normative package (legislative decrees from 1099 to 1107) was enacted to tackle illegal mining and formalize ASM mining that took place informally.

The exploitation agreement, or *contract mining* agreement, between the titleholder (usually an LSM company) and the ASM miner constitutes an alternative requirement to the possession of mining rights to prove the condition of the ASM miner. Through this type of agreement, the holder of a mining right authorizes ASM miners to develop ASM activities to extract minerals in a part or in the total area of their mining concession, in exchange for a consideration. This requirement is the most problematic, and it is very difficult for ASM miners to secure such a contract (Cano & Kunz, 2022). The holders do not want to sign an exploitation contract with the miners, even though the miners pay a royalty to the holders. There is also no one who compels the owner to sign the contract, since the Ministry of Energy and Mines is only one more facilitator and does not have the power to sign the contract. And without compliance with this requirement, formalization is impossible (Responsible Mines, 2015). Few concession holders have supported the formalization process of artisanal miners operating in their concessions. On the contrary, those who have done so have encountered more challenges than solutions of benefits later (Cano, 2020; MINAM, 2017; MINEM, 2019).

2.6. Coexistence Cases in Colombia

This study identified thirteen cases of coexistence in Colombia (Table 2.3), all in gold except for one with copper as the main commodity. Four of the cases are in operational status: three of these are underground gold mining, and one is alluvial gold mining. Two of the projects

are in the feasibility stage and six are in the exploration stage. Most of the cases are in the Antioquia department, followed by three cases in Nariño department and one each in Caldas, Santander and Córdoba (Figure 2.2). The projects are located in different geologic environments; four projects are located in the Middle Cauca Belt, the most prolific gold belt in Colombia, two of them are in the Antioquia Batholith, one is in the Santander Plutonic Group, and four of them are not located in any scientifically defined metallogenic belt. In the following sections, we provide a brief narrative to contextualize each case, with the majority of the descriptive data presented in the tables.

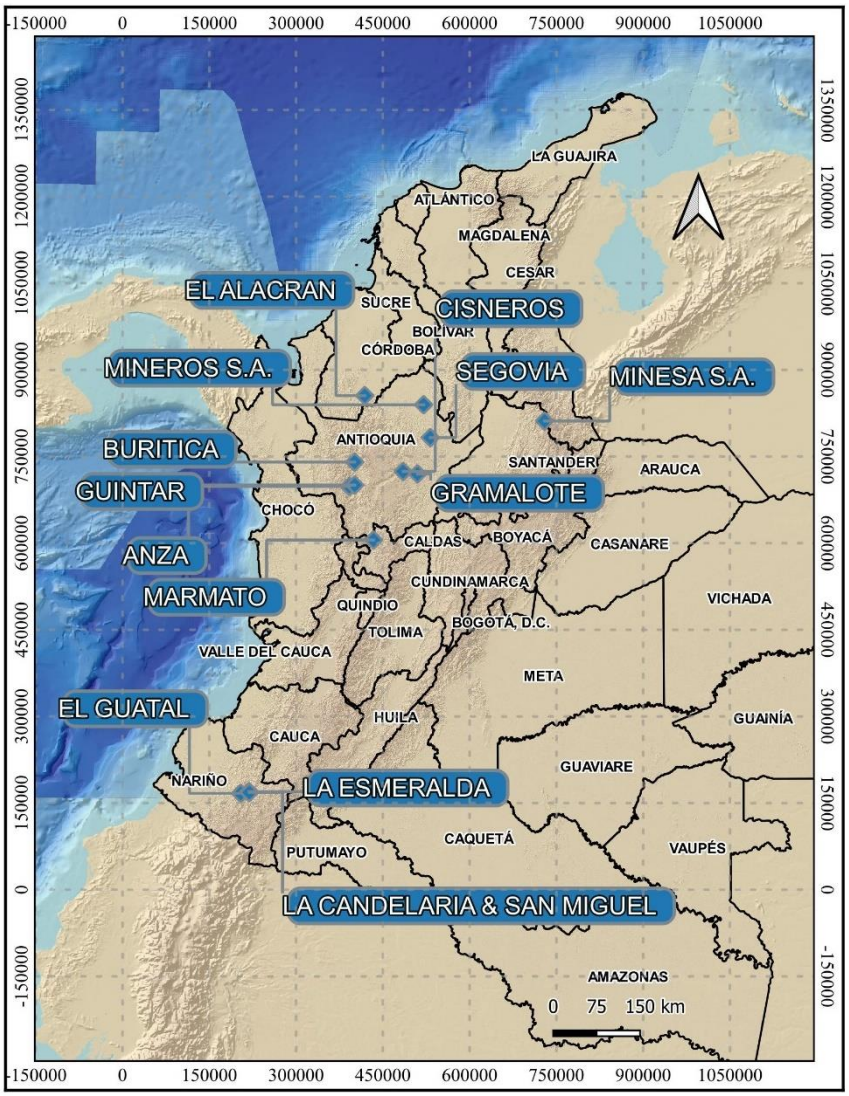

Figure 2.2 Location of coexistence cases found in Colombia. Coordinate system UTM 18N, WGS 84. This figure does not appear in the original paper.

2.6.1. Exploration Stage.

Güintar - Royal Road Minerals. The Güintar exploration project is in the municipality of Anza in the department of Antioquia. The project is property of Royal Road Minerals (RRM), a junior exploration company whose main shareholder, with a 18% stake, is the Canadian LSM company Agnico Eagle Mines Limited. Royal Road Minerals is developing its Güintar project under a joint venture (JV) agreement with Mineros S.A. The company recognizes the presence of ASM communities in its mining titles but has not advanced in any kind of negotiations.

Anza - OroSur Mining. The *Anza* exploration project is also in the municipality of Anzá in the department of Antioquia, contiguous to the Güintar project. Anza project is a property of Oro Sur Mining, a junior exploration company that is listed on the Toronto Stock Exchange. The project is operated under a JV agreement with Agnico Eagle Mines Limited and Newmont. The company recognizes the presence of ASM communities in its mining titles but has not advanced into any negotiations.

Nariño - Royal Road Minerals. Royal Road Minerals (RRM) has established a contractual structure for formalization initiatives under the formalization subcontract legal framework, which benefits both the company and the local miners. In exchange for handing over part of its titles and assisting local miners with the formalization process, RRM is paid a quarterly royalty equivalent to 3% of the doré extracted from the newly formalized mining operations and has the exclusive right to carry out all exploration activities on and around these operations. If, through the exploration process, the company discovers a project that meets its size criteria, it may earn back in up to 70% of the formalized title area by achieving certain exploration goals (Royal Road Minerals, 2019).

El Alacrán - Cordoba Minerals. The El Alacrán copper deposit has more than 700 ASM miners working in gold mining at the time of this writing. Most of these miners come from the municipality of Zaragoza, Antioquia, who discovered the mine in the early 1980s. In 1995, the El

Alacrán Association of Artisanal Miners (ASOMINAL) was established; however, some of its members had previously begun the formalization processes in 1987. The formalization was attempted in 1997, 2002 and 2008. In 2007, the national government responded negatively to the 2002 request (El Heraldo, 2021). Today, the area of the El Alacrán mine is under contract and granted to Cordoba Minerals, a Canadian junior exploration company.

The ASM miners of El Alacrán and the junior exploration company Cordoba Minerals have been in conflict since the arrival of the company in 2015. In this period, miners have allowed the exploration work, although they manifest their status as traditional miners and claim rights to the mineral deposit. Recently, the company changed its approach and appealed to the administrative protection that led to the military and police operation *Aquiles* in March 2021, during which they seized equipment and closed 16 mining operations (El Heraldo, 2021; Defensoría del Pueblo, 2021). The ASM miners feel stigmatized because they are related to armed groups that also operate in the region, but demand the company and authorities recognize their status as traditional miners, claiming they are not related to any armed group (El Heraldo, 2021; Valdivieso, 2020).

Gramalote Ltd – JV B2Gold and AngloGold Ashanti. Gramalote started a pilot formalization process in San Roque in 2018 with 18 traditional informal miners from the La María rural community. In July of that year, the company, with the support of the Secretariat of Mines of the provincial government of Antioquia, signed an act of mediation with the ASM miners through which a formalization subcontract would be granted; 16 mining production units were legalized in a 15-hectare (ha) area. Gramalote has since continued its support for the formalization process being rolled out by the San Roque Municipal Administration, signing seven new subcontracts with 40 miners in Cristales, Manizales and El Diluvio (AngloGold Ashanti, 2019; Garagan et al., 2019).

Soto Norte - Minesa S.A. With its mining title located in the municipality of California in the department of Santander, the Soto Norte gold deposit is owned by the Mubadala Group. In

March 2022 Aris Gold became the operator of the project by acquiring 20% interest of the project with the option to acquire a further 30% interest (Aris Gold, 2022). The Soto Norte project is in feasibility stage and expects to start production in the short term. Minesa S.A. recently signed a formalization subcontract with 160 ASM miners.

The ASM miners that have been seeking formalization in Soto Norte for more than 30 years support Minesa S.A. (El Tiempo, 2020). Given the slowness of the formalization processes with the government, the ASM miners organized and approached the company to propose formalization options under the terms of the formalization subcontract. The first association, called *Calimineros,* has 160 associated ASM miners. They have already achieved the agreement mentioned above.

The second association, called *Asopromisoto*, includes 56 members and is in the process of negotiation with the company at the time of this writing. Only one association of ASM miners, *Artemineros*, achieved its formalization under the Special Reserve Area (ARE) and the government bestowed its title. The miners feel the government's policies aimed at combating illegal mining do not differentiate informal artisanal mining, and is condemning them to lose their livelihood, so they see in the company the support they need to continue with their work.

2.6.2. Production Stage

Marmato - Aris Gold. Aris Gold operates the Marmato mine in Colombia, where a modernization and expansion program is under way. Aris Gold is performing optimization of the Marmato Upper mine, which is in production, and is advancing the construction of the Marmato Lower mine project in Colombia. In April 2021, Aris Gold awarded the engineering, procurement and construction management (EPCM) contract to Wood PLC. Possibilities for coexistence between LSM and ASM arise because the Marmato Deep Zone is amenable to mining by a large-scale underground operation. The ore differs in morphology and composition, requiring economies of scale that would not be possible for ASM. If underground development is pursued

by a large-scale company such as Gran Colombia Gold (GCM), and if coexistence is prioritized in the large-scale mine's design and operation, small-scale mining could feasibly continue at shallower depths in the Zona Alta concession (Holley et al., 2020).

Buriticá Mine - Zijin Mining Group. The Buriticá mine is located in the municipality of Buriticá in the department of Antioquia and is currently owned by the Chinese company Zijin Mining Group. Zijin acquired the Buriticá mine in 2019 through a USD$ 1 billion cash payment to Canadian junior Continental Gold when it purchased 100% of its shares. The Buriticá mine is an underground operation with a 3,000-tpd beneficiation plant.

During the early exploration period after the discovery of the Buriticá gold deposit, there was an ASM rush into project area. This situation escalated to a conflict between the LSM company (Continental Gold) and the ASM community. After a military intervention by the Colombian government, the company made several subcontracts of formalization and achieved four agreements for the purchase of ore from formalized ASM associations and one operating contract with a group ASM miners.

From the perspective of the ASM miners, the terms of the contracts offered by the company ignored their interests. According to the miners, the company had a dominant role as titleholder, which is why it set the hiring rules it wanted and without any state regulation because the state was "absent" (Restrepo Parra, 2019). The ASMs expressed dissatisfaction that the state handed over titles to the multinational company; however, the objective of their position was not to reverse the situation, but to get the company to involve them in its business (Restrepo and Martinez, 2019).

Segovia - Gran Colombia Gold. Gran Colombia Gold holds titles for the exploitation of gold in an area of approximately 9,000 hectares in the mining district of Segovia-Remedios. These mines have been in continuous operation for over 150 years and have produced an estimated 5 million ounces. Operations include the El Silencio, Providencia and Sandra K underground mines in the municipality of Segovia, and the Carla underground mine in the

municipality of Remedios (SRK, 2020). Gran Colombia Gold's business model incorporates local informal miners through its artisanal mining model, which historically has represented 10-15% of Segovia's gold production. As of early 2021, the company has agreements with 56 third-party miner groups with a total of 2,500 miners exploiting portions of the veins under contract in designated areas within its titles.

Table 2.3 Location of the coexistence cases in Colombia.

LOCATION AND GENERAL INFORMATION								
Mine Site	**Country**	**Department**	**MUNICIPALITY / DISTRICT**			**PROJECT / OPERATION**		
			Direct Influence	**Regional Influence**	**Regional Influence**	**Company**	**Stage**	**Local Name**
Buriticá	Colombia	Antioquia	Buriticá	Santafé De Antioquia	Giraldo	Zijin Mining Group	Operation	Buriticá Mine
Segovia			Segovia	Remedios	N/A	Gran Colombia Gold Ltd	Operation	Segovia
Gramalote			San Roque	Santo Domingo	Cisneros	Gramalote Ltd (AngloGold Ashanti & B2Gold)	Feasibility	Gramalote
Cisneros			Cisneros	San Roque	Santo Domingo	Antioquia Gold	Operation	Cisneros
Mineros S.A.			El Bagre	Nechí	N/A	Mineros S.A.	Operation	El Bagre
Guintar			Anza	N/A	N/A	Royal Road Minerals	Exploration	Guintar
Anza			Anza	Betulia	Caicedo	Newmont - Agnico Eagle + Anza Mining JV	Exploration	Anza
Marmato		Caldas	Marmato	Riosucio	N/A	Gran Colombia Gold Ltd	Feasibility / Construction	Marmato
El Guatal		Nariño	La Llanada	Sotomayor	N/A	Royal Road Minerals	Exploration	El Guatal Mine
La Esmeralda			Sotomayor	La Llanada	N/A	Royal Road Minerals	Exploration	La Esmeralda Mine
La Candelaria & San Miguel			Sotomayor	La Llanada	N/A	Royal Road Minerals	Exploration	La Candelaria and San Miguel Mines
El Alacrán		Cordoba	Puerto Libertador	Montelíbano	N/A	Cordoba Minerals	Exploration	El Alacrán
Minesa S.A.		Santander	Vetas	California	Bucaramanga	Minesa S.A.	Feasibility	Sotonorte

In the territory of Segovia and Remedios, community organizations have emerged, such as the Mining Board of Segovia and Remedios, to defend ASM mining in the region, as well as the Humanitarian Action Corporation for Coexistence and Peace of Northeast Antioquia (CAHUCOPANA).

Table 2.4 Geologic characteristics of coexistence cases in Colombia.

GEOLOGIC CHARACTERISTICS						
PROJECT / OPERATION			GEOLOGY		MINERALIZATION	
Mine Site	**Stage Of the Project**	**Main Commodity**	**Metallogenic Belt**	**Host Rock**	**Mineralization Style**	**Deposit Type**
Buriticá	Operation	Gold	Mid Cauca Belt	Igneous Intrusive	Veins	LS-IS Epithermal gold
Segovia	Operation	Gold	Segovia Batholith	Igneous Intrusive	Veins	Oxidized Pluton-Related Gold Deposits
Gramalote	Feasibility	Gold	Antioquia Batholith	Igneous Intrusive	Stockwork	Structurally Controlled Intrusive-Related Gold Deposit
Cisneros	Operation	Gold	Antioquia Batholith	Igneous Intrusive	Veins and veinlets	Mesothermal Lode-Gold Deposit
Mineros S.A.	Operation	Gold	N/A	Sedimentary	Placer	Placer
Guintar	Greenfields	Gold	Mid Cauca Belt	Igneous Intrusive	Veins and veinlets	Porphyry
Marmato	Operation	Gold	Mid Cauca Belt	Igneous Intrusive	Veins and veinlets	LS-IS Epithermal Gold
Anza	Greenfields	Gold	Mid Cauca Belt¿?	Igneous Intrusive	Stratabound	VMS
El Guatal	Greenfields	Gold	N/A	Igneous Intrusive	Veins and stockworks	Intrusion-Related Gold Deposit
La Esmeralda	Greenfields	Gold	N/A	Igneous Intrusive	Veins and stockworks	Intrusion-Related Gold Deposit
La Candelaria & San Miguel	Greenfields	Gold	N/A	Igneous Intrusive	Veins and stockworks	Intrusion-Related Gold Deposit
El Alacrán	Pre-feasibility	Copper	N/A	Volcaniclastic Rocks	Stratabound	VMS
Minesa S.A.	Feasibility	Gold	Santander Plutonic Group	Metamorphic Dynamic	Vein	Epithermal HS

Cisneros - Antioquia Gold. The Cisneros gold mine from Antioquia Gold is in the municipality of Cisneros, Antioquia. Antioquia Gold is listed on the Toronto Stock Exchange. Its largest shareholders are Consorcio Minero Horizonte, and its main shareholder capital is of Peruvian origin. This mine is operational, with a 600-tpd capacity plant that is partially fed with ore purchased from ASM miners and blended with Cisneros mine ore. In this case, is difficult to obtain the perspective of the ASM miners since the company purchases ore from non-disclosed sources (Antioquia Gold Inc., 2019*)*.

El Bagre - Mineros S.A. Mineros S.A. is a Colombian company listed on the Colombian Stock Exchange and, more recently, the Toronto Stock Exchange. It operates the Nechí Alluvial gold asset in the Bajo Cauca region of Antioquia and has other investments in Nicaragua, Argentina and Chile.

In Bajo Cauca in Colombia, Mineros S.A. has operating contracts with ASM miners that operate small dredges and produce gold for the company. Since 2012, the government of Antioquia implemented the “Laboratory of Legalization and Mining Formalization of Bajo Cauca Antioqueño as an effort to achieve the identification and legalization of ASM mining units present in region and department of Antioquia. From that, 155 ASM mining units were identified. Sixty mining units were identified in the municipalities of El Bagre, Nechí and Zaragoza, where Mineros S.A. holds production operations, and 12 ASM mining units overlapped with the company’s titles. However, these 12 ASM mining units were removed from the laboratory because Mineros S.A did not express its intention to make formalization subcontracts (Garcés, 2015). Instead of the formalization subcontracts, Mineros proceeded with operating contracts with these mining units; they remain in force as of the date of this writing and have managed to remain sustainable. Meanwhile, none of the remaining ASM mining units identified by the Laboratory were legalized – that is, to date, none of the participants of the Laboratory are working under the protection of a mining title (Garcés, 2015).

Table 2.5 Mining characteristics of coexistence cases in Colombia.

MINING																
Mine Site	ASM Starting Date of Operation	LSM Starting Date of Operation	Mining Method			ROM Tpd	Estimated Life of Mine (LOM)	Recovery Average %	Cut-Off Grade	Total Proven +Probable Reserve	Resource				Plant Capacity Tpd	Recovery Method
			ASM Mine Type	LSM Mine Type	Mining Method						Measured	Indicated	Inferred	Average Grade		
Buriticá	2000s	Q3 2020	Under-ground	Underground	Long hole stoping	1,000	14 years	93.70%	3 Au g/t	3,710,000 Au Oz	0.54 Au Moz	12.40 Au Moz	4.50 Au Moz	14 Au g/t	3,000	Fine grind > Cyanide leach > CIP > Electrowinning >Onsite refining to Doré bars.
Segovia	Pre-Columbine	1910-1977 2011	Under-ground	Underground	Room and pillar	1,270	5.3 years	90.50%	3.25 - 4.24 Au g/t	670,356 Au Oz	0.150 Au Moz	1.205 Au Moz	1.742 Au Moz	11.93 Au g/t	1,500	Crushing, grinding, gravity concentration, gold flotation, cyanidation of the flotation concentrate, Merrill-Crowe precipitation, and refining.
Marmato	Pre-Columbine		Under-ground	Underground	Cut and fill	1,200	N/A	86.00%	2.7 Au g/t	2,021,000 Au Oz	0.387 Au Moz	3.699 Au Moz	2.172 Au Moz	3.76 Au g/t	1,500	crushing, grinding, gravity concentration, gold flotation, cyanidation of the flotation concentrate, Merrill-Crowe precipitation and refining of the precipitate and gravity concentrate to produce a final gold/silver doré product
Gramalote	Colonial	N/A	Open pit	Open pit	Truck & shovel / loader	30,000	11 years	94.30%	0.15 - 0.20 Au g/t	-	-	2.14 Au Moz	2.83 Au Moz	0.85 Au g/t	30,000	primary crushing, two-stage grinding with flash flotation, conventional froth flotation, flotation tailings pumping, concentrate regrinding, concentrate leach, counter-current decant (CCD) thickening, carbon-in-pulp (CIP), carbon desorption, gold recovery by zinc precipitation (Merrill Crowe), and cyanide destruction of CIP tailings slurry before the tailings are pumped to the tailings management facility (TMF).
Cisneros	N/A	Q1 2019	N/a	Underground	Cut and fill	N/A	5 years	93.8%	1.66 - 2.95 Au g/t	-	0.0489 Au Moz	0.077 Au Moz	0.1094 Au Moz	5.67 Au g/t	600	crushing (primary and secondary stages) and milling and a wet plant comprising gravity concentration, flotation and filtration of concentrates where gold is recovered
Mineros S.A.	Colonial	1908	Placer	Placer	Dredging		12.7 years	80.00%	34 - 85 mg/m3	1,316,000 Au Oz	1.175 Au Moz	0.036 Au Moz	-	109 mg/m3		Overburden removal and deposit with suction dredges or Brazilian dredges. Gravel removal with dredges. Size classification and gravimetric gold extraction. Final metallurgical processing of doré at the metallurgical plant and laboratory at Mineros' El Bagre complex.
Guintar		N/A	Underground	Project in greenfields exploration stage, no mining information.												
El Guatal		N/A	Underground	Project in greenfields exploration stage, no mining information.												
La Esmeralda		N/A	Underground	Project in greenfields exploration stage, no mining information.												
Candelaria & San M		N/A	Underground	Project in greenfields exploration stage, no mining information.												
El Alacrán	1970s	N/A	Underground	Open pit	Truck & shovel / loader	8,000	17 years	72.5%-77.5%	0.22%CuEq	-	-	0.94	0.03	0.23	8,000	The processing plant will consist of the following unit operations: • primary jaw crushing; • crushed ore handling; • SAG milling; • ball mill secondary grinding in a closed circuit; • rougher flotation unit cells fed from ball mill hydrocyclone overflow with subsequent cleaning and scavenger stages; • concentrate thickening and dewatering (Cu-Au-Ag concentrates); • final tailings thickening and disposal into a WMF; • fresh and reclaim water supply; and • reagent preparation and distribution. Not included in the PEA processing plant, but for consideration in future technical studies, is the addition of a gravity circuit for the recovery of up to 50% of the Au and Ag and the onsite production of doré bars
Anza		N/A	Underground	Project in greenfields exploration stage, no mining information.												
Minesa S.A.	Colonial	N/A	Underground	Underground	Modified Avoca	6000	14	89% - 95%	NSR Cut-off $47/t	5.53 Au Oz	-	9.81 Au Moz	4.2 Au Moz	6.35	6000	Crushing in two underground crushers, grinding, Flotation, dewatering, concentrate transport.

Table 2.6 Demographics of the communities in which the Colombian coexistence cases are located.

DEMOGRAPHICS OF THE COMMUNITIES								
Mine Site	**Municipality**	**Population Municipality of Direct Influence**				**Ethnicity of the Community %**		
		Total	**% Male**	**% Female**	**%Working Age Population**	**Indigenous**	**African-Descendant**	**No Ethnic Group**
Buriticá	Buriticá	7409	52.3	47.7	61.8	0.0	0.36	98.4
Segovia	Segovia	33690	50	50	64.8	1.7	2.7	95.6
Marmato	Marmato	8485	51.1	48.9	65.2	24.83	11.15	64.02
Gramalote	San Roque	17792	50.6	49.4	64.1	0.01	0.31	99.68
Cisneros	Cisneros	8910	47.9	52.1	61.3	0.07	1.23	98.7
Mineros S.A.	El Bagre	47642	50.1	49.9	59.2	1.85	4.64	93.51
Guintar	Anza	6388	51.7	48.3	63.3	0.03	0.34	99.63
El Guatal	La Llanada	5321	49.4	50.6	64.6	0.45	2.07	97.48
La Esmeralda	Sotomayor	8703	50.4	49.6	63.1	0.11	1.92	97.97
La Candelaria & San Miguel	Sotomayor	8703	50.4	49.6	63.1	0.11	1.92	97.97
El Alacrán	Puerto Libertador	35362	51.8	48.2	57.5	16.44	1.5	82.06
Anza	Anza	6388	51.7	48.3	63.3	0.03	0.34	99.63
Minesa S.A	Vetas	1762	51.1	48.9	64.6	0.06	0	99.44

Table 2.7 Access to utilities and public services where the Colombian coexistence cases are located.

ACCESS TO UTILITILITIES AND PUBLIC SERVICES									
Mine Site	**Municipality**	**Basic Services**						**Multilevel Poverty Index (MPI)**	**Health Service Coverage**
		Energy	**Water**	**Sewer**	**Gas**	**Waste**	**Internet**		
Buriticá	Buriticá	98.40	84.20	46.90	0.90	38.70	9.60	51.3	100
Segovia	Segovia	94.40	75.00	54.50	12.30	86.40	29.10	42.8	75
Marmato	Marmato	96.80	71.90	54.80	3.10	49.80	12.00	37.6	87
Gramalote	San Roque	97.7	72.1	53.7	38.4	65	14.3	40.8	100
Cisneros	Cisneros	99.50	66.30	64.70	56.60	85.20	27.00	28.8	100
Mineros S.A.	El Bagre	95.3	71.6	48.5	27.4	70.7	15.1	52.7	N/A
Guintar	Anza	96.4	74.5	34.4	0.6	34.8	3.3	47.1	N/A
El Guatal	La Llanada	97	73.2	56.6	0.3	53.9	2.5	33.6	N/A
La Esmeralda	Sotomayor	96.5	84.5	52.2	0.8	45.6	2.7	44.9	N/A
La Candelaria & San Miguel	Sotomayor	96.5	84.5	52.2	0.8	45.6	2.7	44.9	N/A
El Alacrán	Puerto Libertador	90.9	48	18.1	12.4	28.8	3.4	58.9	N/A
Anza	Anza	96.4	74.5	34.4	0.6	34.8	3.3	47.1	N/A
Minesa S.A	Vetas	99.1	63.6	37.3	41.3	62.2	12.3	31.9	N/A

Table 2.8 Colombia coexistence strategies summary.

COEXISTENCE ESTRATEGIES SUMMARY					
Mine Site	**Coexistence**	**strategy 2**	**Strategy 2**	**LSM project Stage**	**ASM Form of organization**
Buriticá	Yes	Formalization sub-contracts	Contract mining	Production	ASM companies
Segovia	Yes	Contract Mining	N/A	Production	Community associations
Gramalote	Yes	Formalization sub-contracts	N/A	Feasibility	ASM companies
Cisneros	Yes	Ore Purchase	N/A	Production	ASM companies
Mineros S.A.	Yes	Contract Mining	N/A	Production	ASM Companies
Guintar	No	N/A	N/A	Exploration	N/A
Anza	No	N/A	N/A	Exploration	N/A
Marmato	No	N/A	N/A	Construction	Community associations
El Guatal	Yes	Formalization Sub-contract	N/A	Exploration	Community associations
La Esmeralda	Yes	Formalization Sub-contract	N/A	Exploration	Community associations
La Candelaria & San Miguel	Yes	Formalization Sub-contract	N/A	Exploration	Community associations
El Alacrán	No	N/A	N/A	Pre-Feasibility	Community Associations
Minesa S.A.	Yes	Formalization Sub-contracts	N/A	Feasibility	Community associations

2.7. Coexistence Cases in Perú

We identified seventeen cases of coexistence in Perú (Figure 2.3), six with copper as the main commodity and eleven in gold (Table 2.7-1). Ten cases are in in production stage: Three of these are open-pit LSM operations, two are underground LSM gold mining, and five of the cases are processing plants that purchase and process ore from ASM miners. Two of the projects are in the feasibility stage and three are in early stages of exploration and pre-feasibility stage.

2.7.1. Exploration Stage

Ollachea - Minera IRL. Minera IRL's Ollachea project is in the Puno district, about 250 kilometers north of Lake Titicaca on the eastern escarpment of the Andes. In September 2013, the Peruvians government approved the project's environmental impact study and permits for

construction. The company also signed an unprecedented 30-year surface rights agreement in 2012 and, as part of that long-term agreement, the community of Ollachea will earn a 5% participation interest in the mine once it begins commercial production (Minera IRL, 2020). Geologically, Ollachea is an orogenic gold system. The local geological setting is bedded slates and sandstones that are structurally deformed and in close proximity to intrusive bodies. Gold mineralization occurs within a well-defined shear zone and is contained within seven discrete west-striking, north-dipping structures.

Figure 2.3 Location of coexistence cases found in Perú. Coordinate system UTM 17S, WGS 84. This figure does not appear in the original paper.

Pinaya - Kayzen Discovery. The Pinaya project covers 100.65 square kilometers and includes more than 10 kilometers of strike length within the Andahuaylas-Yauri Porphyry Belt in southeastern Perú. This Eocene-Oligocene Age belt hosts numerous productive and world-class porphyry and skarn systems, including Las Bambas, Tintaya, Constancia, Haquira and Antapaccay (Kaizen, 2016). The project's estimated measured and indicated resource totals 41.7 Mt grading 0.324% copper and 0.489 g/t gold or contained metal of 298 million lbs. of copper and 696,000 ounces of gold. The project also has an Inferred resource of 40.2 million tonnes grading 0.36% copper and 0.30 g/t gold, containing 145,000 tonnes of copper and 388,000 oz. of gold (Cole et al., 2016).

Artisanal and small-scale mining appears to have started in the 1960s with a drift that has since been cleaned and sampled for a distance of over 200 m. More recently (probably since about 1994), artisan miners excavated the present-day historical workings. Both the drift and historical open cut are located on the Antaña concession. Elsewhere, there are numerous small pits and excavations where artisan miners exposed copper oxides, specular hematite, barite, pyrite and chalcopyrite associated with quartz veins, shears and/or strongly altered zones (McCrea, 2006).

Prior to Kaizen's involvement with the project, there was a long ongoing issue with the encroachment of artisanal miners on to the property, mainly due to the lack of a firm fulltime company presence due to hiatuses between work programs (Cole et al., 2016).

Tambo Grande – Manhattan Minerals. The Tambogrande project is in the department of Piura province of the Piura region in northwestern Perú. Tambogrande achieved prominence for successful community opposition of Manhattan Minerals' mining development in the area. Manhattan Minerals, a Canadian junior exploration company, obtained mineral rights of the Tambogrande project in 1996. The LSM company discovered a large copper and gold deposit under the town of Tambogrande (Alvarado Merino, 2010).

The local Church and other social organizations such as the Confederación Nacional Coordinadora de Comunidades Afectadas por la Minería (CONACAMI), joined the Frente de Defensa de Tambogrande y el Valle de San Lorenzo led by engineer Godofredo Garcia Baca in a common front against mining. (Portugal Mendoza, 2005). Mr. Garcia Baca was shot dead by an unknown gunman in his farm in Somate Bajo, Piura, on 31st of March 2001 (Muradian, et al., 2003).

The Tambo Grande deposits are within the upper 3% of all VMS deposits of their type globally (Franklin et al., 2005) The deposits are the largest Mesozoic VMS deposits in Perú and are the most positive economic potential group of VMS deposits in South America. The Tambo Grande VMS group comprises three world class deposits TG1, TG3 and B5; the most important are TG1 with 109Mt, grading 1.6% copper Cu, 1.0% Zn, 0.5 g/t Au and 22g/t Ag, and TG 3 with 82 Mt grading 1.0% Cu, 1.4% Zn, 0.8 g/t Au and 25 g/t Ag. The TG1 deposit also has an oxide zone of 16.7 Mt grading 3.5 g/t Au and 64 g/t Ag (Winter, 2008).

Los Chancas - Southern Perú Copper. The Los Chancas project is a large porphyry copper–molybdenum deposit. in the Apurímac region of southern Perú. Los Chancas have an estimated inferred mineral resource of 1,433 million tonnes of ore grading 0.45% copper, and an estimated indicated mineral resource of 150 million tonnes of ore grading 0.50% copper. The company has tried to expel ASM miners from the area, and the Apurimac environmental prosecutor has dismissed the demands because the ASM miners are in the REINFO formalization database (Wiener, 2019; Cano, 2020). The ASM miners in this area are not full-time miners; they carry out ASM gold mining when gold prices are favorable. The ASM miners have not attempted to approach the company to discuss coexistence options (Cano, 2020).

Rio Blanco S.A. – Zijin Mining Group Co. 51% Ownership. The Rio Blanco copper and molybdenum porphyry Cu-Mo (Chen et al., 2022) mine is located in Henry's Hill in the El Carmen de la Frontera district, Huancabamba province, Piura region. It is among the ten largest undeveloped copper mines in the world with estimated reserves and resources of 7.11 million

tonnes of ore grading 0.57% Cu. It is estimated it will have an annual production of 200,000 tons of fine copper and 3,000 tons of molybdenum concentrates.

At present, the owner of the project is a consortium led by Chinese miner Zijing Mining Group Co. with Chinese copper miner Tongling and Xiamen C&D, a trading and real state conglomerate. The consortium known as Xiamen Zijin Tongguan Investment Development Co. has not signed operating agreements with the informal miners for its concessions. ASM miners at the project's operation area, together with the rest of the population in the provinces of Huancabamba and Ayabaca, have directly opposed the mining activity of the company.

The social organization in the territory where the project is intended to be developed has played an important role in the development of the conflict around the Rio Blanco mining project. There are two very old communities, Segunda and Cajas, and on the other hand Yantas, which has its origins in colonial times, and which were recognized as peasant communities in 1945 and 1983, respectively. They were very organized, to the point of establishing actions of punishment to the *comuneros* who ventured to work for the company. To date, the project is halted, In the meantime, the company continues to develop social responsibility activities and small projects in the area (De Echave et al., 2009).

2.7.2. Production Stage

Shahuindo mine - Pan American Silver*.* The Shahuindo open-pit gold mine is in the district of Cachachi in the Cajabamba Valley, northern Perú, in the Centro Poblado Algamarca. Pan American Silver purchased Shahuindo when it acquired Tahoe Resources in February 2019. In May 2016, the Shahuindo mine went into commercial production (Pan American, 2019) despite strong opposition to the project in defense of land and water (Grufides, 2015).

Although it was a traditional activity, artisanal miners have begun to operate in the vicinity of the Shahuindo concessions since 2005 and then, without authorization from the company, they entered the Cerro Anticlinal de Algamarca within the concession. Since 2006,

miners have been organized within the Association of Artisanal Miners of San Blas (AMASBA), though another group of miners is also present in the area. In 2012, the AMASBA board of directors was changed, defining as one of its objectives to comply with the formalization process through coordination with Sulliden Shahuindo S.A.C. (Cano & Quiñones, 2020; Cano, 2020).

Sulliden Shauindo S.A.C., and mainly Tahoe Resources began hiring non-governmental organizations (NGOs) to guide negotiations with artisanal miners for several years, including drafting agreements for exploitation with the participation of the General Directorate of Mining Formalization (DGFM). The main NGO, participating as an intermediary, withdrew from the negotiation at the indication of Pan American Silver, signifying a setback in the relationship with ASM miners (Cano & Quiñones, 2020). At the time of this writing, Pan American Silver had not disclosed any coexistence agreements with the ASM miners working at its concessions, nor the advance in any negotiation process. On the other hand, AMASBA continues its artisanal gold extraction activities, though they hope to reach an agreement with the mining company to continue operating in these areas (Cano & Quiñones, 2020).

Poderosa - Compañía Minera Poderosa. The underground operations of the LSM mining company Poderosa are in the Pataz province. LSM activity in the area dates back to the 1920s, the company was founded on May 5th, 1980, and began its activities in 1982 (Poderosa, 2020). Poderosa estimates ongoing activities at least until 2029 in its two ore processing plants Santa Maria and Marañon, as well as exploration work in the Pataz gold batholith to replace reserves (Cano, 2020). The La Poderosa complex includes the Poderosa, La Lima, Papagallo, El Tingo and Consuelo mines.

Poderosa agreed to sign exploitation contracts with ASM miners through its local mining formalization initiative as part of its corporate social responsibility (CSR) program. By 2013, Poderosa had signed 234 contracts with ASM miners, largely based on the sole consideration of the delivery of the extracted ore for which the international value of gold was paid per the approved marketing protocol.

Parcoy - Consorcio Minero Horizonte (CMH). CMH is a private company financed with Peruvian capital, with 37 years of experience in the sector, and is producer of gold mineral resources. Its main center of operations is the town of Retamas, district of Parcoy, province of Pataz, department of La Libertad (Jáuregui et al., 2017). The company was established in 1978 with the aim of processing gold tailings abandoned since 1963 (CMH, 2021). Currently, CMH has its two main units in the province of Pataz: The Administrative Economic Unit (AEU) of Parcoy and the AEU Los Zambos. In 2017, it achieved production of 2,000 t/d (Ampuero, 2017) in (Cano, 2020).

Currently, the mining company has signed operating agreements with various groups of informal miners through the promotion of the creation of communal companies, including the CCA community company Nuevo amanecer de Curaubamba Community Company and Artisanal Miners Company United of Huariracra Esperanza Parcoy, which are operating formally (Ampuero, 2017; Cano, 2020). These communal ASM companies have an agreement in place outlining the company allows ASM mining activity in certain areas of its concessions in exchange for ASM companies selling their ore produced to the LSM company.

Bolsa del Diablo - Consorcio Minero ATE. Consorcio Minero ATE is a private Peruvian mining company with a Canadian investor that holds a 99.9% stake while a Peruvian investor has 0.01%. The LS Epithermal deposit Au-Ag *Bolsa de diablo* is located about 34 km north of the city of Las Lomas, which borders with the district of Suyo. (Rodríguez et al, 2010).

By 2020, the mining company had signed operating agreements with artisanal miners located within its concessions; these agreements basically establish that miners can extract existing ore in the area in exchange for selling it exclusively to the mining company. The company is not carrying exploitation activities in its concessions, and for that reason there is no competition for the ore between the company and ASM miners (Cano, 2020).

Cascajo Blanco - Compañía Minera Leona de Oro and Consorcio Minero ATE. The mining company Leona De Oro is a private Peruvian mining company with concessions in the

district of Suyo, Ayabaca province, though most of its concessions are not exploited by the company. ASM mining in the area dates back 15 years. The ASM community has shown interest in the formalization process, and the company is willing to support them by signing operating agreements that basically establish that miners may extract existing ore in exchange for selling it (not necessarily exclusively) to the mining company (Cano, 2020).

Cascajo Blanco is a copper and gold porphyry deposit ranging in value up to 0.13% copper. Narrow quartz-pyrite veins hosted in both the andesite and the Cascajo Blanco quartz-porphyry contain high grades of gold greater than 6 g/t that are currently being worked by informal miners immediately west and northwest of the quartz-porphyry.

Chala One Processing Plant - Inca One. Inca One Gold (INCA) is a Canadian-based gold producer operating two fully permitted gold ore processing facilities in Perú. The facilities are Chala One and Kori One, and both are located in the province of Caravelí, Arequipa region. The Chala One plant has a processing capacity between 100 to 150 tons per day and Kori has a processing capacity of 350 t/d (Inca One, 2020a; Inca One, 2020b; Inca One, 2021).

At the time of this writing, the mining company has not signed any operating agreements with the groups of informal miners present in its concessions. However, the company recognized that it works with the small-scale miners who sell the ore they extract exclusively, even indicating that it covered 50% of their demand. Though, these agreements or contracts are not related to the promotion of the mining formalization process (Cano, 2020).

Veta Dorada Processing Plant – Dynacor. Dynacor is an industrial gold ore processor engaged in precious metal sales through the processing of ore purchased from the ASM industry. It is listed on the Toronto Stock Exchange and headquartered in Montreal, Canada. In late 2016, the Veta Dorada gold ore processing plant, a carbon-in-pulp (CIP) operation, opened at a 300-tonne-per-day capacity (102,000-tonne-per-year capacity).

As of August 5, 2021, Dynacor increased its operations to a fully expanded ore processing capacity of 430 tpd (146,200 tpy). The plant is located in Chala, but the company has purchasing offices in Trujillo, Chimbote, Nasca, Chala, Secocha, Misky, Pedregal and Juliaca. The company also has a crushing plant in Trujillo. The transportation cost of the ore is paid by the ASM miners, which goes to the Chala plant (except for the ore that is crushed in Trujillo). The average grade of ore purchased and processed by the company is around 0.9 oz/ton, and the plant operates with a cut-off grade of 0.3 oz/ton (Dynacor, 2021).

*Mina El Toro - Summa Gold*Summa Gold is developing the Operación Isabelita project, which is a high -sulfidation epithermal gold deposit located in El Toro Hill. El Toro is located 144 km east of Trujillo, in the department of La Libertad, Sánchez Carrión province and Huamachuco district, in the Central Cordillera of the northern Andes. The community claims that in this area's ASM miners have been producing gold since 2000 (Red Muqui, 2020a).

However, since 2006, Summa Gold Corporation has obtained seven concessions in Cerro El Toro (Red Muqui, 2020a). This project will involve an investment of $145 million between 2019, when it began the operation, and the end in 2026 (Summa Gold, 2019). The company claims El Toro Hill was invaded by illegal miners. The company has offered to incorporate them into the company, allowing them to receive the corresponding benefits in accordance with the labor law. There is no ongoing formalization process, though the mining company offers "labor conversion" plans and has asked the government for firmness against illegal mining activity (Cano, 2020).

Minera Paraiso S.A.C. Processing Plants. The Paraiso SAC Mining Company began operations in 1999 processing low-grade ore and tailings from ASM amalgamation processes. Subsequently, vat leaching processes were implemented in the Ocoña area. In 2001, the company moved its operations to Chala, in the province of Caravelí, where it purchased and processed low-grade tailings and high-grade ore material (12-16 Au g/t). The company

overcame a series of difficulties and conflicts in relation to the purchase of material and reached an understanding with ASM miners (Minera Paraíso, 2019).

Relave - Compañía Minera Caravellí Processing Plant. Compañía Minera Caravelí (CMC) started operations in July 1995. It then decided to install a pilot cyanidation plant with activated carbon that had a capacity of 150 tonnes per day. The company's mining deposits, the exploitation for which dates to pre-Hispanic and colonial times, are in the Huanu-Huanu district, Caravelí province, Arequipa department. CMC is the titleholder of mining concessions totaling 11,000 hectares (ha) in area. The company does not have any formal agreement in place with area ASM miners; instead, they have verbal agreements that allow ASM miners to work in exchange for royalties (Wiener, 2019; Cano Roncagliolo, 2020). Most ASM miners present in the area are not full-time miners, and only engage in ASM during favorable gold prices (Cano, 2020).

Table 2.9 Location of the coexistence cases in Perú.

Mine Site	LOCATION AND GENERAL INFORMATION							
	Country	Department/Region	MUNICIPALITY / DISTRICT			PROJECT / OPERATION		
			Direct Influence	Regional Influence	Regional Influence	Company	Stage	Local Name
Shahuindo	Perú	Cajamarca	Cachachi	Cajabamba		Pan American Silver	Production	Shahuindo Mine
Poderosa		La Libertad	Pueblo Nuevo	Campamento	Zurumilla	Compañía Minera La Poderosa	Production	Poderosa
Parcoy		La Libertad	Parcoy	N/A		Consorcio Minero Horizonte	Production	Parcoy
Bolsa Del Diablo		Piura	Suyo	Ayabaca		Consorcio Minero Ate S.A.C.	Production	Bolsa Del Diablo
Cascajo Blanco		Piura	Pichacani	Ayabaca		Consorcio Minero Ate S.A.C. Y Minera Leona De Oro	Production	Cascajo Blanco
Ollachea		Puno	Shupluy	Ollachea	Chichacori	Minera Irl	Feasibility	Ollachea
Pinaya		Puno	Santa Lucia	San Antonio De Chuca	Callalli	Kaizen Discovery Inc	Exploration	Pinaya
Chala One		Arequipa	Caravelí	Chala		Inca One Gold Corp	Production	Chala One Processing Plant
Veta Dorada		Arequipa	Caravelí	Chala		Dynacor	Production	Veta Dorada Processing Plant
Tambo Grande		Piura	Tambo Grande			Manhattan Minerals Corp (Extinguida)	Exploration	Tambo Grande

Table 2.9 Continued

Mina El Toro	Perú	La Libertad	Huamachuco	Shiracmaca		Summa Gold	Production	Mina El Toro
Mpsac Carabayllo		Lima (Department)	Carabayllo			Minera Paraiso SAC	Production	Mpsac Carabayllo
Mpsac Trujillo		La Libertad	Trujillo					Mpsac Trujillo
Mpsac Relave		Arequipa	Caraveli	Tacota				Mpsac Relave
Mpsac Secocha		Arequipa	Secocha					Mpsac Secocha
Mpsac San Luis		Arequipa	San Luis					Mpsac San Luis
Mpsac Chala		Arequipa	Caravelí	Chala				Mpsac Chala
Mpsac Atico		Arequipa	Atico					Mpsac Atico
Mpsac Cusco		Cusco	Cusco					Mpsac Cusco
Mpsac Carabeli		Arequipa	Caravelí					Mpsac Carabeli
Mpsac Misky		Arequipa	Misky					Mpsac Misky
Los Chancas		Apurímac	Aymaraes	Puquio	Abancay	Southern Perú Copper Corp	Pre - Feasibility	Los Chancas
Relave		Arequipa	Caraveli	Tocota	Relave	Compañía Minera Caravelí	Production	Relave
Intigold Atico		Arequipa	Caraveli	Atico		Intigold Mining Now Calibri Resources Inc	Closure	Atico
Rio Blanco		Piura	El Carmen de la Frontera	Huancabamba		Zijin Mining Group & Monterrico Metals	Feasibility	Rio Blanco
Lagunas Norte		La Libertad	Otuzco	Quiruvilca		Barrick	Production	Lagunas Norte

Table 2.10 Geologic characteristics of coexistence cases in Perú. N/A: Indicates that the ASM ore is coming from several sources and is impossible to determine the geological characteristics of the origin.

GEOLOGY						
PROJECT / OPERATION			**GEOLOGY**		**MINERALIZATION**	
Mine Site	**Project Stage**	**Main Commodity**	**Metallogenic Belt**	**Host Rock**	**Mineralization Style**	**Deposit Type**
Shahuindo	Production	Au - Ag	Franja XXI-B	Sedimentary	Veins and Veinlets	Epithermal HS
Poderosa	Production	Au (Pb - Zn - Cu)	Franja II Orogenic Au - Pb - Zn - Cu Carboniferous - Permian	Igneous Intrusive	Veins and Veinlets	Orogenic
Parcoy	Production	Au (Pb - Zn - Cu)	Franja II Orogenic Au - Pb - Zn - Cu Carboniferous - Permian	Igneous Intrusive	Veins and Veinlets	Orogenic
Bolsa Del Diablo	Production	Au - Ag	Franja XII Epithermal Au - Ag Paleocene	Igneous Extrusive	Stockworks and vetiform structures	Epithermal LS
Cascajo Blanco	Greenfields	Cu - Mo	Franja X Porphyry Cu-Mo. Late Cretaceous	Sedimentary	Stockwork & narrow epithermal quartz pyrite veins	Porphyry Cu - Mo
Ollachea	Feasibility	Au - Cu	Franja III	carbonaceous metamorphosed sediments	Shear Zone	Orogenic
Pinaya	Greenfields	Au - Cu	Andahuaylas-Yauri Porphyry-Skarn Belt	Sedimentary	Disseminated + Stratabound	Porphyry Cu - Au + Skarn

Table 2.10 Continued

Chala One	Production	Au	N/A	N/A	N/A	N/A
Veta Dorada	Production	Au	N/A	N/A	N/A	N/A
Tambo Grande	Pre-Feasibility	Cu > Au - Ag - Pb – Zn	Franja VII VMS - Albian	Igneous Extrusive	Massive Sulphide	VMS
Mina El Toro	Production	Cu - Au	Franja XX	Sedimentary	Disseminated	Epithermal HS
Mp Sac	Production	Au	N/A	N/A	N/A	N/A
Los Chancas	Exploration	Cu-Mo	Franja XV	Breccia, Quartz Monzonite Porphyry, Granodiorite Porphyry, Quartzite	Disseminated	Porphyry Cu - Mo
Relave	Production	Au	Franja IX	N/A	N/A	N/A
Intigold Atico	Greenfields	Au + Ag	Franja IX	Igneous Intrusive	Veins and Veinlets	Hydrotherma l Qz Veins
Rio Blanco	Feasibility	Cu – Mo + Au	Franja XX	Portachuela Batholith (granodiorite, diorite, tonalite)	Disseminated	Porphyry Cu - Mo
Lagunas Norte	Closing	Cu > Au - Ag - Pb – Zn	Franja XXI-B	Sedimentary + Volcanics	Disseminated + Stratabound	Epithermal HS

Table 2.11 Mining characteristics of coexistence cases in Perú. *Private company, limited information is available to the public. **Processing plant, no Resource/Reserve information available, it is difficult to stablish the origin of the ore. ⁑Average for 2021. ⁂Average grade calculated from gold production 2021.

MINING																
Mine Site	**ASM Starting Date of Operation**	**LSM Starting Date of Operation**	**Mining Method**			**Run Of Mine (ROM) Tpd**	**Estimated Life of Mine (LOM)**	**Recovery Average %**	**Cut-Off Grade Au g/t**	**Total Proven +Probable Reserve**	**Resource**			**Au Average Grade g/t**	**Plant Capacity Tpd**	**Recovery Method**
			ASM Mine Type	**LSM Mine Type**	**Mining Method**						**Measured**	**Indicated**	**Inferred**			
Shahuindo	1940	2016	Underground	Open Pit	Truck & Shovel / Loader	15,800	10 years	73% Au	0.18	1,612,900 Au Oz	0.18 Au Moz	0.22 Au Moz	2.59 Au Moz	0.54	36,000	Gold from the Shahuindo mine is extracted from the ore via heap leach and then processed by carbon-in-column, adsorption-desorption-refining (ADR) operations.
Poderosa*		1982	Underground	Underground	N/A	1100	> 9 years	91.04% Au	N/A	743,885 Au Oz	0.8 Au Moz	N/A	N/A	14.05	1365	
Parcoy*		1990	Underground	Underground		1750	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2000	
Bolsa Del Diablo*		N/A	Underground	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Artisanal
Cascajo Blanco*		~2005	Underground	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	> 6	N/A	Artisanal
Ollachea		N/A	Underground	Underground	N/A	1,500	11 Years	90.3% - 86.2% Au	1.4 Au g/t	-	-	1.13 Au Moz	0.6 Au Moz	-	1.500 - 3000	The plant design includes a crushing and grinding circuit, followed by gravity concentration. The gravity concentrate is processed in a cil circuit and gold is recovered from the loaded carbon in a conventional elution - electrowinning plant with smelting of the gold to a doré bullion. The process also includes effluent treatment, tailings filtration and preparation of cemented paste backfill required during mining operations.
Pinaya	1960s	N/A	Underground and open cut.	Open pit.	N/A	N/A	N/A	70% Au	0.25 Au g/t	-	0.158 Au Moz	0.497 Au Moz	0.39 Au Moz	0.33	N/A	Oxide material processed using a heap leaching method, ordinary flotation processing of sulphide mineralized material to produce a bulk copper. Concentrate with gold credits.
Chala One**		2013	N/A	Processing Plant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43⁑	100 to 150	Crushing, grinding, milling and carbon-leaching circuits and carbon desorption plant.
Veta Dorada**		2016	N/A	Processing Plant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78⁂	430	Carbon-in-pulp (CIP) operation.

Table 2.11 Continued

Tambo Grande		N/A	Underground	Open Pit	Truck & Shovel / Loader	7500	3.5 Years for Au/Ag Deposit	90% Au	1 Au g/t Oxide.	1.855,672 Au Oz	N/A	0.903 Au Moz	2.15 Au Moz	3.5 Oxide 0.5 Sulfide	10000 - Up To 20000	The flow sheet for oxide ore includes the following basic criteria: sag and ball milling will be used to grind the ore to 80% passing 40 µm; the milled product will be thickened and subjected to conventional leaching in cyanide; the pregnant solution will then be separated from the barren tailings using counter current decantation; cyanide destruction on the tailing stream, using the so2/air technique, will also be incorporated into the flow sheet; pregnant solution will be clarified and de-aerated in a conventional merrill-crowe circuit and the precious metals recovered from solution by zinc precipitation; and the precious metal sludge will be upgraded to produce a gold/silver-bearing doré for shipment to a refinery.
Mina El Toro		2019	Underground	Open Pit	Truck & Shovel / Loader	N/A	10 Years	N/A	N/A	N/A	0.14 Au Moz	0.62 Au Moz	0.32 Au Moz	0.49	N/A	Heap leaching, adsorption, desorption, chemical reactivation, electrowinning and casting, to get the doré bar.
Mp Sac**		1998	N/A	Processing Plant	N/A	N/A	N/A	93% Au	N/A	N/A	N/A	N/A	N/A	12 – 16	250	Collection, reception, crushing, sampling, grinding and classification. Leaching and adsorption-desorption-refining (adr) operations.
Los Chancas*		N/A	N/A	Open Pit	N/A	N/A	N/A	84.5% Cu	NSR Cut-off US$6.11/t	N/A	N/A	1,648 Mlb Cu	14,165 Mlb Cu	0.50%	108,000	Assumed conventional flotation technology for sulfide mineralization and conventional heap leach and solvent extraction/electrowinning (sx/ew) technology for oxide mineralization.
Relave**	Pre-Hispanic	1995	Underground	Processing Plant	N/A	N/A	N/A	98% Au	N/A	N/A	N/A	N/A	N/A	1 - 11	150	Collection, reception, crushing, sampling, grinding and classification, tank leaching.
Intigold - Atico**	N/A	N/A	Underground	Underground Closed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Closed
Rio Blanco		N/A	Underground	Open Pit	N/A	N/A	20 years	N/A	0.4%t	7.11 million tonnes of ore grading 0.57% Cu					N/A	The process includes crushing, milling, and flotation.
Lagunas Norte		March 2005	Underground	Open Pit	Truck & Shovel / Loader	42000 to 63000	20+ Years	81.88% Au	1.10 To 1.169 Au g/t Sulfide 0.237 To 1.196 Oxide	3.700.000 Au Oz	0.05 Au Moz	0.72 Au Moz	0.05 Au Moz	1.36	42000 To 63000	Crushing, and extraction of precious metals using heap leaching and merrill crowe recovery

Table 2.12 Demographics of the communities in which the Peruvian coexistence cases are located.

DEMOGRAPHICS OF THE COMMUNITIES								
Mine Site	**Municipality**	**Population Municipality of Direct Influence**		**Ethnicity Of the Community %**				
		Total	**% Male**	**% Female**	**%Working Age Population**	**Indigenous**	**African-Descendant**	**No Ethnic Group**
Shahuindo	Cachachi	23524	52.0	48.0	65.3	7.01	6.4	6.12
Poderosa	Pueblo nuevo	11629	50.05	50.0	74.2	1.78	9.0	8.91
Parcoy	Parcoy	18730	62.7	37.3	75.4	8.7	5.6	15.8
Bolsa Del Diablo	Suyo	11179	51.6	48.4	69.5	1.89	6.11	7.74
Cascajo Blanco	Pichacani	5679	47.7	52.3	77.27	98.37	-	0.2
Ollachea	Shupluy	1840	48	52	67.23	94.73	-	0.15
Pinaya	Santa Lucia	7028	46.6	53.4	72.6	90.42	-	1.25
Chala One	Caravelí	4259	51.3	48.7	73.4	22.55	3.64	8.4
Veta Dorada	Caravelí	4259	51.3	48.7	73.4	22.55	3.64	8.4
Tambo Grande	Tambogrande	107495	51.0	49.0	69.2	2.27	11.89	7.17
Mina El Toro	Huamachuco	66902	48.1	51.9	67.5	4.09	0.11	16.26
Mpsac Atico	Atico	5215	55.1	44.9	74.7	18.34	6.86	9.9
Los Chancas	Puquio	13919	49	51	71.3	81.26	0.03	1.79
Relave	Caraveli	4259	51.3	48.7	73.4	22.55	3.64	8.4
Intigold Atico	Caraveli	4259	51.3	48.7	73.4	22.55	3.64	8.4
Rio Blanco	Huancabamba	27599	48.3	51.7	71.0	7.15	2.80	6.38
Lagunas Norte	Otuzco	24169	48.2	51.8	72	5.75	5.16	6.42

Table 2.13 Access to utilities and public services where the Peruvian coexistence cases are located.

ACCES TO UTILITILITIES AND PUBLIC SERVICES									
Mine site	**Municipality**	**Basic services**						**Poverty level % MPI**	**Health service coverage**
		Electricity	**Water**	**Sewer**	**Gas**	**Waste**	**Internet**		
Shahuindo	Cachachi	58.76	94.6	94.6	8.17	-	0.6	-	82.8
Poderosa	Pueblo nuevo	93.72	99.751	99.75	74.6	-	16.39	-	77.3
Parcoy	Parcoy	84.87	72.403	72.4	63.06	-	6.67	-	72.2
Bolsa Del Diablo	Suyo	81.76	99.758	99.76	51.91	-	3.1	-	84.0
Cascajo Blanco	Pichacani	55.42	99.225	99.23	36.36	-	1.5	-	83.52
Ollachea	Shupluy	87.75	99.837	99.84	35.98	-	0.54	-	97.8
Pinaya	Santa Lucia	73.73	95.973	95.97	79.26	-	8.12	-	70.9
Chala One	Caravelí	92.88	91.359	91.36	87.84	-	14.1	-	64.5
Veta Dorada	Caravelí	92.88	91.359	91.36	87.84	-	14.1	-	64.5

Table 2.13 Continued

Tambo Grande	Tambogrande	85.23	99.435	99.44	40.73	-	3.12	-	70.2
Mina El Toro	Huamachuco	82.61	97.301	97.3	45.91	-	7.49	-	83.1
Mpsac Atico	Atico	89.62	91.218	91.22	95.42	-	17.5	-	68.4
Los Chancas	Aymaraes	92.84	88.426	88.43	73.05	-	5.16	-	90.9
Relave	Caraveli	92.88	91.359	91.36	87.84	-	14.1	-	64.5
Intigold Atico	Caraveli	92.88	91.359	91.36	87.84	-	14.1	-	64.5
Rio Blanco	Huancabamba	73.09	97.366	97.37	31.12	-	6.22	-	88.6
Lagunas Norte	Otuzco	88.62	99.028	99.03	39.22	-	5.72	-	81.3

Table 2.14 Perú coexistence strategies summary.

COEXISTENCE ESTRATEGIES SUMMARY					
Mine Site	**Coexistence**	**strategy 2**	**strategy 2**	**LSM project Stage**	**ASM Form of organization**
Shahuindo	No	N/A	N/A	Production	Community associations
Poderosa	Yes	Ore purchase	N/A	Production	Community associations
Parcoy	Yes	Contract mining	Ore purchase	Production	Community companies
Bolsa Del Diablo	Yes	Ore purchase	N/A	Production	Community associations
Cascajo Blanco	Yes	Contract mining	Ore purchase	Production	Community associations
Ollachea	No	Royalty Agreement	N/A	Feasibility	Community associations
Pinaya	No	N/A	N/A	Exploration	N/A
Chala One	Yes	Ore purchase	N/A	Production. Processing plants	N/A
Veta Dorada	Yes	Ore purchase	N/A	Production. Processing plants	N/A
Tambo Grande	No	N/A	N/A	Exploration	Community association
Mina El Toro	No	Labor conversion offer	N/A	Production	N/A
Mpsac Atico	Yes	Ore Purchase	N/A	Production Processing plants	N/A
Los Chancas	No	N/A	N/A	Pre-feasibility	Community associations
Relave	Yes	Royalty agreements	N/A	Production. Processing plants	Community associations
Intigold Atico	No	Royalty agreements	N/A	Closure	N/A
Rio Blanco	No	N/A	N/A	Feasibility	Community associations
Lagunas Norte	Yes	Contract mining	N/A	Production	Community associations

*Atico - Intigold and Calibrí Resources Inc.*In November 2017, there was a confrontation between a group of mine workers and members of the National Police at the facilities of the Santiago de Compostela mine, owned by Intigold Mining S.A. and located in the district of Atico, province of Caravelí, Arequipa region. At that time, the confrontation ended with the death of one person (Convoca, 2020).

Intigold, which was in closure, accepted ASM miners working in its mining concessions in exchange for the payment of a 25% royalty (Red Muqui, 2020b). The company increased this percentage to 40%, and the ASM miners did not accept the increase.

In January 2020, the mining company issued a statement indicating that it was the focus of invasions around its activities. In October 2020, around 300 ASM miners protested demanding Intigold Mining does not charge them royalties exceeding 30% of per-day extractions. (Convoca, 2020).

In December 2020, the clashes continued, this time at Mina Calpa in Calca, Ático province, where three ASM miners were wounded by bullets. The ASM miners accused the company of sending armed people to evict them.

Lagunas Norte – Barrick. Barrick's Minera Barrick Misquichilca S.A is an LSM company focused on the extraction and processing of gold. It is in the department of La Libertad, province of Santiago de Chuco, district of Quiruvilca. Barrick began open-pit operations there in 2005 with a construction investment of $340 million. The project's concessions cover a large territory including important overlapping of both gold and coal deposits, though much of the coal is outside of the mine's pit. Production at Lagunas Norte reached production of more than 1 million ounces of gold annually at its peak. At the end of 2018, Barrick suspended the expansion of Lagunas Norte due to the project's low profitability.

In 2014, Barrick and the Alto Chicama Artisanal Miners Association (AMACHIC) signed a five-year renewable operating contract for the exploitation and exploration of coal in certain areas of the mining concession. The formalization of AMACHIC was approved in 2015 under Barrick's sponsorship, and in its first year it managed to formalize more than 400 ASM miners in about 76 areas. The Association of Carboneros de La Libertad, another mining association in the area, is now beginning the formalization process, also with Barrick's support (Cano, 2020; Cano & Quiñones, 2020).

2.8. Analysis and Discussion

2.8.1. QCA Outcomes

We used QCA to assess the impact that certain (qualitative) variables have on a given outcome. To accomplish this, we made use of dichotomous variables, admitting only two states: presence (or in logical terms, true) and absence (or, in logical terms, false). Both states are presented in base 2 (0 indicates absence and 1 indicates presence). Table 2.15 presents the criteria used to calibrate the information. An important aspect to keep in mind is Boolean negation. This logical operation transforms values 0 into 1 and vice versa. For example, the negation of the set of male population greater than 50% is the set of male population less than 50%.

Table 2.15 Assumptions used to calibrate the data set.

Variable	Calibration
LSM company type	Senior mining company = 1 Junior mining company = 0
Mineralization Style	Placer, Veins&Veinlest Stratabound = 1 Veins&Stockwork, Disseminated = 0
Deposit Type	High Grade - Low tonage = 1 Low Grade - high tonage = 0
ASM Mine Type	Underground = 1 Open pit or Placer = 0
LSM Mine Type	Underground = 1 Open pit or Placer = 0
% Male	%Male > %Female =1 %Female > %Male = 0
% Female	Male>Female =1 Female>Male = 0
Indigenous	Indigenous people >15% = 1 Indigenous people <15% = 0

From the construction of these independent and dichotomous dependent variables, we obtained what is referred to as a “truth table” from our raw data (coded as 0 and 1). Truth tables have as many rows (solutions) as possible combinations of values in the independent variables: The number of rows that a truth table will have can be calculated as 2^k (where k is the number of independent variables).

Once all variables have been calibrated in the dataset we can proceed to the next step, which is running the algorithm and the generation of the truth table. Several lines will have a

frequency of zero, which means that none of the cases in the sample are explained by them. Solutions that resulted in a case frequency of 0 have been removed and only solutions that contain at least one success case are presented. The last step to generate the truth table is to decide if each combination (solution) explains the outcome or not. Sorting the table by consistency column and choosing a threshold of 1 we insert the value of 1 or 0 in the column with the outcome variable. Choosing 1 or 0 defines if a combination explains the outcome or not. After this step, we proceed to obtain solution sets.

FsQCA computes three solutions: a complex solution, a parsimonious solution, and an intermediate solution. The *complex solution* presents all the possible combinations of conditions when traditional logical operations are applied. The *parsimonious solution* set is a simplified version of the complex solution, based on simplifying assumptions, and presents the most important conditions which cannot be left out from any solution. These are called “core conditions” (Fiss, 2011) and are identified automatically by fsQCA. Finally, the *intermediate solution* is obtained when performing counterfactual analysis on the complex and parsimonious solutions including only theoretically plausible counterfactuals (Liu et al., 2017; Ragin, 2008b). All solutions that only appear in the intermediate solution are called *“peripheral conditions”* and peripheral conditions are removed from the parsimonious solution so, an easy way to identify the core conditions is to examine the parsimonious solution since it does not include peripheral conditions (Pappas and Woodside, 2021).

The findings are organized in the table 2.16 using the notation introduced by Reing and Fiss (2008), according to which black circles (“●”) indicate the presence of a condition, and circles with a cross-out (“R”) indicate its absence. Furthermore, large circles indicate core conditions, and small circles refer to peripheral conditions. Blank spaces in a solution indicate a “don’t care” situation in which the causal condition may be either present or absent.

Table 2.16 Configurations for achievement Successful coexistence.

	SOLUTION				
Configuration	**1**	**2**	**3**	**4**	**5**
Senior Mining Company		●	●	●	●
Mineralization Style	●	⊗	●	●	●
High Grade-Low Tonage Deposit Type	●	⊗	●	●	●
Underground ASM Mine Type	●	⊗	●	●	⊗
Underground LSM Mine Type	●	⊗	●	⊗	⊗
Presence of Indigenous people	⊗	⊗	⊗	⊗	⊗
Presence of African-Descendant People	⊗	⊗	⊗	⊗	⊗
Presence of Mediator	●	●	⊗	⊗	●
LSM Operation Stage	●	⊗	⊗	●	●
Organized ASM community	●	●	●	●	●
Consistency	1	1	1	1	1
Raw Coverage	0.5	0.125	0.125	0.125	0.125
Unique Coverage	0.5	0.125	0.125	0.125	0.125
Overall solution consistency	1				
Overall solution coverage	1				

The solution table shows that the set analysis results in five solutions exhibiting acceptable consistency (1) and furthermore indicates the presence of both core and peripheral conditions. The first observation that appears consistent along the five solutions are: a) no presence of Indigenous people, b) no presence of African-Descendant people in the ASM community, c) presence of a mediator, and d) presence of a high grade-low tonnage deposit type. We propose these as conditions for successful coexistence. The type of LSM company in solution 1 is blank which means that the coexistences may be successful in this combination with a Senior LSM company as well as with a Junior LSM company. Solution 2 indicates that an LSM company with an organized ASM community, either in a company or in an association with the presence of a mediator is enough condition to have a successful coexistence as long as the community does not belong to an any ethnic minority. Solutions 3 and 4 combined indicate that the LSM operation stage can be either exploration or production the mine type can be either

underground or open pit and with absence of mediator as a peripheral condition. Solution 5 indicates that under the presence of a Senior company the successful coexistence will achieve if the LSM and ASM type of mining is not performed underground.

The following discussion integrates our QCA analysis with our qualitative observations and test aspects of the original hypothesis that particular coexistence models rely on specific technical and social criteria. Technical aspects such as type of LSM company, stage in the mining cycle of the project, deposit type, mineralization, or mining type, do not determine whether coexistence is achieved but can influence the coexistence model. Social aspects such as the type of ASM mining community, the ethnicity of the community and forms of organization condition do determine whether or not coexistence is achieved. For example, it is more feasible to achieve coexistence between LSM and ASM when the ASM community does not belong to an ethnic minority. Coexistence is easier to attain when the communities are organized because this reduces the power imbalance between the parties. Finally, we observe that involvement of independent mediators such as civil organizations or NGOs facilitates the achievement of coexistence.

2.8.2. Coexistence According to the type of LSM Company: Junior vs. Senior

This study indicates that the presence or absence of efforts towards coexistence does not depend on the type of LSM company. In Colombia, coexistence does not depend on the type of LSM company that operates the projects, both junior and senior companies have decided to make agreements with ASM miners there. Also, there are senior companies that, for many years, worked without agreements with ASM miners and there are junior companies that make agreements in very early stages as others which do not see the need to approach the ASM.

In Perú, five out of 17 cases of coexistence are with junior exploration LSM companies; and most cases of coexistence are led by senior LSM companies. Five of the cases correspond

to processing plants, which can be considered LSM companies. One of these companies, Minera Paraiso SAC, has several plants around Perú. These types of plants are not common in Colombia, perhaps due to differences in the legal framework between the two countries and security concerns.

2.8.3. Coexistence according to the stage in the mining cycle

The cases of coexistence founded in Colombia and Perú cover all the stages of the mining cycle, from early exploration to production. In Colombia, there are four cases of coexistence in the operations stage, which basically corresponds to the only four LSM gold mine sites in operation in Colombia. In Perú, eight cases of coexistence in the operations stage were found. The gold mining industry is more developed there than in Colombia and, for that reason, more projects in the operations stage are found — though not all of them have coexistence agreements in place with ASM miners. Due to the incipient mining industry in Colombia, the cases of coexistence in greenfields to feasibility stages are more common. It is to be expected that more and more junior exploration companies will converge with ASM miners in Colombia as prospectors and junior exploration companies rely on ASM miners as vectors of exploration to develop new projects with a view to becoming LSM projects.

2.8.4. Ethnicity of ASM Communities

All the coexistence agreements achieved in Colombia and Perú are signed with ASM communities that are non-minority ethnicities (predominantly *Mestizo*), whereas the projects in Perú and Colombia where there indigenous and ethnic minorities comprise a significant proportion of the population have not achieved coexistence agreements. This indicates that the ethnicity of the community is an important factor that determines the achievement of coexistence agreements. In Colombia, the Mineros S.A., Buriticá, Segovia, Minesa, Gramalote and RRM coexistence agreements are made with non-minority *Mestizo* ASM communities. In El Alacrán, the Indigenous population is 16.4%; interactions between LSM and ASM are tense,

and there is no coexistence agreement. In Marmato the Indigenous population is 24.8%, and the Afro-descendant population accounts for 11% of the population of the municipality; there is no coexistence agreement in place, so the ASM community works separately from the LSM mining activity.

In Perú there are no mining projects in coexistence with ethnic minorities ASM communities. Poderosa, Parcoy and Lagunas Norte are in districts where the population is mostly non-ethnic minority (*Mestizo)*. Processing plants such as Chala One and Veta Dorada are in the Caraveli district, where the population is mostly *Mestizo*. In contrast, coexistence has not been achieved in Cascajo Blanco, Ollachea, Pinaya and Los Chancas, where the communities are mostly Indigenous. In Puno, in the district of Santa Lucía, 90% of the population is Indigenous and the relationship with Kaizen Discovery is tense. Likewise, in Los Chancas in the district of Puquio, where the population is 81.26% Indigenous, Southern Perú Copper has not signed operating agreements with the ASM groups present in its concessions.

Two factors are important to consider in this context. First, Indigenous and other ethnic minority communities commonly have had negative experiences with extractive industries and settler colonialism and have worldwide borne a disproportionate share of the burden of resource extraction (Radcliffe et al., 2004). Given this history, such groups may be less willing to negotiate with or engage in coexistence with LSM companies. Secondly, the United Nations has called for free, prior, and informed consent of Indigenous peoples with regard to resource development in their communities (UN General Assembly, 2007). Those LSM companies that have not engaged with Indigenous communities miss a potential opportunity, since coexistence agreements may be one mechanism of ensuring free, prior, and informed consent of the community.

2.8.5. Forms of Organization

The form of organization of ASM miners plays an important role in the success or failure of coexistence processes. The database examination shows that a structured form of organization of the community as a cooperative, association, civil organization or even as a company helps in the achievement of a coexistence agreement by reducing the power imbalance between ASM miners and LSM companies and facilitating the communication between third parties with decision-making capacity who represent the interest of both parties. As presented above, in the case of Minesa, the coexistence agreement was the initiative of the ASM miners (organized in the Calimineros Association) who proposed a joint work option. The success of this proposal encouraged other ASM miners to organize themselves into associations to present similar proposals to Minesa S.A. In the case of Gramalote, the LSM company had to organize a group of ASM miners for La María S.A.S. to advance the formalization subcontract. Continental Gold in Buriticá also organized the ASM miners to be able to advance the processes of formalization for the mining operation.

In the latter cases, the ASM miners that could not be included in the organizations lost the opportunity to be formalized. In cases where attempts to advance mining projects by LSM companies have failed, there also seems to be a strong component of good organization by the communities. A good example of this is the Rio Blanco project in Perú, where the strong social organization of the Segunda y Cajas and Yantas communities were key in the halting of the project.

2.8.6. Coexistence According to the Mineralization Type and Type of Deposit

Analysis of the database shows that the mineralization style and type of deposit do not determine the achievement of a coexistence agreement but can determine which coexistence model is applied. Epithermal gold deposits and placer deposits which achieved coexistence are more likely to use the ore purchasing or contract mining agreement of coexistence. In contrast,

formalization subcontract agreements are more common at disseminated mineralization style deposits with zones with higher grades and lower tonnage amenable to ASM, if the LSM company pursues the same commodity.

We also observed that the geological characteristics of these deposits are key to predicting the potential presence of ASM in any determined deposit type. The mineralization style and deposit types associated with high grade and low tonnage are vein form epithermal deposits; strata-bound deposits such as VMS; brecciated or stockwork zones of porphyry deposits; and oxidized enrichment zones of intrusion-related gold or porphyry deposits. Obviously, alluvial or placer gold deposits are of interest of ASM miners because gold is found free gold (Gold that can be recovered by concentrating methods and is easily recovered by panning or another gravity method). In this section, we will discuss the models of coexistence found in Colombia and Perú according to the mineralization style and the deposit type.

In Colombia, the Buriticá, Marmato and Sotonorte (Minesa) projects are epithermal gold deposits, and the mineralization style is vein-hosted. Segovia and Gramalote are intrusion-related gold deposits, and there are zones with vein mineralization styles and zones with stockwork mineralization styles. In Marmato, the ASM community is located mainly atop the hill where the epithermal deposit veins outcrop and the LSM company is developing a disseminated style, porphyry-type deeper deposit. In Buriticá, ASM miners and the LSM company are mining the same steeply dipping vein style LS-IS epithermal gold deposit but working in different areas of the deposit, according to the coexistence agreement. In Perú, the case of Lagunas Norte, where ASM miners exploit coal seams while the LSM company exploits an epithermal gold deposit. Also note the cases of Parcoy and Compañía Minera Poderosa, where both exploit the same type of deposit in the same underground type of mining, but in different areas or localities within the project. Both are good examples of coexistence models in vein-form deposits.

Pinaya, Mina el Toro, Tambo Grande and Lagunas Norte are all examples of disseminated deposits in Perú. Only Lagunas Norte has an agreement with ASM miners, but in

this case the commodity of interest is different. The LSM company is interested in gold and the ASM miners are interested in coal and the coexistence model achieved is Formalization. Pinaya and Mina El Toro and Tambo Grande's common characteristic is that the ASM miners and the LSM companies pursue the same commodity (gold) and, at those three sites, there are no coexistence agreements, and the LSM companies present in these sites have their projects halted.

2.8.7. Coexistence According to Mining Type

The mining type does not determine the achievement of coexistence, but it may determine the model of coexistence. There are no contract mining agreements in open pit projects in our database, but we found formalization and sub-contracts of formalization agreements in projects at open pit sites. underground and alluvial mining operations are more likely sites for contract mining and ore purchasing agreements. This conclusion may be influenced by the fact that to date in Colombia, there are no open-pit gold mines in operation. The LSM mines in operation in Colombia with coexistence agreements with ASM miners are underground operations, such as Cisneros, Buriticá and Segovia all of these operations have in place ore purchase agreements and operation contracts. The Soto Norte project is in the feasibility stage; if the environmental permit is received it will be another LSM underground gold mine in Colombia with operation contracts in place. All the ASM mining operations in these agreements are for underground ASM mining. To date, Poderosa in Perú is the only underground LSM operation with ore purchase coexistence agreements. The ASM miners who sell the ore to the company also operate ASM underground gold mines.

Gramalote and El Alcrán in Colombia are mining projects in the feasibility and pre-feasibility stages, respectively. Both projects have design plans for open-pit mining but only Gramalote has achieved sub-contract of formalization coexistence agreements. The ASM mining community in both projects used to work in ASM open-pit mining before the arrival of the

LSM company. In Perú, Shahuindo and Lagunas Norte are open-pit operations, and the ASM miners have a formalization coexistence agreement with the LSM companies for ASM underground production. In the case of Shahuindo, the ASM miners sell the ore produced in the ASM underground operations for processing at the Shahuindo LSM plant.

Mineros S.A. is the only LSM alluvial mining operation in Colombia. ASM miners in a coexistence agreement with the company are operating in the same type of mining with just small differences in their dredge type, specifically that Mineros S.A uses bigger bucket dredges and the ASM miners use hydraulic dredges, which take the ore by suction and then obtain the gold by gravity.

The most representative site of alluvial mining in Perú is Madre de Dios, there are not known LSM-ASM coexistence agreements in place at this moment in this site.

2.8.8. Other Factors Influencing the Type of Coexistence.

Other factors that can influence the type of coexistence include commodity prices and changes in market conditions. Projects with marginal financials and with the presence of ASM communities may not be attractive for development by LSM companies due to the cost of the coexistence process; however, a shift in the price of a commodity can make it attractive, should there be enough free cash to afford the extra expenditures. Regulatory authority decisions may also influence the approach that companies implement in their relations with the communities. In Gramalote, with the granting of the environmental license for the mining project, the environmental authority urged the LSM company to work on the “coexistence with the existing vocations”, and one of them is the ASM activities that are in the area and considered ancestral, and this implied their responsibility of supporting the regularization and formalization processes led by the government (Issuu, 2015).

2.8.9. The Role of the Governments, Civil Organizations and NGOs as Mediators

It is important to highlight the role of mediators in establishing coexistence between LSM and ASM. The analysis of the data indicates that the presence of a mediator facilitates the achievement of a coexistence agreement especially in Colombia where the confidence in the government is low. However, there is no trend indicating that the presence of a mediator leads to a certain model of coexistence, In Perú and Colombia, several successful examples demonstrate the effectiveness of a mediator figure in bringing the two parties closer together (Cano and Kunz, 2020). In Colombia, Mineros S.A sought the support of the USAID Oro Legal program to validate the working conditions of the ASM miners included in the process; in this case it was essential to articulate the interests of the parties, assess the risks and manage a work plan. The Colombian government, through its mining authorities, was not involved because the coexistence strategy was based in a private agreement between the parties. In Buriticá, The ASM miners denounced the absence of the state and for that reason the Company had the opportunity to modify the terms of the formalization contract (Restrepo and Martinez, 2019). In the territory of Segovia and Remedios, community organizations have emerged, such as the Mining Board of Segovia and Remedios, to defend ASM mining in the region, as well as the Humanitarian Action Corporation for Coexistence and Peace of Northeast Antioquia (CAHUCOPANA). In Segovia and Remedios community organizations argue that the state supported the growth of LSM mining in the area, resulting in increased social conflict and armed violence (Bernal-Guzmán. 2018, PBI Colombia, 2020). Lagunas Norte in Perú, Barrick and AMACHIC recognized the participation of the government as an important actor for the agreements – in particular, the active presence of the then-Vice Minister of Mines and the regional government for legal advice on the formalization process (Cano and Quiñones, 2020). Conversely, cases such as Shahuindo in Perú and Alacrán in Colombia lack this support from an independent third party or a mediator, and the LSM and ASM parties did not find points of convergence mainly due to distrust or lack of will.

2.9. Conclusions

Through the analysis of the 28 coexistence study cases compiled in the database for this study, several factors appear to influence the success of the coexistence endeavor, or the selection of the coexistence model. Ethnicity of the ASM community is one of the social characteristics that determines the achievement of a LSM – ASM coexistence agreement. In cases where mining communities continued in conflict or in passive coexistence with the LSM companies, or where LSM companies had to leave the projects, communities have had a long mining tradition and are Indigenous or Afro descendant minority ASM communities, sometimes these communities are protected by mining titles granted by the government, such as in the case of Marmato, or have constitutional protection. These characteristics give these communities superior bargaining power over LSM companies compared to those ASM communities that do not belong to a particular ethnic minority community and which do not have a long mining tradition. ASM communities who do not belong to any ethnic minority are in a situation of power imbalance, are often stigmatized as illegal, could ends in displacement, relocation or, depending on the will of the LSM company, in a formalization agreement (Royal Road), formalization subcontracts (Gramalote, Buriticá) or operating contracts (Segovia, Mineros). In Perú, the outlook seems to be better for ASM communities and ASM ancestral communities, but in any case, it depends on the will of the mining titleholder for coexistence to be successful.

This study found that the role of mediators is important to reach a LSM -ASM coexistence agreement, especially in countries where high levels of government corruption are perceived. In Colombia, the cases in which an independent mediator has been involved have ended in successful coexistence (e.g., Gramalote, Mineros). The cases in which the national government has been involved as a mediator continue in latent conflict with periods of tense calm and periods of direct confrontations (e.g., Marmato). In Perú, government mediation has been useful and effective, unlike in Colombia. This is perhaps due to a policy more aimed at

protecting ASM miners without neglecting the rights of LSM companies and the lower government corruption perceived in Perú.

This research found that mineral deposit type, the mineralization style, and the type of mining does not seem to be a feature that affect whether or not the parties will achieve coexistence but can affect the model of coexistence chosen. In several different types of gold deposits, we have seen successful cases of coexistence in Colombia and Perú from porphyry-type and epithermal-type to VMS and orogenic deposits. In any case, it is obvious ASM miners will always be found where there are high grades and low tonnages, typically in vein form, stratabound or placer deposits. However, in these types of deposits, you can find narrow areas of grades that are not economically exploitable with LSM industrial methods. These zones can be offered under operation contracts or under formalization subcontracts to ASM organizations. On the other hand, deposits can have two well-defined areas. In the case of porphyry systems, such as Marmato, there are shallow vein form epithermal zones of high grade suitable for ASM miners, and deep zones with low-grade, high-tonnage disseminated mineralization in porphyry-type deposits which can be operated independently by LSM companies under subcontracts of formalization. Likewise, in the reduced intrusion-related gold-type deposit of Gramalote, there is a stockwork area that can be exploited in open-pit manner and peripheral areas with quartz veins and sulfides that can be exploited by underground mining methods by ASM miners under subcontract of formalization. In Perú a good example is the Barrick Lagunas Norte open-pit mining project which is an epithermal gold deposit type but in peripheral areas coal seams are exploited by ASM miners. It is also proven that it is possible to reach contract mining coexistence agreements in placer deposits where mining is done by dredging, as in the case of Mineros S.A in Bajo Cauca, Antioquia. As the type of mining depends on the characteristics of the deposit. the type of mining does not seem to pose an impediment for the achievement of coexistence agreements between ASM and LSM.

2.10. Funding

Funding for this research was provided by the National Science Foundation NSF Award #1743749.

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CHAPTER 3.

VALUING INVESTMENTS IN THE FORMALIZATION OF ASM MINERS: THE CASE OF GRAMALOTE GOLD PROJECT IN COLOMBIA

A paper submitted to the Resources Policy Journal

Felipe Rodríguez-Novoa[4,5], Elizabeth Holley[4]

3.1. Abstract

An increasing number of coexistence cases between Large Scale Mining Companies (LSM) and Artisanal and Small-Scale Mining (ASM) communities have been reported in the developing world. This paper applies a previously published valuation model which incorporates the risk associated with project suspension from social conflict into a mining project's net present value (NPV). The LSM company, owner of the mining project, has invested in formalization of ASM miners present in its mining title areas as part of a strategy of coexistence between ASM-LSM. We found that these types of investments are minimal in comparison with the investments required to reduce technical risks. We conclude that the application of ASM-LSM coexistence strategies can reduce the risk associated with social conflicts, add value to mining projects, and strongly impact the project´s NPV. Nevertheless, it is necessary to continue to manage the coexistence processes in the long run in order to mitigate this type of risk. Furthermore, we conclude that investments in formalization of ASM miners are an opportunity to engage with ASM communities, enabling a social license to operate for LSM while protecting ASM livelihoods.

[4] Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, United States.
[5] Primary researcher and author , corresponding author

3.2. Introduction

There is a growing appreciation that unmitigated social risk in large-scale resource extraction translates to financial consequences for the company and negative impacts for communities (Franks et al., 2014; Davis and Franks, 2014; Thomson, 2016; Teschner and Holley, 2020). Particularly in the global south, Artisanal and Small-Scale Mining (ASM) can be a large source of social risk to large-scale mining projects. When Large Scale Mining (LSM) companies work in areas where ASM occurs, there is a risk that the large-scale project will be halted due to social conflicts with artisanal and small-scale miners (Fritz et al., 2018; Hilson et al., 2020; Huggins, 2022;). A recent study compiled 30 instances of coexistence between ASM and LSM in Latin America alone, finding that nearly all led to some form of conflict (Rodríguez-Novoa and Holley, 2022). For example, the Marmato deposit in Colombia has a long tradition of ASM, and LSM interest in the site has led to decades of recent conflict (Holley et al., 2019; 2022; Delgado et al., 2022). In other cases, such as Rio Blanco, Tambo Grande, and Mina El Toro in Perú, and Mineros del Chocó S.A., in Chocó Region in Colombia, conflict between LSM and ASM miners has led to loss of access to the area for the LSM operators (Holley et al., 2022; Rodríguez-Novoa and Holley, 2022). Furthermore, fluctuations in commodity prices, changes in management, and merges and acquisitions can make negotiations between LSM and ASM miners difficult even in the short term (Thomson, 2016; Hilson et al., 2020).

In large scale mining, traditional engagement and corporate social responsibility (CSR) strategies for social risk reduction include a) Stakeholder engagement through information and social investment campaigns, and b) labor arrangements such as offers of training to people in mine-affected communities so that they eventually become employees of the LSM company. Fraser (2021) showed that is possible to deliver more sustainable results when LSM companies can collaborate with communities to invest in and resolve shared problems by reframing

stakeholder engagement to identify opportunities for both parties to benefit. Furthermore, this study concludes that the common interest in water could be conflictive but also creates opportunities to build joint solution giving the opportunity to LSM companies to contribute to the sustainable development and reduce the risk of social conflict-induced project suspension. Coexistence agreements between LSM and ASM operators are a contractual approach to identify, establish, and maintain this type of mutual benefit (Rodríguez-Novoa and Holley, 2022).

The authors of the present study envision coexistence between ASM and LSM as the capacity to build synergies and operate peacefully together at the same ore deposit, at the same time, at different scales, while respecting the livelihoods of the people involved in ASM, as well as the rights and obligations of the LSM company to its shareholders and the legal jurisdictions in which it operates (Rodríguez-Novoa and Holley, 2022). Particularly in Colombia, LSM companies are increasingly employing coexistence strategies in an attempt to mitigate social risk and avoid the suspension of mining projects. The most common modality is geologically-driven ASM – LSM formalization subcontracts, in which the LSM company allots an area within its title for ASM operators to mine. This is similar to the model of 'autonomous co-existence' introduced by Hilson et al. (2020) in which ASM is supported through policy reform and access to geological information in order to operate in separate spaces from LSM. A key aspect of the success of this model is that it integrates the geological and other technical constraints with the historical and cultural context of the ASM communities involved in the activities to preserve their livelihoods (Holley et al., 2019). In Colombia, this model has been adopted by several LSM companies: Gran Colombia Gold (GCM) has sub-contracts of formalization with ASM operators at their Segovia and Remedios operations, as does Continental Gold at their Buriticá operation, as does Royal Road Minerals at its Nariño exploration areas. This paper focuses on the sub-contract of formalization between the LSM company Gramalote Limited and the ASM company La María S.A.S. (Simplified Stock Company, by its acronym in Spanish). Although the strategy has helped ensure progress of the

LSM projects, it has a high financial cost for LSM companies, particularly related to providing technical and financial support for ASM miners to conduct the formalization process.

Large Scale Mining (LSM) companies usually consider investments made in coexistence strategies as a cost burden to the project. Instead, we propose that such expenses could be considered investments that ultimately offer a financial benefit if the strategy ensures project continuity or reduces the risk of project abandonment due to conflict. It is well accepted that LSM companies spend millions of dollars to reduce the technical risk of the projects in exploration to feasibility stages, such as structural, geotechnical, geology, and resource estimation risks (Environmental Resources Management, 2016; Rio Tinto, 2011; Upton, 2016; Mitchell, 2019). Such expenditures are usually easy to justify to shareholders. On the other hand, it can be difficult to obtain funds to reduce social risks in exploration stage projects. This paper addresses the need to demonstrate the value of social risk reduction practices to shareholders, markets, and decision-makers.

This contribution comprises a case study of coexistence between ASM and LSM efforts at Gramalote, Colombia. In 2019, Gramalote agreed to provide legal and technical support for the formalization subcontract and the ASM transition to underground mining as part of a coexistence agreement. The paper explores the mining history, community context, and the interactions between LSM and ASM including the 2019 coexistence agreement. In order to show the financial impact of the coexistence agreement for the LSM company, the paper applies a previously published valuation model which quantifies the relationship between social risk and the NPV of a mining project, adapted from Teschner and Holley (2020).

Gramalote is an LSM gold project in Colombia, owned by Gramalote Limited, a 50/50 Joint Venture between AngloGold Ashanti (AGA) and B2gold. In 2020, B2gold became the manager of the project. When operational, Gramalote is planned to be Colombia's first large-scale open-pit gold mine. Approximately 500 artisanal miners operated on Gramalote Hill before the arrival of AGA and before the company announced the discovery of a deposit exploitable at

large scale. For the project to move to the construction stage, Gramalote must comply with the requirement of Corporación Autónoma Regional de las Cuencas de los Ríos Negro y Nare (CORNARE), which is the environmental permitting authority in Colombia, regarding the relocation of the Providencia community settled in the area of direct influence of the project (ADIP) and the relocation of the ASM miners operating in the Gramalote Hill (Garagan et. al., 2019). This case study allows us to explore how investing in the ASM communities will financially impact the project from the large-scale miner's perspective.

3.3. Methods

The present article draws on literature review for the case history of Gramalote project through data gathering from several sources including press releases, technical reports and sustainability reports of the LSM companies forming the Joint Venture (JV) of Gramalote; AngloGold Ashanti and B2gold Corp. We also draw on public reports from local environmental and mining authorities, such as the Environmental Impact Assessment (EIA) report, the mining plan of the project and interviews with former and current employees of the company were held, as well as site visits conducted by the author between 15th of July and 5th of August 2022

3.3.1. The Teschner and Holley Decision Tree Valuation Model

The Decision Tree Valuation Model proposed by Teschner and Holley (2020) provides investors with an estimate of monetary risk to the company based on stakeholders' concerns and expectations. In the model, a series of decision trees are applied to a project's Discounted Cash Flow (DCF) and a social risk-adjusted NPV is calculated based on the likelihood of project suspension and the potential for lost opportunities. According to the model, a suspended project requires no further funds, and it is impossible to recover additional revenues. Closure costs should therefore be included in the DCF model as development costs. Additionally, abandonment costs are assumed to be zero, so that if a project has to be suspended, it has no value in salvage or for sale. Each year's decision value should include these values when they

are not zero. As part of this model, the risk of a mining project being suspended due to social conflict is incorporated into its valuation, and stakeholders' perspectives are taken into account together with all other technical factors.

Using Equation (3.1), the model calculates Net Present Values (NPV) for each project year., where The NPV of the mine if it was forced to suspend operations at the end of year x is Vx, f_{NPV} is the NPV function (discounted at the cost of capital) and C_x is the cash flow for year x expressed in currency units. As a result of a project suspension at the end of year x, these possible outcome values are kept in the model. When the project is halted, all costs for that year are assumed to have been spent and all revenues have been recovered.

$$V_x = f_{NPV}\,(C_A, \ldots C_{-1}, C_0, C_1, \ldots C_Z) \tag{3.1}$$

Based on the cash flow of the project, the model constructs a decision tree. In each year, the project may suspend or continue operations. P_x is the probability that a social conflict event will cause a venture to suspend in each project year. Thus, the weighted average of all future outcomes is the social conflict risk-adjusted net present value of the project at any given time.

Q_x is the probability that the project will advance through project year x. This probability is calculated by multiplying the likelihood that the venture will reach the project year by the likelihood that it will not be halted during that year. These values can be calculated using Equation (3.2). Q_z is the likelihood that the project reaches its full designed life. It is calculated using Equation (3.3). The Q_x values increase as the project advances and past decision points are removed from the calculation.

$$Q_x = Q_{x-1}(1 - P_x) \tag{3.2}$$

$$Q_z = 1 - \sum_{i=A}^{Z-1} Qi \tag{3.3}$$

Taking the product of the likelihood that a project reaches a target year (S1) as well as the likelihood that it is suspended in that year (S2), a modeler can calculate the likelihood of an

operation being suspended in that year (S_x). (Equation (3.4)). Hence, the accumulation of all S_x values represents the likelihood that the project will be suspended due to social conflict in the course of the analysis period.

$$S_x = Q_x P_x \tag{3.4}$$

A social conflict-induced-suspension risk (R_x) is calculated using these values. In any given year x, R_x refers to the amount of risk that is reduced as the project advances from year x to year x+1 (Equation (3.5)). A project's total social-conflict-induced-suspension risk (R_{total}). is represented by the sum of all future R_x values. (Equation (3.6)). In other words, R_{total} can be described as the 'risk cost' associated with the project's social conflict conditions. It is equivalent to the conventional, DCF NPV (or V_z) less the social conflict risk-adjusted NPV.

$$Rx = \frac{\sum_{i=x+1}^{Z} ViSi}{\sum_{i=x+1}^{Z} Si} - \frac{\sum_{i=x}^{Z} ViSi}{\sum_{i=x}^{Z} Si} \tag{3.5}$$

$$Rtotal = \sum_{i=A}^{Z} Ri \tag{3.6}$$

The model proposed by Teschner, and Holley (2020) suggests that the project's financial value can be equally improved by reducing the chance of company-community conflict (P_x). There are two approaches proposed to find P_x; the first one is the *suspension likelihood as a function of the project stage*. It is based on the study of Davis and Frank (2014). During the study, 50 prolonged conflicts between companies and communities were examined as part of the report, they noted both the stage of the mines and whether there was any suspension or abandonment of mining-related activities as a result of the conflict. Using this study, we can determine the likelihood of suspension if a company-community conflict occurs at a particular stage (Ps) and is half of the P_x value. To determine the value of P_x, one must determine the likelihood that conflict will arise in the first place (P_c). P_x results by the result of the product of the two sub-variables results. $P_x = P_c \,.\, P_s$.

The second approach is called *uniform suspension likelihood*, this approach is not stage-dependent and applies to a uniform P_x value over the project´s life. Based on the cash flow of the project, the model constructs a decision tree, for this reason, it is applicable to projects that count with at least a Preliminary Economic Assessment (PEA) or projects in pre-feasibility, feasibility, or more advanced stages.

In this study the *stage-dependent approach* will be applied to calculate the social conflict-induced-suspension risk (R_x) for the Gramalote project. The application of this model to the coexistence processes in the early stages of the mining cycle is useful to quantitatively assess the impact of stakeholder influence on the valuation of the project, as well as expenditure on stakeholder coexistence agreements.

3.4. Study Area.

The Gramalote Deposit is located In Colombia, in the Department of Antioquia, 230 km northwest of the Colombian capital of Bogota and 80 km northeast of the Antioquia capital Medellin. Access to the project site can be made by paved road. Depending on the weather and traffic conditions the trip from Medellín takes approximately 3 hours (100 km by road) and from Bogotá approximately 8 hours (410 km by road).

The Gramalote gold deposit is hosted in the Late Cretaceous Antioquia Batholith (Cediel and Cáceres, 2000 and Cediel et al, 2003). The deposit is hosted in rocks which range from granodiorite to tonalite. It also has small dioritic dikes and the mineralization is not associated with a specific type of lithology.

Major lineaments within the batholith are generally west-northwest through northwest-trending and record rotation and sinistral shearing events. Subordinate zones of north-south extension and northeast-striking shear are related to the regional sinistral shear patterns and appear to provide an important control of the occurrence, shape and distribution of the hydrothermal alterations and gold (± Cu, Mo, Pb, Zn, Ag) mineralization of the Gramalote

Deposit. The Gramalote deposit local scale lineaments are controlled by the Nus River valley Lineament to the north, and the Cristales Shear Zone to the south. (Garagan et al., 2019, Rodríguez, 2009).

The hydrothermal alteration and mineralization of the Gramalote deposit are entirely structurally controlled. The main alteration is restricted to small selvages – from millimeters to a few centimeters – of K-feldspar or sericite. The selvages are around sheeted veinlets and veins that range from a few millimeters to 15 cm. wide. Free gold occurs as argentiferous gold coeval with several tellurides and bismuth sulphosalt minerals. The silver to gold ratio is approximately 1:1. In situ saprolite mineralization is found above fresh mineralization. The saprolite mineralization thickness varies from five meters to 50 meters, was actively mined by ASM miners and represents a small percentage of the total mineralization (Garagan et, al., 2009).

The Gramalote deposit is an example of structurally controlled, intrusive-related gold deposits. (Garagan et al., 2019, Rodríguez, 2009). Importantly, for the context of this study, the mineralization is characterized by high grade veins which are amenable to exploitation by ASM, which are contained within a larger zone of disseminated mineralization which makes the deposit attractive to large-scale exploitation. The mineralization is strongly structurally controlled, and spatially related to highly differentiated granitoid intrusions. Sheeted veins are planar and often parallel to regional structures. The veins are generally extensional with no offset of walls, although some vein systems may also include shear-hosted veins. Relatively restricted alteration zones are most obvious as narrow alteration selvages along the veins. The alteration generally consists of the same non-sulphide minerals as occur in the veins, typically albite, potassium feldspar, and biotite **(**Lefebure and Hart, 2005). It is important to note that this type of structurally controlled mineralization allows the development of sectors of stockwork where the density of veins and veinlets are higher and can be treated as a disseminated deposit that can be mined as an open pit using LSM mining techniques. Likewise, other sectors where narrow spaces were mineralized in single veins that are not as amenable to open pit or

underground LSM techniques. These sectors are more suitable for ASM mining that handles much lower production costs and minor dilutions because they do not use heavy machinery and the tunnel developments do not generate as much dilution.

3.5. History

The total area of indirect influence of the project (AIIP), defined by the Environmental Impact Assessment (EIA), is about 1,859 km², and it has a population of 56,175 inhabitants located in the Municipalities of Maceo, San Roque, Cisneros, and Yolombó. These four municipalities are part of two important subregions of Antioquia: Middle Magdalena Valley (MMV) and Northeast Antioquia. San Roque, Maceo, and Cisneros share characteristics that allow group them as the municipalities of the Nus area (Integral, 2015)

The Area where the Gramalote deposit was discovered has been subject of gold mining from Pre-Colombian times to present day. The human occupation of the Gramalote project area of influence has been driven mainly by gold mining, the Antioquia Railway construction, political violence in the 1950s, and finally the emergence of new economic activities, such as agricultural or the execution of infrastructure projects. During the 19th century, the boom in the exploitation of gold in northeast Antioquia was the force that drove the settlement, favoring the arrival of Black slaves, Indigenous and mestizos, as laborers to mine gold. Between the late 19th and early 20th centuries, the construction of the Antioquia Railway gave life to the current municipalities of Santo Domingo, San Roque, Cisneros, Maceo and Caracolí. From the 50s, two events of violence occurred that facilitated migration out of this territory. The post-WW-II global crisis caused the temporary decline and stagnation of mining activity, and on the other hand, the beginning of the bipartisan political violence of the mid-twentieth century, which lasted until the end of the 1970s. Between 1990 and the mid-2000s there was an unprecedented escalation of violence in this territory (Jaramillo y Londoño, 2018). In the specific case of San Roque, the

location of paramilitary training camps produced almost complete rupture of the social fabric, sowing fear and hopelessness (Jaramillo y Londoño, 2018; Integral, 2015)

The intensely dynamic history of territory, settlement, and repopulation in the region has led to a varied population. The region is home to traditional settlers working in agriculture, gold mining and other existing economic activities. Traditional peasants, who are small farmers dedicated to subsistence agricultural activities, come from areas such as Southwest Antioquia, North Antioquia, and a few from the East of Antioquia. There are also traditional cattle ranchers, farmers from the Middle Magdalena and some areas of Cordoba, who settled on the banks of the river. Finally, more recent migrants focused on gold extraction have temporarily settled in mining areas.

Sugarcane farming is one of the main agricultural activities in the vicinity of Gramalote. This is an important economic activity that creates jobs from the processing of sugarcane. The main derivative from this activity is the production of *panela*. A large number of families in the villages that make up the ADIP depend on this activity, showing the strong economic vocation related to this activity and the use of the land given for years (Integral, 2015). Extensive cattle farming is practiced in the area, large tracts of land are used to raise livestock, but the employment it generates is minimal.

The community of Providencia represents the population that lives in the properties that will be totally or partially required by the Project. This is the closest community to the project. This community emerged, with the arrival of workers for the construction of the Railway and the construction of one of its stations, in the middle of large farms dedicated to cattle activities owned by companies or landed aristocracy. Providencia is a place of commercialization preferred by the mining groups of the area of direct influence, due to its location and ease of transaction. In Providencia, Gramalote Colombia registered 438 households, the average number of members per household is 3.6 people and the average number of children is 2.0 children (Integral, 2015).

The communities directly impacted by the Gramalote project were grouped into two areas, *Specific Direct Area of Influence (*AIDP) and *Area of Direct Local Influence* (AIDL) in the Environmental Impact Assessment of the project (Integral, 2015). The area of influence incorporates the geographical space in which the components of the abiotic, biotic and socioeconomic environments would be potentially affected by the construction and operation of the project. The *Area of Direct Influence* (AID) is the area where it is expected to be affected by the project activities on the different systems that comprise a territory: abiotic, biotic and socioeconomic, as well as the interrelationships between them. For the socioeconomic environment, the AID was divided into two: *Specific Direct Area of Influence* (AIDP) and *Area of Direct Local Influence* (AIDL), depending on the degree and form of involvement. The AIDP Refers specifically to the population that lives in the properties that will be totally or partially required by the Project, and to the areas whose population develops economic activities (harvesters, miners, or other activities) that will be directly affected by the construction or operation of the Project. The AIDL are villages and localities close to the project that, although there are no specific impacts generated by the activities and project works, can be affected by different factors. The AIDL includes in its analysis the characteristics of the AIDP, allowing to differentiate the population that lives in the properties required by the Project and that it will be necessary to resettle, always having as an element of analysis of the territorial context of which it is part (village, locality, or sector).

3.5.1. Artisanal and Small-Scale Miners.

Artisanal and small-scale gold mining is one of the most significant economic activities in the ADIP. In the Gramalote Hill zone, a stockwork mineralization style zone is also oxidized and was for many years hydraulically mined to mobilize ore by gravity into an *entable* (ASM processing plant) powered by hydraulic power. In 2015, Gramalote Limited identified 139 working groups dedicated to ASM mining in the IDIP. At that time half of this population (47.5%)

was located in Gramalote Hill mining about 10cm wide, steeply dipping quartz veins with gold grades averaging of about 10 grams/tonne where the main gold deposit of the project is located. In recent years, the presence of artisanal miners has increased in the area of the LSM mining project and surveys dated 2019 indicated approximately 660 miners were active in the area. Forty percent of these miners were occupying the ADIP such as the Gramalote Ridge (Garagan et. al., 2019). Production of gold from alluvial deposits throughout the Nus River valley is also common since the 20th century (Garagan et. al., 2019). The LSM mining company is interested in mining the Gramalote Hill area (bulk tonnage, low-grade), and the agreement with the ASM miners involved a relocation (under the Sub-contract of Formalization model) into an area of vein-style mineralization for ASM miners to work.

3.5.2. The Mining Companies.

The LSM owners of the project are the Senior South African gold producer AngloGold Ashanti (AGA) and the Canadian mid-tier B2Gold in a 50-50 joint venture. The operator is currently B2Gold. Both LSM companies are listed on London, Canadian, and US stock exchanges, among others. Since the 1990s several exploration companies visited the area, but exploration conducted by AGA from 2002 to 2007 ended in the declaration of the discovery of the deposit in 2009 (B2gold., 2009). In 2008 B2gold acquired 51% of the project (AGA retaining 49%) to create the Gramalote Colombia Ltd Joint Venture (Gramalote JV) and the project continued into pre-feasibility under the management of B2gold. In addition, AGA transferred its interests in additional claims contiguous to the original Gramalote property to the Gramalote JV. By 2010, AGA regain the management of the project to perform feasibility studies while B2Gold retained a 49% interest in the JV. In 2017, Gramalote Colombia Ltd managed by AGA completed a detailed project assessment. B2Gold elected to only fund $5.0 million of the 2018 Gramalote Project and reduced its interest in the JV to 48.3%. In 2020, after negotiations to modify the Shareholder’s Agreement with AGA, B2gold agreed to fund the first $13.9 M of

expenditures to increase its ownership from 48.3% to 50% and became the manager of the project. B2gold has also indicated its intention to enter the construction phase (Garagan et al., 2019, B2Gold, 2019).

3.5.3. Other Stakeholders.

In the AIIP, in the neighboring municipality of Cisneros, the LSM company Antioquia Gold has its Cisneros Gold Mine. Antioquia gold is listed on the Toronto Stock Exchange. Its largest shareholders are Consorcio Minero Horizonte, and its main shareholder capital is of Peruvian origin. This mine is in the operation stage and has a plant with a capacity of 600Tpd that is partially fed with ore purchased from ASM miners blended with the Cisneros mine ore (Antioquia Gold Inc*.* 2019*)*. Several junior exploration companies hold exploration titles around the Gramalote project.

Other important stakeholders of the project are the mining and environmental authorities. The local government that is represented by the Government of Antioquia, which has a delegation for mining contracting and entitling, supervision, monitoring and control of mining titles, exploration and exploitation work granted by the National Mining Agency, (resolution 810 of December 28, 2021). Through the Government of Antioquia's Secretariat of Mines, it acts as a mining authority within the department of Antioquia. The regional environmental authority is exercised by CORNARE and since it is an LSM Project, The National Environmental Licensing Authority (ANLA) is the one that has the jurisdiction of environmental licensing for the project.

3.6. Stakeholder Engagement

Gramalote Colombia Ltd has made several attempts to gain access to Gramalote Hill by engaging with its stakeholders. The first negotiations with the group of ASM miners working on the hill were made around 2011 when AGA was the project manager. In this first attempt the company’s strategy was an alternative livelihood program with two options. ASM miners could choose to either 1) receive employment in the LSM company or 2) receive financial support

from the LSM to undertake other businesses instead of mining. This program did not achieve the desired results. ASM miners who tried to start other business mostly failed, due to lack of knowledge on how to manage a business or by lack of market to sell the products, and some returned to mining at Gramalote Hill. For the group of ASM miners who took the option of becoming employees of Gramalote Colombia, it was difficult to operate under the working conditions demanded by the company, and some did not comply with the schedules or meet the standards of industrial safety. This group of ASM miners formed the first union of workers of Gramalote Colombia and started a protest to demand better working conditions, salaries, and shifts that lasted several days, delaying the exploration activities of the company. After legal action brought by the company, this protest was declared illegal and the employees who participated in it and who belonged to the union were dismissed.

3.6.1. Conflicts

AngloGold Ashanti Colombia started exploration activities around the Gramalote project in 2003. Other companies reviewed the area previously in the nineties but did not conduct advanced exploration activities such as systematic soil sampling or core drilling. During the first stages of exploration, there were no serious conflicts that stopped the operations of the LSM company. Permits for surface mapping, soil sampling, and exploration drilling were always performed by the LSM company, with no disruptions due to social conflict.

Conflicts began to appear in more advanced stages of exploration when the company, under the management of AGA, decided to move towards feasibility and construction of the project in 2011. At that point it was necessary to access Gramalote Hill by reaching an agreement with the artisanal and small-scale miners that worked there. This strategy generated the first and only major conflict with the community which ended in the suspension of the company's operations for several days from 2nd of September 2017 to the 20th of September 2017 (El Tiempo, 2017). There was material damage to the company's facilities, and some

company workers were held hostage. After this conflict, some other episodes of discordance between the company and the community occurred, but none of these episodes had a strong impact on the operation of the company or has led to the suspension of operations or material damage.

3.6.2. The Coexistence Agreement with ASM

After this negative experience, Gramalote Colombia Ltd changed its relationship strategy with the artisanal and small-scale miners. With the obligation imposed by CORNARE when delivered the Environmental License, Gramalote Colombia implemented and developed a pilot coexistence plan through the Mining Formalization Plan. This plan began in 2018 and is being developed with a group of miners formalized in 18 Mining Production Units.

The commitment of Gramalote Colombia to this first group of miners includes technical, financial and legal support in creating formal small mining companies. For example, Gramalote Colombia helped the miners prepare and obtain environmental permits (EIA) and draft mining plans. They also provided technical training in safety and mining as well as metallurgical analyses for gold processing alternatives and they designed and constructed a community processing plant. Finally, they helped the community draft a community business model.

La María S.A.S. is a ASM company established to bring together ASM miners located in the ADIP of Gramalote. This is a formal mining company that received an area within the mining title of Gramalote that the LSM company ceded under a contractual modality included in the Colombian mining law called "*Sub-contratos de Formalización*" (Formalization Subcontracts). Under the agreement, the company relinquishes a specific portion of one of its mining titles to develop an ASM mining project. This area will be under contract for 4 years and at the end of this period, the agreement can be finished, reviewed, or extended for four more years. The agreement reached with La María S.A.S. also includes technical support in the areas of, geology, mining, metallurgy, engineering, and legal also the agreement included financial

support to start and maintain their operations. There is commitment of the company to build a processing plant when Gramalote Colombia Ltd starts the construction stage of LSM development. To date, the ASM of La María SAS sell their ore to nearby medium-scale mining company Antioquia Gold.

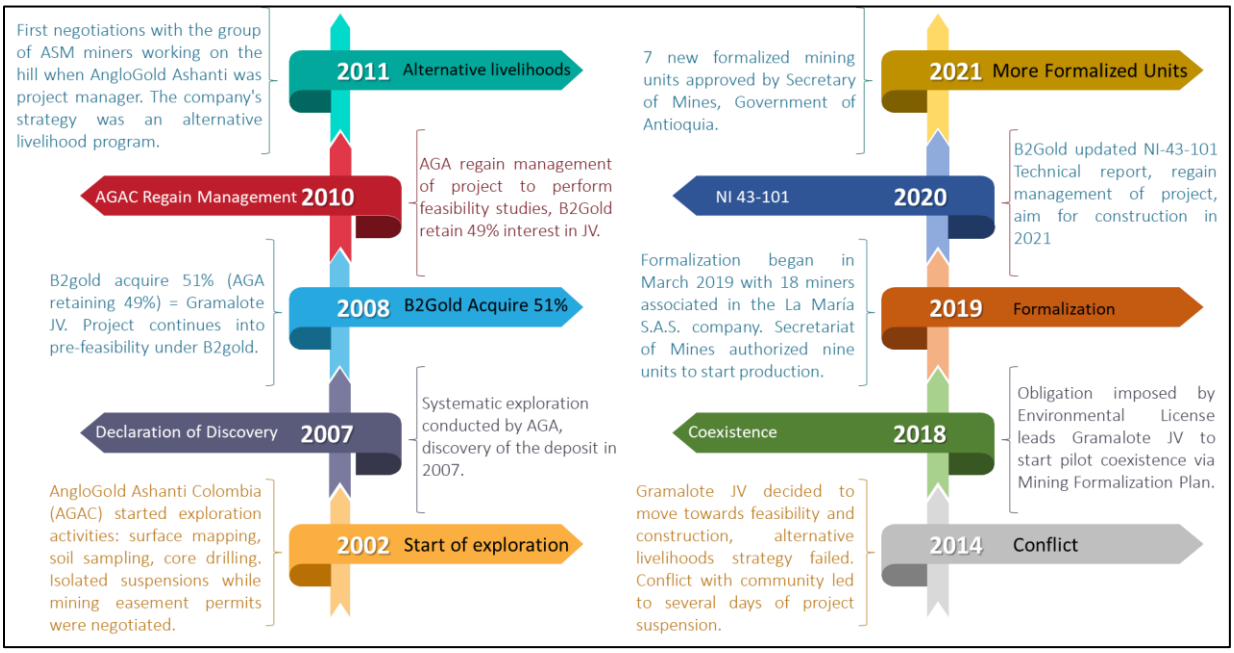

Figure 3.1 Timeline of the Gramalote Project.

3.7. Modeling.

3.7.1. Gramalote Financial Economic Assessment.

In 2020 B2Gold updated its NI-43-101 technical report, a feasibility study format which is required by publicly traded mining companies on the Toronto stock exchange. The report included a new financial economic assessment for the Gramalote Project. The pre-tax (Figure 3.2 and Table 3.1) and after-tax (Figure 3.3 and Table 3.2) DCF at a discount rate of 5% were calculated using the annualized cash flow values released by B2gold in the 2020 technical report. The results are slightly different of those presented in the technical report. B2gold calculated a pre-tax $NPV_{5\%}$ of $1,027 million while the calculated pre-tax $NPV_{5\%}$ on this study is $1,002.6 million. The after-tax $NPV_{5\%}$ calculated by B2gold is $671 million while the After-Tax

$NPV_{5\%}$ calculated in this study is $654.7 million. The After-Tax IRR does not vary between the two calculations.

3.7.2. Decision Tree Valuation Model Application.

The pre-feasibility study released in 2020 (Garagan, 2020) estimates that the construction costs would be $900 million, the payback period is 3.6 years, and the mine would have 14 years of life. The project also considers eight years for closure. To apply the Decision Tree Valuation model to the Gramalote project, the first step is to calculate the chance that a social conflict event will force it to suspend in that year (P_x). This study applies the *stage-dependent approach* in order to calculate P_x, using Davis and Franks' statistics to obtain P_s and an estimated value of 0.10 for Pc. This study identified only one major conflict (2nd of September 2017 to the 20th of September 2017) in the time period between 2010 when AngloGold Ashanti announced that it would be advancing the project to the feasibility stage, and 2020 when B2gold completed the pre-feasibility study, In this case, P_c was calculated by dividing one major LSM company – ASM community conflict event by the ten-year period prior to the release of the pre-feasibility study.

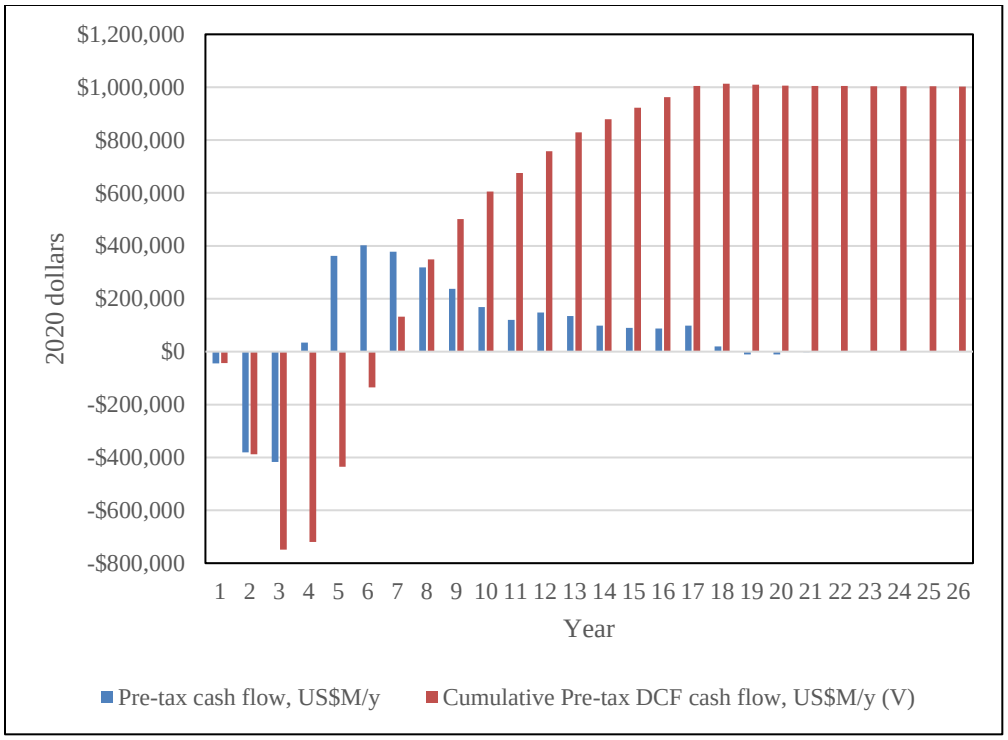

Figure 3.2 Gramalote pre-tax cash flow at 5% IRR.

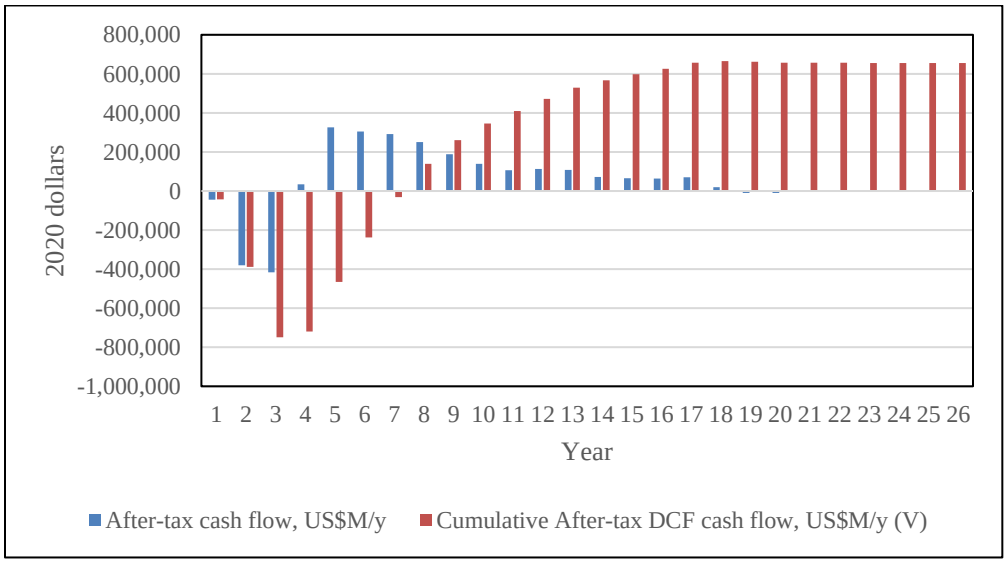

Figure 3.3 Gramalote after-tax cash flow at 5% IRR.

Table 3.1 Pre-tax DCF calculation for Gramalote Project. Modified from the cash flow forecast reported by B2gold (Garagan, 2020).

PRE-TAX DCF CALCULATION

Discount rate 5.0%

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Pre-tax cash flow, US$x1000	-$44,984	-$380,700	-$416,798	$34,739	$362,476	$401,771	$377,943	$318,592	$237,729	$168,371	$120,731	$147,782	$134,674
NPV factor	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530
Pre-tax DCF, US$x1000	-$42,842	-$345,306	-$360,046	$28,580	$284,009	$299,808	$268,597	$215,636	$153,242	$103,365	$70,589	$82,291	$71,420
Cumulative Pre-tax DCF cash flow, US$x1000	-$42,842	-$388,148	-$748,194	-$719,614	-$435,605	-$135,797	$132,800	$348,436	$501,678	$605,043	$675,632	$757,923	$829,343

Year	14	15	16	17	18	19	20	21	22	23	24	25	26
Pre-tax cash flow, US$x1000	$98,254	$89,309	$87,875	$98,588	$19,757	-$10,354	-$10,229	-$2,402	-$1,203	-$1,203	-$1,203	-$1,203	-$1,353
NPV factor	0.505	0.481	0.458	0.436	0.416	0.396	0.377	0.359	0.342	0.326	0.310	0.295	0.281
Pre-tax DCF, US$x1000	$49,625	$42,959	$40,257	$43,014	$8,209	-$4,097	-$3,855	-$862	-$411	-$392	-$373	-$355	-$381
Cumulative Pre-tax DCF cash flow, US$x1000	$878,968	$921,927	$962,184	$1,005,197	$1,013,407	$1,009,309	$1,005,454	$1,004,592	$1,004,181	$1,003,789	$1,003,416	$1,003,061	$1,002,680

Pre-Tax Net Present Value (NPV), US$M $1,002,680

Pre-Tax IRR 23.2%

Table 3.2 After-tax DCF calculation for Gramalote Project. Modified from the cash flow forecast reported by B2gold (Garagan, 2020).

AFTER-TAX DCF CALCULATION

Discount rate: 5.0%

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
After-tax cash flow, US$x1000	-$44,984	-$380,700	-$416,798	$34,739	$325,343	$304,570	$291,085	$250,719	$189,039	$139,153	$107,028	$113,465	$107,876
NPV factor	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530
Pre-tax DCF, US$x1000	-$42,842	-$345,306	-$360,046	$28,580	$254,915	$227,275	$206,869	$169,696	$121,856	$85,428	$62,577	$63,182	$57,209
Cumulative Pre-tax DCF cash flow, US$x1000	-$42,842	-$388,148	-$748,194	-$719,614	-$464,699	-$237,424	-$30,556	$139,141	$260,997	$346,425	$409,002	$472,183	$529,392
Year	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
After-tax cash flow, US$x1000	$72,672	$65,097	$63,210	$70,758	$19,757	-$10,354	-$10,229	-$2,402	-$1,203	-$1,203	-$1,203	-$1,203	-$1,353
NPV factor	0.505	0.481	0.458	0.436	0.416	0.396	0.377	0.359	0.342	0.326	0.310	0.295	0.281
Pre-tax DCF, US$x1000	$36,704	$31,313	$28,957	$30,871	$8,209	-$4,097	-$3,855	-$862	-$411	-$392	-$373	-$355	-$381
Cumulative Pre-tax DCF cash flow, US$x1000	$566,097	$597,410	$626,367	$657,238	$665,448	$661,350	$657,495	$656,633	$656,222	$655,830	$655,457	$655,102	$654,721

After-Tax Net Present Value (NPV), US$x1000	$654,721
After-tax IRR	18.1%

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3.7.3. Adjusted Valuation for the Gramalote Project.

The value calculated for P_x was 0.04 for the construction stage and 0.01 for the operation stage by combining Davis and Franks´ statistics (P_s) and the likelihood that conflict will occur in the first place (P_c) obtained by the analysis of the history of the project. The model determines a total social risk (R_{total}) of $892.8 million for Gramalote during the whole life of the project including closure. The pre-tax social conflict risk-adjusted NPV at 5% discount rate is $109.9 million (See Table 3.3).

Table 3.3 Risk-adjusted Pre-tax DCF Calculation for Gramalote Project at a Discount Rate of 5%.

Risk-Adjusted Pre-tax DCF calculation

Discount rate **5.0%**

Stage	Construction	Construction	Construction	Construction	Operation	Operation	Operation	Operation	Operation	Operation	Operation	Operation	Operation
Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Pre-tax cash flow, US$x1000	-$44,984	-$380,700	-$416,798	$34,739	$362,476	$401,771	$377,943	$318,592	$237,729	$168,371	$120,731	$147,782	$134,674
Cumulative Pre-tax DCF cash flow, US$x1000	-$42,842	-$388,148	-$748,194	-$719,614	-$435,605	-$135,797	$132,800	$348,436	$501,678	$605,043	$675,632	$757,923	$829,343
Ps	0.44	0.44	0.44	0.44	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Pc	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Px	0.04	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Qx	0.96	0.91	0.87	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77
Sx	0.0421	0.0402	0.0384	0.0368	0.0074	0.0074	0.0073	0.0073	0.0072	0.0071	0.0071	0.0070	0.0069
Rx Risk in project Year	$24,270	$93,559	$201,652	$282,840	$60,283	$49,869	$39,678	$31,058	$24,952	$21,107	$18,872	$15,286	$11,792

Stage	Operation	Operation	Operation	Operation	Operation	Closure	Closure	Closure	Closure	Closure	Closure	Closure	Closure
Year	14	15	16	17	18	19	20	21	22	23	24	25	26
Pre-tax cash flow, US$M/y	$98,254	$89,309	$87,875	$98,588	$19,757	-$10,354	-$10,229	-$2,402	-$1,203	-$1,203	-$1,203	-$1,203	-$1,353
Cumulative Pre-tax DCF cash flow, US$x1000	$878,968	$921,927	$962,184	$1,005,197	$1,013,407	$1,009,309	$1,005,454	$1,004,592	$1,004,181	$1,003,789	$1,003,416	$1,003,061	$1,002,680
Ps	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Pc	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Px	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Qx	0.76	0.76	0.75	0.74	0.74	0.73	0.72	0.72	0.71	0.70	0.70	0.69	0.68
Sx	0.0069	0.0068	0.0067	0.0067	0.0066	0.0066	0.0065	0.0064	0.0064	0.0063	0.0063	0.0062	0.0062
Rx Risk in project Year US$x1000	$9,376	$6,961	$4,125	$43	-$1,015	-$698	-$268	-$198	-$191	-$186	-$183	-$191	$0

R_{total} Total social Risk US$x1000	$892,792
Pre-tax Net Present Value (NPV), US$x1000 (Vz)	$1,002,680
Social Conflict Risk Adjusted NPV US$x1000	**$109,889**

3.8. Discussion.

Applying the decision tree model shows that the risk is higher during the second and third years of construction when it reaches a peak. At this point, the joint venture would have invested 842.5 million dollars, would have not yet seen any return and the chance of suspension would be relatively high (See Figure 3.4).

Since the company decided to enter into the coexistence agreement with the ASM miners, there have been no conflicts that have led to delays or stoppage of the project. The coexistence strategy has facilitated LSM access to Gramalote hill and enabled the development of exploration and engineering activities to advance. Based on this study's results, the investment made by the LSM company in the coexistence strategy result in a reduced risk for the company valued at $892.8 million ($R_{total}$) thus, adding value to the project. While it is impossible to completely eliminate the risk of social conflict with ASM miners, according to this model, the coexistence process will help minimize the risk of conflicts and manage it in the long run.

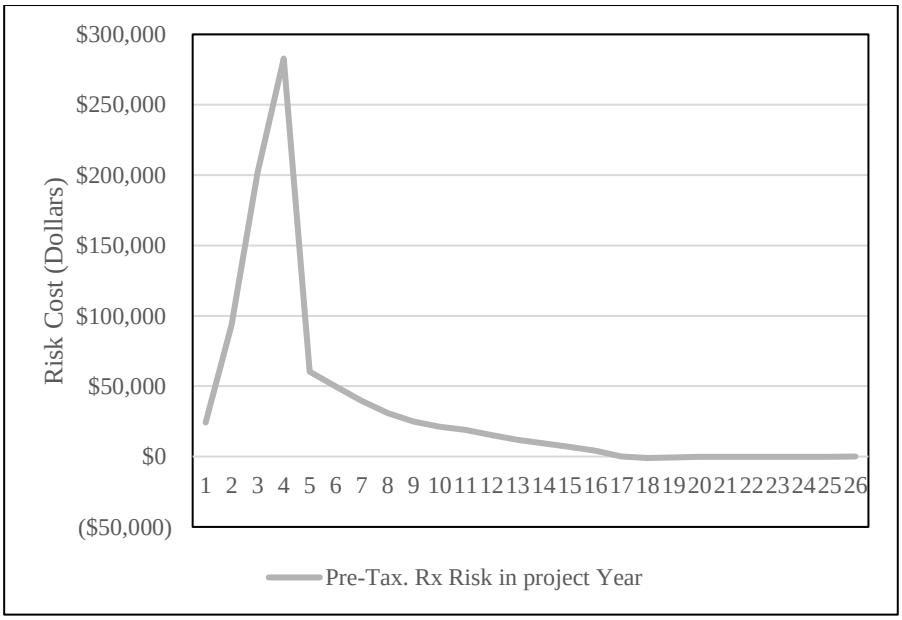

Figure 3.4 Pre-tax. R_x risk in a project year.

Risk Analysis.

The pre-tax social conflict risk-adjusted NPV at 5% discount rate is $109.9 million, a risk analysis was performed changing the P_x probability and the discount rate by -40% to +40%. The results are shown in tables 3.4 and 3.5.

Table 3.4 Risk analysis calculations for variations of P_x between -40% to +40%

P_x	%CHANGE	PRE-TAX NET PRESENT VALUE (NPV), US$M (VZ)	RTOTAL TOTAL SOCIAL RISK US$M/Y	SOCIAL CONFLICT RISK ADJUSTED NPV	DISCOUNT RATE
0.06	-40%	$1,002,680	$ 871,360.77	$ 131,319.65	5%
0.08	-20%	$1,002,680	$ 882,115.79	$ 120,564.63	5%
0.10	**0%**	**$1,002,680**	**$ 892,791.61**	**$ 109,888.81**	5%
0.12	20%	$1,002,680	$ 903,381.04	$ 99,299.39	5%
0.14	40%	$1,002,680	$ 913,876.90	$ 88,803.52	5%

Table 3.5 Risk analysis calculations for variations of the discount rate between -40% to +40%

DISCOUNT RATE	% CHANGE	PRE-TAX NET PRESENT VALUE (NPV), US$M (VZ)	RTOTAL TOTAL SOCIAL RISK US$M/Y	SOCIAL CONFLICT RISK ADJUSTED NPV	PC
3%	-40%	$ 1,277,333.42	$ 1,078,815.51	$ 198,517.91	0.10
4%	-20%	$ 1,132,334.23	$ 980,683.81	$ 151,650.43	0.10
5%	**0**	**$ 1,002,680.42**	**$ 892,791.61**	**$ 109,888.81**	0.10
6%	20%	$ 886,562.78	$ 813,914.41	$ 72,648.37	0.10
7%	40%	$ 782,409.65	$ 742,991.00	$ 39,418.65	0.10

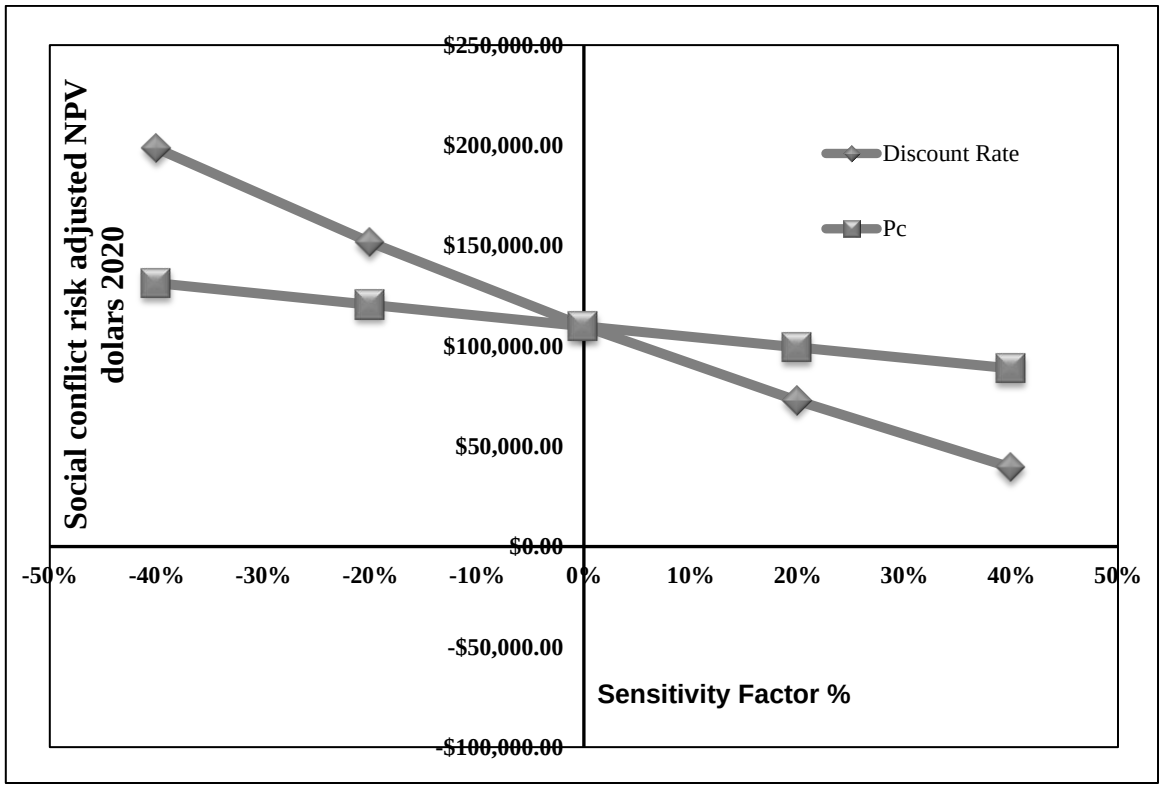

Figure 3.5 Social Conflict risk Adjusted NPV Sensitivity Analysis.

Figure 3.5 shows the variation of the social conflict risk adjusted NPV (R_{total}) of the project in both situations, by varying the P_x and by varying the discount rate. It can be

observed that the variation of R_{total} is higher in the latter. The variation of +40% in P_c represents a variation of +20% in R_{total} . Meanwhile the variation of the discount rate of +40% represents a variation of +81% in R_{total} . Therefore, the value of the risk is not as sensitive to the variation of P_x as it is to the stage of the project.

The sensitivity of the Px probability may be relatively low, but its initial impact is very significant. With a Pc of 0.10 (a conflict every 10 years), the cost of social conflict is very high. For a project with an NPV of approximately one billion dollars, the Rx cost is 900 million dollars; however, if the probability is increased, the impact does not change much. The most important thing is to avoid the occurrence of any type of social conflict because it can destroy almost completely the value of a project if it occurs. Accordingly, LSM companies should increase their budgets in order to invest in social engagement from an early stage in the mining cycle in order to reduce the possibility of conflict with local communities.

Here we compare the results of our Gramalote case study to that of the Pebble project in southwestern Alaska (Table 3.6), where Teschner and Holley (2020) first applied the social risk valuation approach. Both projects are proposed open pit gold mines exploiting intrusion-related deposits, although Pebble also hosts significant copper and molybdenum, and the total resources of gold are ~20 times larger than Gramalote. At Gramalote the primary source of conflict is access to the gold itself, and whether artisanal and small-scale miners can maintain access to ASM livelihoods. At Pebble, the conflict is centered on potential environmental impacts to Bristol Bay, which is an important subsistence, commercial, and recreational salmon fishery. In 2011 Northern Dynasty Minerals Ltd, released the feasibility study showing strong financials with a pre-tax NPV of about $6 billion and an IRR of 14% using a discount rate of 7% ((Northern Dynasty Minerals, 2011)). Exploration was conducted via a partnership between the junior company Northern Dynasty Minerals Ltd and the major mining company Anglo American PLC. The latter initiated an extensive stakeholder dialogue exercise (Holley and Mitcham, 2016) but left the partnership in 2013 after investing over half a billion dollars in the project. Application of the

social risk valuation model to the Pebble Project indicated that the conflict risk-adjusted NPV was 1.1 billion, about $4.8 billion dollars less than the traditionally determined NPV (Teschner and Holley, 2020). The Pebble project has not achieved social license and remains undeveloped (Holley and Mitcham, 2016).

In the case of Gramalote Project the company successfully managed to improve their relationship with one of the most important stakeholders by implementing coexistence agreements with ASM miners present in the area. Until now, the LSM company has avoided the impact of the social risk valued at $892.8 million. Gramalote is still undeveloped due to technical and economic factors that impact the project in the wake of the COVID pandemic. Although the future of the LSM project appears promising, there is no guarantee that any project will remain conflict-free.

For both Pebble and Gramalote, the impact of social risk on the valuation of the mining projects is very high, and the conflict risk-adjusted NPV makes both projects financially unviable. At sites such as Pebble where the chief concern is environmental impact, we suggest that the conflicts are likely to be complex and involve numerous stakeholders from many sectors (e.g., the fishing industry, environmental NGOs, local communities, tourists, and non-local advocates). Such conflicts are less likely to be resolved with a single type of negotiation. In contrast, Gramalote is an area highly impacted by gold mining since colonial times, and the conflict is between two types of stakeholders operating in the same economic sector. This comparison illustrates that not all projects will have a viable mechanism to dramatically reduce social risk, but coexistence agreements should be considered as a possible strategy at sites such as Gramalote where the conflict is centered on ASM-LSM interactions.

Table 3.6 Main technical and social differences and similarities between the Pebble and Gramalote Projects.

CHARACTERISTIC	PEBBLE	GRAMALOTE
MAIN COMMODITY	Cu and Au	Au and Ag
SIZE OF DEPOSIT	Measured and Inferred resources. 6,456,000,000Tonnes @ 0.40%Cu and 0.34g/t Au 56.92 Blibs Cu 70.57 Moz Au	Measured and inferred resources. 129,200,000Tonnes @ 0.68g/t Au and 1.01g/t Ag 2.83 Moz Au 4.2 Moz Ag
TYPE OF MINE PROPOSED	Open Pit	Open Pit
MAIN STAKEHOLDER	Salmon Fishery Industry	ASM mining industry
LOCATION	Relatively pristine ecosystems	Highly impacted ecosystem
SOCIAL LICENSE	Not achieved	Achieved In good standing
STATUS	Suspended (By the Government)	Suspended
REASON FOR SUSPENSION	Lack of Social License	Financial feasibility

The present study provides a new view into the costs and benefits of social risk reduction in mining. The mining industry is accustomed to the fact that investment in exploration and other technical aspects leads to a reduction in geological, safety, and other operational risks. These investments generate value to mining projects by reducing uncertainty and reclassifying resources from inferred resources to measured resources, in the exploration stages, with the possibility of being converted into reserves considering modifying factors such as mining, processing, metallurgy, and others, where the social factor is also included (Figure 3.6) (CIM, 2014). Lassonde (1990) developed a hypothesis that is widely accepted in the mining and financial industry: the value of a mining project fluctuates throughout the life-cycle of the Project. The Lassonde effect is more pronounced for junior mining companies that have only one project and do not have projects in production to generate cash flow. In this case the valuation of the company is a direct reflection of the value of the exploration project. The Lassonde Curve (Figure 3.7) reflects the evolution of a company's share value throughout the mining cycle. Since the Lassonde hypothesis was published in 1990, the industry and informal authors had interpreting the Lassonde curve as the reflect of the valuation of a company in response to the stage of the project (exploration and discovery, assessment, financing, construction, production and closure) (Kuching, 2020,

Gillissie's, 2021, Hughes', 2021, LePan's, 2019). Only a few of them had involved in their interpretations or modifications the concept of social risk. Trench et al., 2014, identified that in exploration, non-technical risks are relatively low, spike during feasibility and construction, then decline steadily when production begins. Following this argument Teschner and Holley, 2019 identify that many of the complications of the modern feasibility studies are due to social risks. For example, between the beginning of exploration and the discovery, the stock has the potential to appreciate more, precisely because of the high risk that this period involves. All this is based on technical or economic risk (e.g., funding or fluctuation of the commodity). We suggest that social risk must also be considered. For example, an exploration project can lose all its value due to social reasons even before reaching discovery, and the same applies for the subsequent stages. Taking into account the observations made by Davis and Franks (2013) in conjunctions with our observations at Gramalote and other sites in Colombia, the highest social risk is between pre-feasibility and construction. In Colombia, during the decade of the 2000s, several projects were discovered, such as Gramalote, Buriticá, La Colosa, and Quebradona, but only Buriticá went into production. Colosa and Quebradona are halted in the feasibility stage. Only Gramalote is addressing the social risk by investing in coexistence agreements in its feasibility stage.

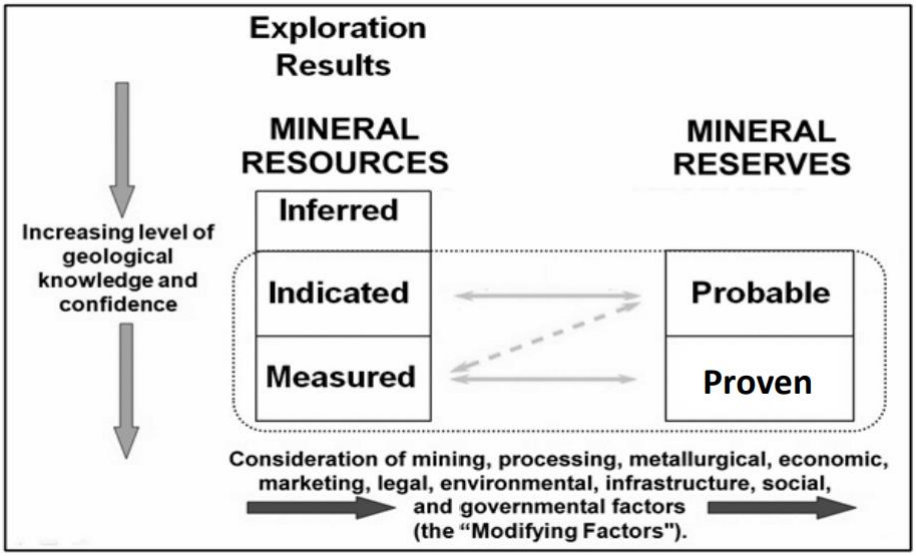

Figure 3.6 Relationship between Mineral Reserves and Mineral Resources.

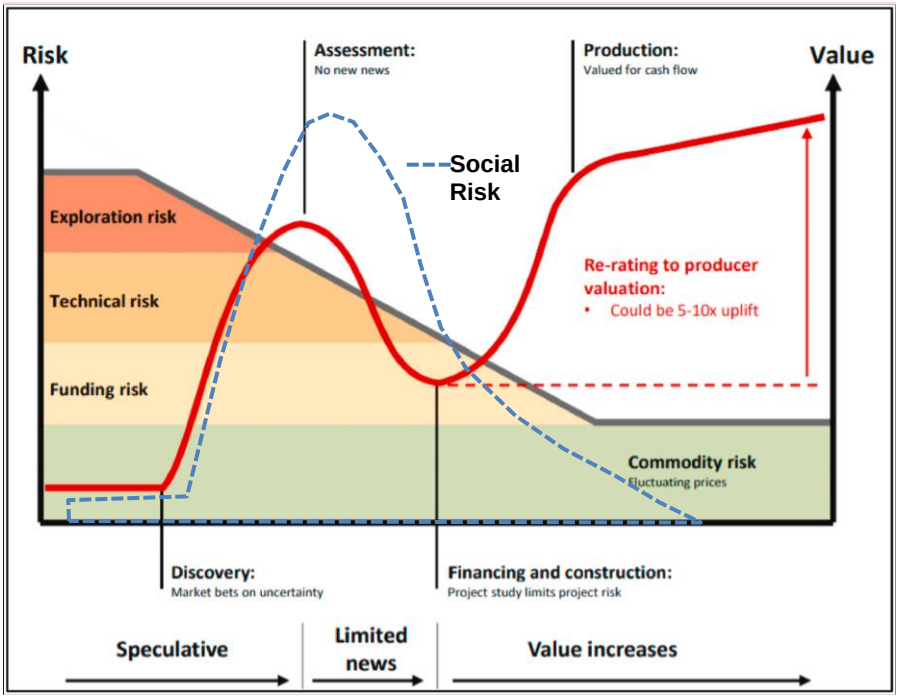

Figure 3.7 Lassonde Curve (Modified from Widdup, 2017)

At Gramalote, the LSM company invested approximately COP$2,000,000.000 (USD$ 600,000) in the coexistence strategy through the implementation of ASM formalization subcontracts. The average cost of core drilling for exploration in Colombia is about USD$ 300/m. This amount includes the cost of moving rigs, building platforms, drilling, sampling transport, sampling preparation, and laboratory analyses of the samples. The amount spent in the coexistence is equivalent to approximately 2000 meters of core drilling or about 10 drillholes. For a project with more than 942 drillholes totaling 173,482.24 m (Garagan et al., 2020), this social investment equates to about the 1% of the total drilling of the project. We suggest that the relatively minor social investment has an outsized positive impact on the project by reducing risk.

Sustainability is a concept that considers ecological, social and economic dimensions, recognizing that all must be considered together to find lasting prosperity (Dimoska and Dimoska, 2018). Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. (UN, 1987) The Sustainable

Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity (Inter-Agency and Expert Group on SGD Indicators (IAEG-SDGs, 2016). The investment in a coexistence agreement with ASM miners by LSM companies implies the formalization of the ASM miners. Hilson and Maconachie (2020) argue that formalization of ASM in Sub Saharan Africa contributes to mineral production and revenue, employment, and agriculture. Thus, contributing directly in some of the 17 SDGs, such as (1) No poverty, (2) End Hunger, (5) Gender equality (8) Decent Work and Economic growth, (10) Reduce inequalities (Hilson and Maconachie, 2020). Therefore, the investment in coexistence made by the LSM company may also be considered a *Sustainability Investment.* Because it supports licit livelihoods by preserving the livelihood of the ASM miners involved, reducing the social risk by strengthening governance, reducing the poverty, reducing hunger, reducing mercury contamination of water, and supporting decent work and economic growth.

We suggest that the methods applied in the present work are an example of how one might assess the financial return on sustainability investments. Various methods have been proposed, including the Return on Sustainability Investment (ROSI; Atz, et al. (2014). That approach seeks to monetize the tangible and intangible benefits of sustainability actions with five actions: 1. Identify material sustainability strategies and actions, 2. List potential benefits that might drive financial and societal values from Sustainability actions. 3. Quantify costs and benefits associated with sustainability. 4. Build scenarios, document assumptions, and iterate research. 5. Monetize and calculate the value of all benefits. The approach used in the present work fits into the third category.

This methodology can be complemented for the case of LSM companies in whose projects or mining operations invest in coexistence, or LSM companies that have within their areas of operation ASM miners with whom they have not initiated coexistence processes, to evaluate the impact of the investment or contemplate the possible return on future

investment in LSM – ASM coexistence applying the Decision Tree model in step 3 in order to quantify costs and benefits associated with sustainability.

Despite the potential benefits of coexistence agreements, they do introduce new types of risk for the LSM company. Once the ASM miners are formalized and incorporated into a legal vehicle S.A.S, they can be approached by investors from all over the world interested in purchasing stocks. This situation introduces a risk for the LSM company, which could hypothetically be brought into a partnership with another LSM company or other institution by virtue of the coexistence agreement. The ASM operators may be interested in the financial benefits brought by outside investment but could risk losing access to livelihoods or may be brought into partnership with bad actors. At Gramalote, the LSM company includes a clause in their formalization sub-contracts that obliges the ASM to maintain at least 51% of their shares in the mining company S.A.S, which is created for that purpose. Governments and law makers could implement some restrictions in the negotiation of rights over contracts or companies accessed by ASM miners under coexistence processes in order to protect them.

In Peru it has been evidenced that artisanal miners once formalized are obliged to comply with all the requirements of the law but without any technical support to do so (Martinez et al. 2021). It is clear that success of formalization requires support for ASM miners to fulfil their obligations. In the case of Colombia, the formalization sub-contracts, such as the case of coexistence between Gramalote and La María provide continuous and long-term support from the LSM company and the authorities.

3.9. Conclusions

This study shows that investment in coexistence between LSM companies and ASM communities can reduce the risk associated with social conflicts, add value to mining projects, and strongly impacting the project´s NPV. In comparison with the amount of investment needed to reduce the technical risks associated with mining projects, investments to reduce social risks seem relatively modest. Investments in coexistence

between LSM companies and ASM communities can also be seen as investments in sustainability that helps achieve the SDGs. As already explained can generate a return. This return on sustainability investment can be calculated by combining the ROSI methodology and the Decision Tree methodology when it comes to LSM projects or companies operating ASM-LSM coexistence processes.

In the same way that LSM companies reduce technical risks, they should invest in stakeholder engagement from the start of the project to reduce the social risk. Companies invest millions of dollars even in deposits with strong geological characteristics, such as Pebble, in order to better understand geology, geotechnics, hydrology, and other technical characteristics, but this level of investment in knowing and understanding the community or the stakeholders of the project is not usually seen at the beginning of the exploration phases of the mining projects. This task is usually undertaken once the deposit has achieved a pre-feasibility stage and maybe at this point is too late to obtain a social license to operate.

New operational models are required for the LSM industry to grow in global south countries such as Colombia where ASM mining is widespread. Coexistence processes can ensure that both LSM mining projects and ASM mining communities develop by creating value for LSM company shareholders and wealth in ASM communities. Markets and the mining industry are increasingly valuing good practices in CSR. However, exploration geologists and investors must make initiate a paradigm shift to work collaboratively with ASM miners if LSM companies move into such areas. In this case study, we demonstrate how social risks associated with ASM miners in LSM mining projects can be managed relatively inexpensively. We also show that the presence of ASM miners can be seen as an opportunity to strengthen ties with the community, enabling social license to operate while protecting the livelihood of the people involved in ASM mining.

3.10. Acknowledgments.

The authors thank Dr. Benjamin Teschner, Laura Granada, Casey Gibson, Alejandro Delgado and Linda Jaramillo, who provided helpful discussion and support during this work.

The authors would also like to thank the anonymous reviewers whose comments greatly improved this paper.

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CHAPTER 4.

DOES COEXISTENCE BETWEEN LARGE-SCALE AND SMALL-SCALE MINING CONTRIBUTE TO SUSTAINABLE DEVELOPMENT? A CASE STUDY FROM GRAMALOTE, COLOMBIA

Felipe Rodríguez-Novoa[1,2], Elizabeth Holley[1]. Colorado School of Mines.

A paper to be submitted to the Journal of The Extractive Industries and Society.

4.1. Abstract

Artisanal and small-scale mining (ASM) is an important part of the economy of Colombia. According to some estimates, this sector makes up 85% of Colombia's gold production and plays an important social role through assuring livelihoods for a great number of people. This study evaluates the case of coexistence between the large-scale mining company (LSM) Gramalote ltd and the artisanal and small-scale mining (ASM) community La María. The success of the coexistence is evaluated based on the sustainable community development (SCD) framework (Bridger and Luloff, 1999) and the United Nations sustainable development goals (SDGs). During a field visit to the Gramalote project in Colombia, several interviews with ASM miners and representatives of the LSM company were held. It was found that the SCD framework was largely applied and most of the SDGs were achieved. However, it was found that ASM women working as *chatarreras* (women who work selecting high-grade ore sent to the dump), are the only population group negatively affected by the implementation of the coexistence agreement since the new formalized operations does not have space for chatarreras to work. It is proposed that the strategies to look for the wellbeing of this population during the transition to formalization should be built together between LSM companies, governments, and the ASM community including the chatarreras population. The Gramalote case of coexistence between ASM and

[1] Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, United States.
[2] Primary researcher and author, corresponding author.

LSM is a strategy that can be replicated globally in order to create nodes of sustainable development with the potential to start at the community level and expanding into a regional and national levels.

4.2. Introduction

Mining is an important part of the economy of Colombia. According to some estimates, artisanal and small-scale mining (ASM) makes up 85% of Colombia's gold production and plays an important social role through assuring livelihoods for a great number of people. Historically in Colombia and other parts of the world, large-scale mining (LSM) companies have seen artisanal and small-scale miners in their mining concessions as invaders, even though in many cases, these miners have worked in the territories prior to the company's arrival and have even served as exploration vectors. The way companies have looked to resolve conflicts with ASM miners is by seeking their expulsion with the support of governments and the support of the police and the army (Aubynn, 2009; Yakovleva and Vazquez-Brust, 2018). However, it is recognized that these approaches have not solved the problem and it is necessary to build bridges between ASM miners, LSM companies and local and national governments (Holley et al., 2020; Hilson et al., 2007). In some cases, cooperation between LSM and ASM have addressed health, safety and environment (HSE) impacts, successfully achieving benefits into the community (Ribeiro-Duthie et al., 2017).

Gramalote is a gold mining project in the feasibility stage, located in the department of Antioquia, Colombia, Figure 4.1. The project was discovered by AngloGold Ashanti in 2007, following up on ASM workings present since colonial times. The project is now a 50%-50% joint venture between two LSM companies, AngloGold Ashanti and B2 Gold Corp.

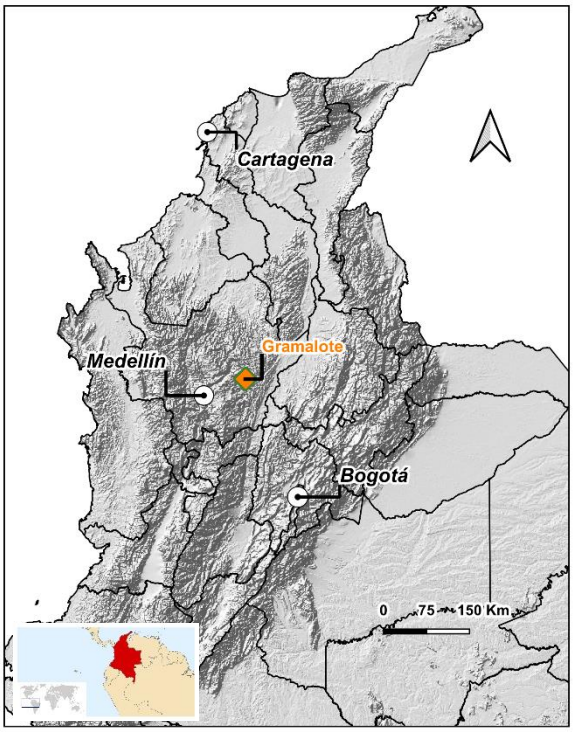

Figure 4.1. Gramalote project Location.

Since 2019, project management has been overseen by B2gold under the company Gramalote Ltd. During the exploration to feasibility stages, the LSM company advanced the project while working in tandem with the area's ASM community. Several attempts to negotiate the liberation of the main pit area had been made with the ASM miners in order to advance to the construction stage of the project. Some examples: payment for their workings and equipment, giving money to start another business to provide services to the company and community and, finally, to include the ASM miners as employees of the project. The most recent agreement with the community of artisanal miners was via Mining Formalization subcontracts.

This study aims to present the case of LSM-ASM coexistence of Gramalote and to evaluate it against the Sustainable Community Framework (SCD), which proposed five dimensions by which to assess sustainable community development (Bridger and Luloff, 1999). Further, this paper evaluates whether this case of coexistence is aligned with the Sustainable Development Goals of the United Nations (SDG) (United Nations, 2015). Sustainable development means different things to different individuals and groups, and for

governments and institutions compared to communities, depending in part on history and current circumstances. Further, the meaning of sustainable development may differ between communities and geologists, since the disciplinary viewpoint of geologists is commonly aligned with the LSM sector. It is often the case that geologists and other mining company professionals are foreigners. In addition to cultural roots, their experience in other localities or their academic training may have contributed to their vision of development, yet they are unaware of the realities and history of the communities they visit. It is common for geologists to make the mistake of trying to impose pre-established concepts of sustainability and development directly upon communities with a different vision, not knowing their customs, conflicts, or desires. This situation can create a source of conflict between communities and the LSM company. Some communities may not agree with the type of development that outsiders are proposing, so it is important to understand the different perspectives of the parties in order to reach an agreement in collaboration and develop strategies that are beneficial to all parties, avoiding the imposition of a single vision and hopefully achieving an agreement that incorporates the different perspectives. The hypothesis assessed here is that the case of coexistence of Gramalote represents one of the few projects in which a coexistence strategy has been developed in collaboration between an LSM company and the ASM community, and that this coexistence agreement implements the SCD framework to contribute to the achievement of several SDGs.

4.3. Methods

The case presented here is based on observations from site visits, mine tours and stakeholder interviews. Site visits and informal interviews were conducted from July through August 2022. During 2020 and 2021, interviews with industry professionals and Gramalote Ltd representatives were also conducted via internet virtual meetings due to COVID restrictions. Data was collected through semi-structured interviews and participant observation with community members, La María and Villanueva small-scale mining companies' employees and shareholders and industry professionals. We individually

interviewed 12 people, including three formalized ASM miners, one informal (illegal) ASM miner, three professional engineers working with formalized ASM companies, and five professional engineers working with the LSM company. All of the ASM mining company representatives were men. The impact of formalization was explored in these interviews by asking both open-ended and closed-ended questions about people's perspectives, changes they had observed as a result of formalization, and challenges they continued to face regardless of formalization. Our research participants were anonymized in this article, except for their affiliation with the mining community or LSM company.

The study also draws material from technical reports on the Gramalote deposit published by Gramalote, B2Gold and AngloGold; legal and regulatory information from the government of Colombia; scholarly literature; news articles; and other information in the public domain.

4.4. Background

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This is a concept that first appeared in 1987 with the publication of the Brundtland Report (WCED, 1987), which warned of the negative environmental consequences of economic development and globalization and sought to find solutions to problems arising from industrialization and population growth. The authors argue that many challenges faced by human beings, such as climate change, water scarcity, inequalities or hunger can only be solved from a global perspective and by promoting sustainable development: a commitment to social progress, environmental balance and economic growth.

As a new roadmap to achieve sustainable development, the United Nations approved the 2030 Agenda containing the Sustainable Development Goals, a series of common goals to protect the planet and ensure the wellbeing of all people (UN, 2015). These common goals need the active involvement of people, businesses, administrations and countries around the world.

4.4.1. United Nations World Sustainable Development Goals

The World Sustainable Development Goals, also known as the Global Goals, are a call from the United Nations to all countries to address the great challenges facing humanity and ensure all people have equal opportunities and can lead a better life without compromising the planet. In September 2015, the 193 United Nations member states adopted “Transforming our World: The 2030 Agenda for Sustainable Development” that included a set of Sustainable Development Goals (SDGs) for 2015-2030.

The agenda provides a successor framework for the Millennium Declaration and the Millennium Development Goals (MDGs) that covered the period from 2000-2015. The SDGs are the world’s comprehensive plan of action for social inclusion, environmental sustainability and economic development. Meeting the SDGs by 2030 will require unprecedented cooperation and collaboration among governments, non-governmental organizations, development partners, the private sector and communities (UNDP, 2016).

There are 17 SDGs: (1) no poverty; (2) no hunger; (3) good health; (4) quality education; (5) gender equality; (6) clean water and sanitation; (7) renewable energy; (8) good jobs and economic growth; (9) innovation and infrastructure; (10) reduced inequalities; (11) sustainable cities and communities; (12) responsible consumption and production; (13) climate action; (14) life below water; (15) life on land; (16) peace, justice and strong institutions; (17) partnerships for the goals.

4.4.2. Bridger and Luloff Framework of Sustainable Community Development (SCD)

Considering the companies which start mining ventures in countries of the Global South such as Colombia are typically foreign companies from the Global North, and also that these ventures are developed in local rural communities, it is important to review how these companies address sustainability for their projects, taking into account their political and social differences. Usually, strategies designed on a national or global scale are applied; however, some authors have criticized the development of these strategies as sustainable development on a global scale might strengthen the economic and social conditions which

support unsustainable practices (Bridger and Luloff, 1999; Yanarella and Levine, 1992). They also argue that, by shifting the focus towards local sustainability, changes are seen and felt in a more immediate way, increasing the chances of generating concrete examples of sustainable development, and successful intervention is more visible (Bridger and Luloff, 1999; Yanarella and Levine, 1992).

Given the heterogeneity of communities with different environmental problems, resource endowments, levels of social and physical development (e.g., geological, topographic and hydric) and different climatic conditions (Bridger, 1994; Luloff and Swanson, 1995; Wilkinson, 1991), a community-level approach allows for the design of policies and practices that are sensitive to the opportunities and constraints inherent to particular places (Bridger and Luloff, 1999).

The framework proposed by Bridger and Luloff (1999) for the ideal-typical sustainable community development is defined in five dimensions:

1. Increasing Local Economic Diversity: This dimension refers to creating or strengthening the local economies in a community so citizens are not dependent on imported goods and can create or produce the goods they need, also creating at the same time, job opportunities and diverse sources of income.

2. Self-Reliance, Political Autonomy and Self Determination: This is the capacity of a community to decide their destiny and take action on what they want to do and how they want to do it while maintaining their identity, traditions and livelihoods.

3. Reduction of Materials and Energy: This is the use of natural resources in such a way that what is used can decompose naturally and fast enough and that no more is used than the earth can provide.

4. Protection of Local Ecosystems and Stewardship of Natural Resources: This dimension aims to be friendly to the environment. Here the goal is not to contaminate or harm plant species or animals present in the area of influence of the project. This dimension also aims to use natural resources appropriately so as not to consume them in full over a short period of time.

5. Social Justice: Equal distribution of opportunities and resources in order to enhance human capabilities while reducing the risk and harms among the citizens of a particular location.

4.4.3. Formalization and Coexistence

In recent studies of ASM formalization processes in Peru (Martinez et al, 2021mixed perspectives on the formalization were observed. The artisanal miners feel that their working conditions have improved, and they are becoming more environmentally aware, but on the other hand, they feel abandoned and still lack access to technical and financial assistance, while they have been persecuted and scrutinized more than when they operated informally.

Since 2010, the government of Colombia has worked on a package of legal tools to achieve formalization for ASM miners. Starting with the law known as the “law of mercury” (Law 1658, 2013) that gave a peremptory time to make illegal the use of mercury for gold amalgamation in ASM operations, the government then introduced a series of legislative acts (Law 1753, 2015; Decree 1073, 2015; modified by Decree 1102, 2017 and Decree 1949, 2017, Decree 1378 de 2015 and Law 2250, 2022) that sought the formalization of ASM operators.

In the past, this process had been extremely complicated. As explained by Veiga and Marshall, (2019), more than 380 different documents were required and, along with associated costs and high technical standards, the formalization of artisanal miners has been very difficult. However, recent legislation established different requirements for granting concession contracts to small-scale miners and beneficiaries of return areas for mining formalization through Decree No. 1378 of 2020 and Law 2250 of 2022. The most common forms of formalization established in Colombian legislation are “Return Areas for Formalization” and “Formalization Subcontracts.”

Formalization subcontracts describe the process through which LSM companies can allocate an area for ASM but retain its mining title (Law 1658 of 2013, Article 11). In terms of the coexistence between LSM and ASM, formalization subcontracts are a tool for LSM

companies to allow exploitation of a granted mineral or another mineral to a group of ASM miners who are doing exploitation work within the same area of the LSM mining concession. In this case, the LSM company keeps rights to the mining title and continues to be responsible for the activities that occur there. Artisanal and small-scale miners must follow health and safety regulations, environmental regulations and others indicated by law, and the LSM company is obliged to verify this compliance. The mining authorities in Colombia are the National Mining Agency (ANM) and, for the department of Antioquia, this authority is delegated to the Secretariat of Mines of the Government of Antioquia.

4.5. Results

4.5.1. Gramalote Coexistence Case.

AngloGold Ashanti Colombia (AGAC) started exploration activities in the vicinity of the Gramalote project back in 2003. Other companies previously reviewed the area in the '90s, but never advanced exploration activities such as systematic soil sampling or core drilling. During the first stages of exploration, there were no serious conflicts causing a stop to operations of the LSM company. Permits for surface mapping, soil sampling and core drilling were always performed by the LSM company, with some isolated suspensions while permits were being negotiated.

Conflicts began to appear in more advanced stages of exploration when the LSM company, under the management of AngloGold Ashanti, granted the environmental permit and decided to move towards feasibility and project construction. At that point, it was necessary to access Gramalote Hill by reaching an agreement with the working ASM miners; at that time, there was no legislation that allowed the formalization. The first negotiations with the ASM group working on the hill were made around 2011.

In this first attempt, the company's strategy was an alternative livelihood program with two options: to 1) offer employment to artisanal and small-scale miners in the company, or 2) offer financial support so the miners who wanted to undertake other businesses could start. The first attempt resulted in the miners who received money undertaking other

economic activities aside of ASM; they did not achieve the sustainability of their businesses, and most of them returned to mining at Gramalote Hill. For the group of miners who took the option of becoming employees of Gramalote Colombia, it was difficult to work under the demanded conditions and they did not comply with the schedules and did not meet industrial safety standards.

This group of ASM miners formed the first union of workers of Gramalote Colombia and started a protest to demand better working conditions, a higher salary, and a better schedule. This protest lasted several days and paralyzed the exploration activities of the company. There was material damage to the company's facilities, and company employees were held and feared for their lives due to the violence of this conflict. This protest, after legal action brought by the company, was declared illegal and the employees who took part in it and who belonged to the union were dismissed.

After this negative experience, Gramalote Colombia Ltd. changed its relationship strategy with ASM miners and started a pilot formalization process in San Roque in 2018 with 18 traditional ASM miners from the La María rural community. The commitment of Gramalote Ltd. to this first group of artisanal miners included technical, financial and legal support to create a formal small mining company, La María S.A.S (La María). It offered support to these companies in preparing and obtaining environmental permits (EIA) and complementary mining plans (PTOC), technical training, metallurgical analysis for the best gold processing alternatives, the design and construction of a community processing plant and a community business model. In July of that year, the company, with the support of the Secretariat of Mines of the government of Antioquia, signed an act of mediation with the ASM miners through which a formalization subcontract would be granted; 16 mining production units were legalized in a 15-hectare area. Gramalote has since continued support for the formalization process being rolled out by the San Roque Municipal Administration, signing seven new subcontracts (which are not part of this study) with 40 ASM miners in Cristales, Manizales and El Diluvio (AngloGold Ashanti, 2019; Garagan et al., 2019). Figure 4.2 shows the Gramalote history.

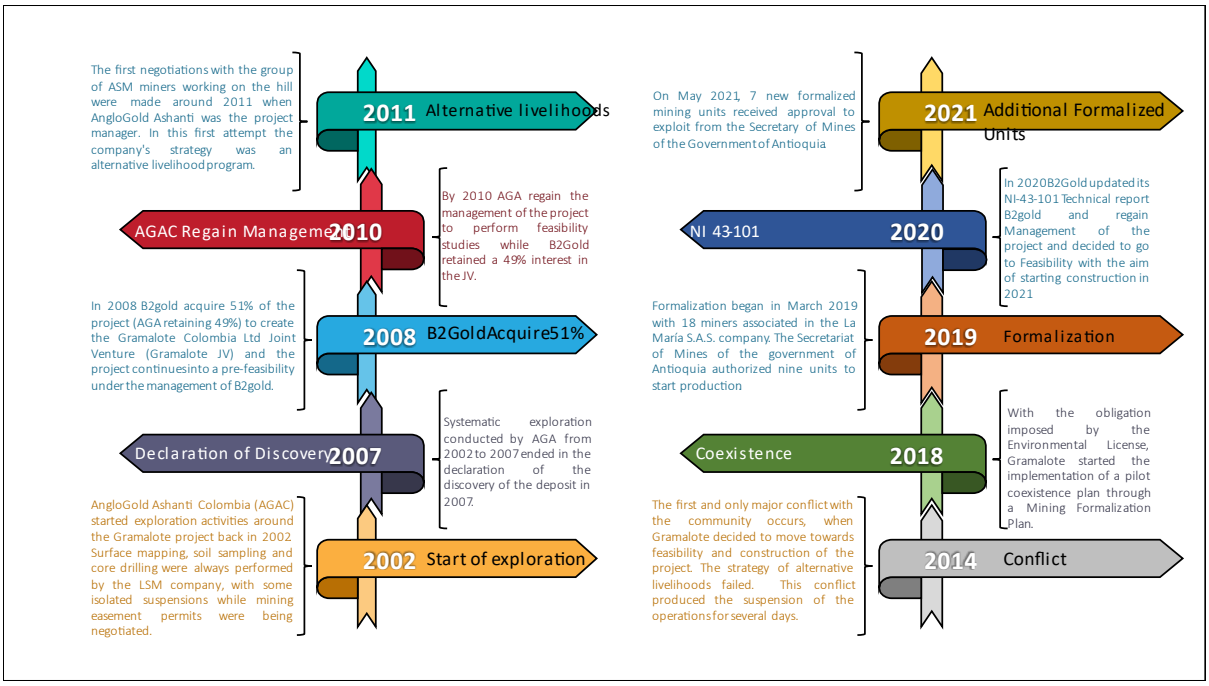

Figure 4.2 Timeline of the Gramalote project. (Rodríguez-Novoa & Holley, 2023)

4.5.2. La María SAS

La María SAS is a formal mining company established to bring together ASM miners located in the Area of Direct Influence of the Project (ADIP). The ADIP is where the direct impacts of the mining project will be manifested both in the construction phase and durig operations. La María received an area within the mining title of Gramalote that the LSM company ceded under a Formalization Subcontract. Under the agreement, the company relinquished a specific portion of one of its mining titles to develop an ASM mining project. The area will be under contract for seven years and, at the end of this period, the agreement can be finished, reviewed or extended for seven more years. The agreement reached with La María also includes technical support in the areas of geology, mining, metallurgy, engineering and legal. The agreement also includes financial support for artisanal and small-scale miners to start operations. The company has committed to build a processing plant when Gramalote Colombia Ltd starts the building stage of its LSM project.

According to the information delivered by La María and Gramalote Ltd personnel, the investment in the formalization process of the artisanal miners of La Maria was around

COP$2,000,000 (two thousand million Colombian pesos), or approximately US$500,000. With this investment, the legal costs of creating the company were covered, as well as the consulting costs for estimating resources to make the Mining Plan (Plan de Trabajos y Obras (PTO)), and the consulting costs to present the Environmental Impact Assessment (EIA) were covered in order to comply with all legal requirements to achieve the mining formalization for this group of artisanal miners.

Once associated in La María SAS, the artisanal miners exchanged their "position" for shares of a legally constituted mining company, the situation created the opportunity for investors to approach the new company partners with the intention of investing in the development of the project in exchange for company shares. Two ASM miners took advantage of the situation, selling 100% of their shares in the project, leaving La María with 16 artisanal miners as partners. Concerned about this situation, the partners decided that no more than 51% of their shares could be sold, so as not to lose control of the company. A professional from the LSM company expressed his concerns on this point:

> *"We have observed that, once the ASM miners are formalized, national and even foreign investors come to offer to invest in the formalized company for future formalization subcontracts; we are thinking of including a clause that prevents these type of negotiations from being made..."*

After the formalization of the La Maria was completed, the company autonomously managed to make 16 joint venture (JV) agreements with 110 additional area ASM miners to increase the number of formalized miners, and the impact of the coexistence process was extended. The operation involved 157 ASM miners on top of the 126 ASM formalized miners, for a total of 256 ASM miners involved.

Currently, the ore extracted at La María is sold to the LSM mining company Antioquia Gold, located in the vicinity of the La María operation. Antioquia Gold and La María have an undisclosed agreement under which the ore is processed at the Antioquia Gold plant and is paid 90% of the gold grade at 90% of the gold spot price at the London Metal Exchange. Antioquia Gold discounts a variable cost of processing according to the grade and a fixed

cost of commercialization per gram of gold. Antioquia Gold requires a minimum grade of 5g/tonne from La Maria to buy the ore.

4.6. Analysis.

4.6.1. La María Formalization

The coexistence between Gramalote Ltd and La María has resulted in the formalization of 126 ASM miners. Most of the 18 original formalized ASM miners are no longer ASM. Two decided to sell their shares to local investors, and 14 additional ASM miners decided to leave the activity and become businessmen, as they now are shareholders of a gold producing company with significant sales. There are still two ASM miners out of the original 18 still working at La María. During a site visit, one of these miners stated that the most important aspect of the formalization process was that he now works without fear, is not persecuted by the police and is not afraid of losing his equipment or going to jail. This has also been observed in studies carried out in Peru on ASM formalization processes. (Martinez, et al, 2021). While the money he previously received when he was not formalized was much higher, as they did not have operating costs, administrative expenses and did not pay taxes or royalties, he acknowledges that his working conditions have improved, as has his overall quality of life.

In addition to the 126 formalized ASM miners, the coexistence process involves 157 ASM employee miners. For these individuals, their working conditions have also changed; they now have a job that offers them social security, which means they are affiliated with the health system and can make contributions to the retirement system. They also have living wages under Colombian laws, which includes periods of paid vacations and other benefits. Also, 100% of the formalized ASMs interviewed mentioned the improvement in the safety of their operations. One formalized ASM miner interviewed said:

> *“Before (the formalization) we worked without organization and our pits were very insecure; now we are obliged to comply with all the mining standards and pay social security that generates a safer work environment.”*

Women who were working as chatarreras lost space during this process of formalization and coexistence. The chatarreo consists of selecting high-grade ore used to be sent to the dump. This work has usually been delegated to women and even children in artisanal mining communities. A professional engineer and manager of La María expressed his concerns about the future of the chatarreras.

> *"With the technification in the production process (at La María), the high-grade ore in the mine waste dumps is almost non-existent and the chatarreras no longer have ore to work with…"*

Of the formalized ASM miners, 100% interviewed expressed their concerns about the lack of inclusion of women in the formalization process, recognizing that the formalization process excluded women from the operation of the formalized ASM mine. During the visits to the La María operations, it was seen that some women involved in La Maria as mine managers, or as safety, environmental or social supervisors, but were not allowed to enter to work in the tunnels. An interviewed ASM miner said:

> *"…it is not for superstition or religious reasons; it is because down there the job requires strength, and women are not strong enough for this job…"*

Other women have had to leave the area and look for other informal artisanal mines where they can continue their work as chatarreras. A professional engineer of La María commented on his plans to include these members of the community in the mining activities of the company:

> *"…we are working on a project to use the tailings to build construction material, such as bricks, to do so, we need to avoid the material with Sulphur, I am planning to involve the chatarreras in the material selection job."*

4.6.2. Productive Linkages

During the site visit to La María, it was seen the process of coexistence also generates an economic dynamic that creates productive chains both forward and backward. Backwards, a need is generated for tools, equipment, consumables and personal protection

elements that are not easy to obtain locally. Seeing this need, one artisanal miner at La María who sold his shares decided to invest part of his profit to open a shop offering these tools and consumables to the area. The opening of restaurants to meet the food demand of La Maria workers was also evidenced. Other services, such as transport services for ore material, has been revitalized thanks to the formalization of La María. All the formalized ASM miners interviewed commented that, after formalization, they earn less money than before. Aware they now are paying taxes and royalties, they also now know their earnings are legal and they have the ability to open a bank account, have access to credit and invest in farms or other legal businesses.

The need for legal, accounting and payroll services has also been generated. Now, La María is a company with more than 250 employees, and as such must keep an accounting function and must make payroll payments on time to comply with all legal requirements. This generated the opportunity to create local companies, where some artisanal miners are now also partners; for example, accounting and payroll issues have in turn generated new local job opportunities. A professional working for La María said:

> *"One of the partners of the La María created his own company to manage payroll and deals with all the payments related to workers' social security."*

4.6.3. Environment

The process of formalization and coexistence between Gramalote Ltd and La María SAS has also benefitted the environment where the project is developed; moreover, 100% of the formalized ASM miners are aware of the positive impact of the coexistence process. During the visit to the La María site, reforestation processes developed by the ASM community were seen, which were part of the obligations of the EIA, where environmental compensation is mandatory. The most interesting thing about this process of formalization and coexistence in environmental terms is the recovery of the San Buenaventura Creek, better known locally as La María Creek. This creek, upstream of the La Maria project,

continues to receive material from artisanal mining tailings and even mercury used in the gold recovery process from ASM miners that have not been formalized.

A professional engineer employee of La María said:

> *"When the Environmental Impact Assessment (EIA) was made for the formalization of La María, water samples were taken from this creek to know its base status, and it was found that the water was completely contaminated and there was no trace of life in it."*

During the site visit, it could easily be seen how, after the work has begun under the standards needed in the formalization process, the water that is delivered to La María Creek now has better quality conditions, allowing it to regain its microfauna.

A professional engineer at La María also said:

> *"...now the San Buenaventura Creek shows traces of life downstream from the La María SAS area of operation, but the creek water is again deteriorated by the feces of the mules that carry the sugar cane to the plant nearby."*

4.6.4. Sub-contracts of Formalization Coexistence Strategy and the SDG.

Hilson and Maconachie (2020) argued the SDGs are difficult goals to achieve for countries where there are no major development opportunities and where governments must find ways to stimulate economic development. The authors also identified ASMs' contribution to mineral production and revenue, contribution to employment and links with agriculture, and argue that the formalization of, and intensified support to, ASMs is one low-cost yet potentially effective option worth pursuing.

Also, according to Hilson and Maconachie (2020), the formalization of ASM sector potentially contributes to SDG1, SDG2, SDG3, SDG5, SDG8, SDG9, SDG10, SDG12 and SDG16 (blue arrows in Figure. 4.3). This study observed the ASM-LSM coexistence case of Gramalote through formalization subcontracts in Colombia also contributes to SDG6, SG11, SDG14, SDG15, SDG17 (yellow arrows in Figure 4.3) in addition to the SDGs they identified.

Figure 4.3 ASM Formalization as ASM – LSM Coexistence Strategy and its potential contribution to the SDGs. Blue arrows show the SDGs potentially impacted by formalization process as observed by Hilson and Macconachie, 2020; Yellow arrows show additional SDGs potentially impacted in the case study of Gramalote; Red arrow shows no impact. (Modified from Hilson and Maconachie, 2020).

The SDGs can be grouped into three segments according to what they impact: Biosphere, Society and Economy. Furthermore, Rockström and Sukhdev (2016) argued that Society and Economy are embedded into the Biosphere (Fig. 4.4).

Biosphere would be impacted by: SDG6, Clean Water and Sanitation; SDG13, Climate Action; SDG14, Life bellow water; SDG15, Life on Land.

Society would be impacted by: SDG1, No Poverty; SDG2, Zero Hunger; SDG3, Good Health and Well Being; SDG4, Quality Education; SDG5, Gender Equality; SDG7 Affordable and Clean Energy; SDG11, Sustainable Cities and Communities; SDG16, Peace, Justice and Strong Institutions.

Economy: The SDGs that impact economy are: SDG8, Decent Work and Economic Growth; SDG9, Industry, innovation and Infrastructure; SDG10, Reduced Inequalities; SDG12 Responsible Consumption and Production.

Gramalote coexistence case impact on Economic dimensions of the SDGs:

The SDGs grouped in the economic dimension impacted by the case of coexistence of Gramalote are SDG8, SDG9 and SDG12. Regarding SDG8, *Decent Work and Economic Growth;* it is clear the process of formalization of ASM miners in La María has led to a better place of work for formalized ASM miners. The economic growth was also observed during the fieldwork, as the ASM miners are included in the economic dynamic of the region and can diversify in agriculture, services, or other legal economic activities since their earnings as ASM miners is now legal.

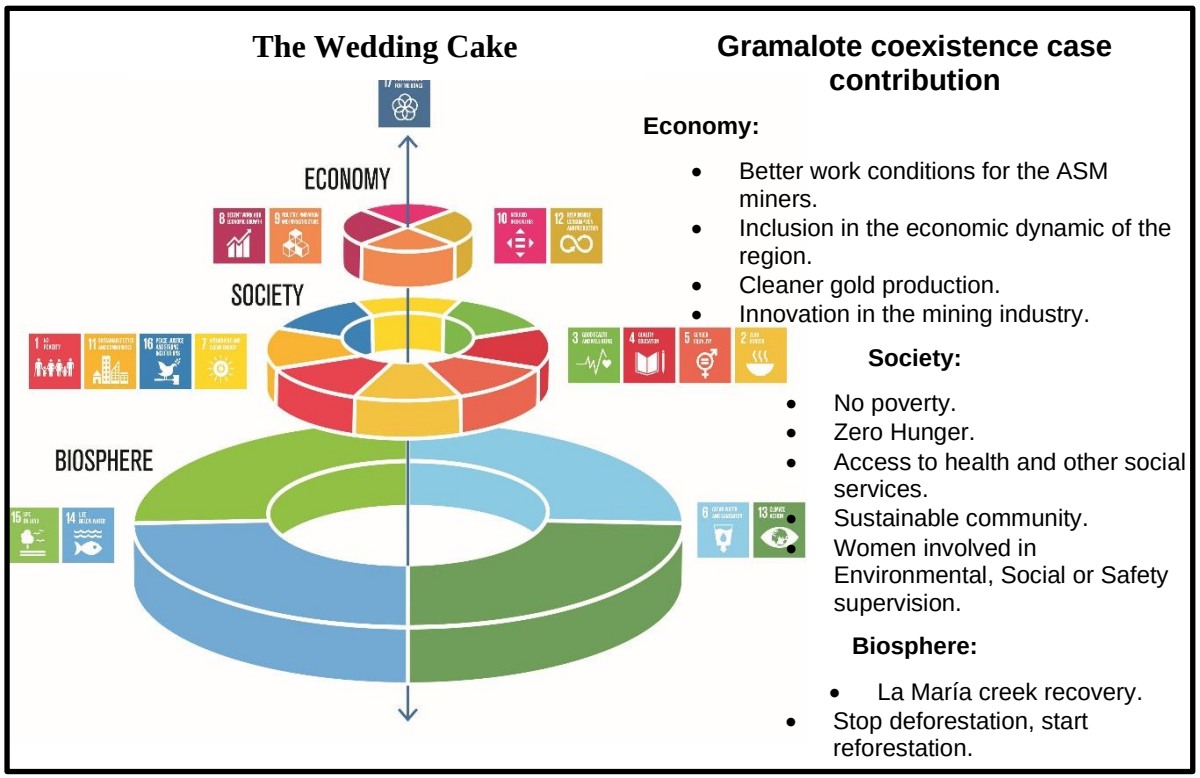

Figure 4.4 The Wedding cake (Rockström and Sukhdev, 2016) and the Gramalote coexistence case contribution to the SDGs.

SDG9, *Industry innovation and Infrastructure:* The coexistence strategy by itself constitutes an innovation process for the mining industry by facilitating the extraction of materials needed for human development and conservating the livelihood of the ASM miners

at the same time. This strategy also contributes to enhance sustainability by resource-use efficiency and adoption of clean and environmentally technologies and industrial processes.

SDG10, *Reduced Inequalities.* The reduction of inequalities is also addressed in the coexistence process by including ASM miners in the health and retirement social system of Colombia. This gives ASM miners the opportunity to access to the same medical services, retirement system and recreation as any Colombian worker.

SDG12, *Responsible Consumption and Production,* is related to gold production. Production by a formalized ASM mine involves the elimination of mercury and the commitment to environmental regulations.

4.6.5. Where is this Case of Coexistence Located in the Bridger and Luloff framework?

According to the Bridger and Luloff framework (1999), the Gramalote coexistence process follows much of what these authors have proposed for Sustainable Community Development (SCD).

Increasing Local Economic Diversity: The illegal production of artisanal gold, although it is very profitable, it generates wealth that could not be easily invested because it comes from an illegal activity. An artisanal miner from La María said he did earn more money before the formalization, but he could not spend or invest it because it came from an illegal activity and had to hide it.

Once formalized, the ASM miners from La María got investment offers to generate profit immediately. This money, now legal, allows revitalization of the local economy. During the field visits to the community the lead author observed that the heavy transport sector is also revitalized, as it is now necessary to transport ore from La María to the Antioquia gold plant. Other new businesses were observed during the fieldwork, such as restaurants, and service companies like accounting, administrative and legal services, were also revitalized. In general, the process of coexistence of Gramalote through the subcontracts of formalization of ASM miners brought to the town a form of legal wealth that has allowed the development of economic dynamics.

Self-Reliance. Political Autonomy and Self Determination: Artisanal miners gathered in a form of legal administration where they are partners with voice and vote and have achieved such autonomy they can make their own decisions about the direction of their business. It was observed during the field visit that they have had the economic capacity to hire professionals in mining, geology, environmental engineering and safety. Aware of the need for this support, they have had to choose who they want to accompany them in their projects. The process of coexistence of Gramalote has given the ASM miners of La María the opportunity to develop their activity within the legal framework but with autonomy, self-reliance and self-determination.

Reduction of Materials and Energy: Natural mineral resources are finite. Production of ASM is slower and aligns more with the resource maintenance approach, in which the protection of natural resources is an explicit objective that is considered on an equal level with economic concerns. Furthermore, during the field visit it was observed that the La María ASM company implemented standards for the management of solid waste and hazardous waste in accordance with the requirements of the EIA.

Protection of Local Ecosystems and Stewardship of Natural Resources: This process of coexistence certainly points directly to the protection of the environment and local ecosystems, as is seen above. During the fieldwork and the visit to the ASM sites it was observed that deforestation has decreased and reforestation has increased. Further more, it was observed that the pollution of watersheds has decreased. However, it is necessary to multiply these processes so that the entire water basin is recovered. It is useless for La María to improve its processes, as downstream the creek is being contaminated.

Social Justice: In this case, the coexistence process of La María seeks equal distribution of opportunities and resources because the ASM miners were organized as company shareholders in such a way that everyone receives equitable benefits. Everyone has access to equal opportunities and equal rights on equal conditions. Acting within the law and performing a legal mining activity, they do not live in fear of being persecuted by authorities, losing their equipment or ending up in jail. All miners involved in the La Maria

coexistence process now work with improved standards, have improved their human capabilities and reduced workplace risk and achieved a better working environment, which has improved the quality of life of the entire locality.

4.6.6. How do the Bridger and Luloff and the SDGs Frameworks Inform Each Other?

The SDGs are the plan of action for social inclusion, environmental sustainability and economic development delineated by the United Nations. The SCD framework proposed by Bridger and Luloff (1999) is a road to reach the SDGs. In can be said that in the Gramalote case of coexistence the SCD framework was largely applied in such a way that it impacted in most of the SDGs. Furthermore, when the SCD framework is applied SDGs are achieved in a sustainable manner in local communities with specific needs.

The coexistence between ASM and LSM applying the SCD framework approach have a chance to become nodes of sustainable local development impacting positively the SDGs by creating local sustainable ASM communities which expands outwards and become the core of regional and national sustainable development.

4.7. Conclusions and Recommendations

The processes of coexistence through mining formalization subcontracts contribute to development from a local perspective, which is more effective than implementing global development strategies. The case study presented in this paper contributes to the ASM community of La María, improving their conditions and approaching what is considered a sustainable community by improving the conditions of self-reliance, political autonomy and self-determination, reduction of materials and energy, protection of local ecosystems and stewardship of natural resources for social justice, as contained in the Bridger and Luloff SCD Framework (1999).

Coexistence processes contribute to the fulfillment of the SDGs and can be fundamental for the development of the mining industry in countries of the Global South. The immediate impacts on SDGs offered by coexistence processes through formalization

subcontracts can be seen in SDG6, SDG8, SDG14, SDG15 and SDG17. The medium and long-term impacts are in SDG1, SDG2, SDG3, SDG9, SDG10, SDG11, SDG12 and SDG16.

The formalization of ASM miners requires high investment; however, for governments, the investments need not represent a significant effort. With tax reduction policies for companies or individuals investing in mining formalization, financing processes can be encouraged to formalization. Access to bank financing for formalization projects is a tool to allow the growth of formalization. Another way to encourage formalization is by making government offices, such as the Colombian Geological Service, the National Mining Agency or the National Environmental Licensing Agency have technical teams with the capacity to carry out geological, mining and environmental studies at a low cost.

The mining formalization policy in which the Government of Colombia has been working has given tools to LSM companies they did not previously have to coexist with ASM miners in their mining titles. However, the application of these tools is not mandatory and depends on the will of the companies. If the government wants to continue advancing the formalization of ASM miners, it is necessary to give more incentives to LSM companies to enter into coexistence agreements.

In Colombia, there are many mining titles held by LSM companies that have ASM mining in the area but have not developed LSM mining projects due to lack of financing. In these cases, there is no formal development of the projects, and there is no opportunity to legalize the artisanal production that takes place within these areas. The government should create policies that generate interest for these LSM companies to formalize artisanal miners, because what is being extracted is a state-owned resource. By removing ASM miners from these areas, there will not be development if the mining company does not build the mine and start producing, thus giving up the opportunity to generate wealth and boost the local economy. Strategies such as reducing or exempting taxes for those who support formalization could be useful.

In this case, the formalization process institutionalized a legal economic dynamic that appeared to positively impact artisanal mining communities and extend to the locality.

Income from formalized ASM miners, although not comparable to the illegal income, now can be easily invested in diverse economic sectors, bringing a stronger local economic dynamic.

Women remain the most marginalized population in artisanal mining communities, and formalization processes are also leaving out women, especially those who work as chatarreras. These formalization processes must place importance on women. The strategies to look for the wellbeing of this population during the transition to formalization should be built together between LSM companies, governments and the chatarrera population.

Finally, coexistence between LSM and ASM is a strategy that address multiple dimensions of the SCD framework. This strategy leaves out the marginalized population of women. The strategy overcome numerous barriers, such as the lack of confidence between the parties, power imbalance and differences of interest. Also, this strategy capitalized on areas of common ground between ASM and LSM, and the strategy could serve as a potential model to be replicated globally in order to create nodes of sustainable development starting at the community level and expanding into regional and national levels.

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CHAPTER 5.

GENERAL CONCLUSIONS

5.1. Integrated Conclusions

This research demonstrates particular technical and social characteristics that are more likely to lead to an ASM-LSM coexistence agreement that benefits both parties. Furthermore, there are characteristics that are needed to be present as well as characteristics that should be absent in order to predict a successful coexistence. The qualitative comparative analysis QCA analysis of the database of coexistence cases between ASM and LSM in Perú and Colombia was useful to identify which characteristics are to be present and which ones are preferred to be absent. First, the characteristics that are preferred to be present are:

The presence of Mediator. Usually, the presence of an independent mediator between the LSM company and the ASM community is found to be important in countries such as Colombia and Perú. The role of the mediator in the successful cases identified was to create trust between the parties and interpret the concerns and interest from both parties to reach common points of agreement.

An organized community. This social characteristic was found in every successful case identified along Colombia and Perú. In some cases, the community was previously organized into associations, cooperatives, or companies. It was found that in these cases the process of achieving coexistence was shorter. In other cases, the process of reaching the coexistence agreement obliged the ASM communities to integrate into one of the above types of organizations making these cases longer and more difficult.

High grade – low tonnage deposit type. This technical characteristic is essential since an ASM miner working in conditions of low technology and low mechanization has difficulties to move and process large amounts of ore per day. On top of that, the recovery in ASM plants is around 20% to 30% due to the rudimentary techniques employed to process the

ore. For these reasons, the best conditions for an ASM miner to work is a high grade – low tonnage type of deposit. The most common style of mineralization in successful coexistence cases is epithermal gold and silver veins, even though, any type of deposit where a zone of high grade and low tonnage can be identified is convenient for an effective ASM – LSM coexistence agreement.

Presence of African-Descendant and Indigenous people. None of the successful ASM-LSM coexistence cases recorded in the database were reached between LSM companies and ASM indigenous or afro descendant communities in Perú or Colombia. Based on the findings of this research, this situation can be explained for two main reasons. First, there are ethnic minority communities that are not engaged in ASM and are not interested in the development of mining activities on their territories. The second reason could be that the community is engaged in ASM and is not interested in coexistence agreements with LSM companies because they are afraid of displacement and losing their livelihoods once LSM mining arrives. Many ethnic minority communities engaged in ASM in Colombia and Perú have a long tradition of ASM and significant influence over their territories. They may also be owners of mining titles and are protected by the laws and the constitutions in both countries. These conditions give such groups greater autonomy and bargaining power over LSM companies. The third reason could be that indigenous or Afro-descendent populations have been traditionally marginalized in these countries and may be overlooked as key actors in the ASM sector. Each case deserves its own considerations and a deeper understanding of their motivations. Although this research does not assess whether this situation is desirable or undesirable, it raises several questions that can be addressed in future research, including: Should LSM development be pursued in territories where ethnic minorities are not engaged with ASM mining, and the communities are not interested in LSM mining in their territories? In cases where the ethnic community is engaged in ASM mining, would these communities be willing to sell ore to LSM companies for processing in industrial plants? Are there other resource development models which

could help such communities protect their livelihoods, autonomy and their territories while protecting the environment?

Other technical conditions, including the stage in the mining project, the mining type (open pit vs underground mining) the type of LSM company and the deposit type do not seem to determine the achievement of a successful coexistence agreement.

From the standpoint of the LSM company the investment in coexistence agreements with ASM communities present in their mining concessions can be seen as an opportunity to mitigate the risk of social conflict and to achieve the social license to operate. Also, the social risk avoided by these types of investments can add value to a mining project by making it attractive to investors for an acquisition or equity investments.

Several cases of coexistence reported in Chapter 2 and the case of Gramalote described in Chapter 3 and 4 show that building strategies together is more sustainable than imposing generic models. The history of Gramalote recalls two attempts of coexistence. The first one based on payments of compensations, employment offers and support to establish new businesses in town. This attempt failed and ended in a social conflict; the company lost the money invested in this strategy, and the ASM miners returned to their workings. The second strategy of coexistence was built together with the ASM community and applied new legal instruments recently developed. As seen in Chapter 3 the second attempt of coexistence was not more expensive than the first one, even though it was a substantial investment, it was relatively low in comparison with the positive impact in the financial value of the project as seen in Chapter 3 but also created a positive impact in the development of the community. This agreement is more sustainable than the previous one and reduced the risk of social conflict to the project.

As said, political decisions that lead to creation of new legal tools and the political will of the regional government to apply and support the parties in the formalization process of La Maria ASM miners was also key in the case of Gramalote as well as in several successful cases reported in Chapter 2. As we see in Chapter 4, this agreement was partly generated from the community outward, which gave the community tools to become legal, grow

economically, have self-determination and independence while allowing the LSM company get its social license to operate and mitigate social risk.

Recently, the LSM companies (AngloGold Ashanti and B2Gold) owners of Gramalote have decided to sell the project as results from an optimized feasibility study suggested the project did not meet the JV's investment thresholds for mine development. However, the coexistence agreement in place allows them to offer a project with lower social risk. On the other hand, the La María ASM miners will now have to be attentive to how things will change once the project is sold since the change in control of the LSM company is the major risk facing the coexistence agreement. For example, it has been observed some recent negative developments in the coexistence situation of Buriticá. For future research it would be interesting to understand in more depth, the situation in Buriticá after the purchase of Zijin Mining. Likewise, it would be interesting to keep track of Gramalote developments in the case it is sold.

It would also be interesting to continue researching the situation of the ASM miners that have not reached agreements with the LSM companies operating in their territories. Is it possible that successful coexistence agreements achieved in Colombia and Perú such as the ore purchase agreement of Dynacor in Perú and Antioquia Gold in Colombia or the model of subcontracts of formalization will reproduce in Colombia and Perú? On the contrary, will these processes fail in the long run?

From the standpoint of the ASM communities, to reach a coexistence agreement with an LSM company represents the protection of their livelihoods and the sustainable development of their communities. The analysis of the case study of Gramalote Ltd, and La María S.A.S found that the coexistence agreement between the LSM company and the ASM community Increased the local economic diversity, improved their self-reliance, political autonomy and self-determination, contributed to the reduction of materials and energy consumption, the protection of local ecosystems and stewardship of natural resources, and partially to social justice. These characteristics are contained in the Bridger and Luloff Sustainable Community Development Framework and locate the community as a case of

sustainable community. Sustainable communities meet the economic needs of their residents, enhance and protect the environment, and promote more humane local societies (Bridger and Lulofff, 1999). Social justice is only partially achieved. The coexistence agreement of Gramalote creates a better work environment, protects children from working in mining activities, and in general creates better social conditions in the community, but when the ASM mine is formalized, most of the chatarreras are left out of the process and only a few of them can access a position in the formalized ASM mine. These women are located in administrative jobs, but these positions can only be reached by a woman who have some degree of academic preparation. Therefore, the vast majority of women are left out. It can be the subject of future research what spaces can be created in a formalized ASM mine for women who work as chatarreras.

The case study of Gramalote Ltd and La María S.A.S. coexistence strategy through formalization sub-contracts also has the potential to contributes to the fulfillment of almost all the United Nations SDGs. The immediate impacts seen on SDGs can be seen in SDG6, SDG8, SDG14, SDG15 and SDG17. The medium and long-term impacts are in SDG1, SDG2, SDG3, SDG9, SDG10, SDG11, SDG12 and SDG16. SDG5 remains unimpacted by ASM formalization processes even in coexistence strategies between ASM and LSM.

Sustainable development can be a strongly contested concept, and depending on the individual or group, it may mean different things. This research is not presenting the ASM perspective of sustainable development, and the lead author notes that individual artisanal miners likely hold varying concepts of development or sustainability. Future studies could examine whether the perspectives of ASM miners or ASM communities align with the concepts of sustainable development as presented here, or other models such as the growth approach or the resource maintenance approach. Detailed case studies of ASM communities coexisting with LSM companies will provide answers to these questions. The SCD approach remains largely untested in the ASM sector and could be used to evaluate other case studies of coexistence from the database presented in this work, or other cases

elsewhere in the world. Such studies could help to determine the usefulness of the framework and aid in the formulation of policy recommendations.

5.2. Costs and Benefits of Coexistence for LSM

Social License to Operate (SLO). LSM companies look for an SLO in areas where ASM is present, and companies find in the coexistence a tool to obtain the trust of the communities and prevent conflicts.

Access to additional mineral resources. Through coexistence with ASM communities, LSM companies can have access to resources that are otherwise uneconomic. ASM can mine resources that the industrial mining processes would find uneconomic due to the costs involved in equipment and the dilution when the veins are narrow. On the other hand, ASM, with the use of manual tools and rudimentary equipment can mine these resources and generate profit (e.g., Hemco Nicaragua).

Financial Costs. Usually, companies that operate in coexistence with ASM communities must incur additional expenses, especially when they decide to support formalization processes, since the mining authorities demand compliance with geological and environmental studies that the ASM cannot afford; Often companies with the intention of to maintaining good relations pay for these studies. In chapter 3 we were able to conclude that the financial costs incurred by an LSM are relatively not too high and can be compensated by a significant reduction in risk that directly impacts the value of the project.

Higher risk in their operations. When companies operate in coexistence with ASM, they face risks associated with the artisanal activity; Usually artisanal miners do not work in safe conditions, and accidents occur involving injured or dead ASM miners; the companies are in solidarity with these facts and must incur in associated expenses (e.g., HEMCO, Nicaragua). We also review how Zijin mining with its Buriticá site has been invaded and has lost control over portions of its operations.

Risk of the company being involved in money laundering, terrorism financing, human rights issues. When ASM are intimidated and extorted by illegal groups or drug trafficking

groups, LSM companies can end up being indirectly and unintentionally involved in illicit businesses such as money laundering and terrorism financing. Likewise, if ASM communities allow child labor, poor working conditions, poor pay, this could involve LSM in human rights issues and affect the reputation of the LSM company.

Large-scale mining companies must evaluate and mitigate the risks. For now, what has been observed in Gramalote seems to indicate that many of these risks have been identified and mitigated. However, other types of coexistence strategies such as ore purchase, cannot control factors such as child labor, human exploitation, money laundering or pressure from armed groups outside the law for ASMs who sell the ore.

5.3. Costs and Benefits of Coexistence for ASM

Better pay. Usually, ASM depends on artisanal processing plants to process their ore. In these processing plants, the ore is milled and only the free gold is recovered by amalgamation with mercury. The free gold corresponds to around 20% to 30% of the gold contained. 70% to 80% of the gold content remains in the tailings. The Tailings are left in payment for the service, and the owner of the center extracts the gold from the tailings by lixiviation with cyanide. The milling and amalgamation process is long and after that, the ASM must go to sell the gold to a local trader who usually does not offer the best prices since he is an intermediary and needs to obtain profit.

When ASM works in coexistence with LSM and the LSM purchase the ore and process the ore in their plant, e.g., Continental Gold in Colombia or Dynacor in Perú, the ASM can obtain a better payment because the LSM usually pays between the 50% to 70% of the gold contained in the ore, at international LME spot prices, and this payment could be as fast as two or three days after the delivery of the ore In Gramalote, Antioquia Gold is responsible for gold commercialization. The ASM miners do not need to worry about it, but the LSM company is paid for that service.

Access to technical support. When ASM and LSM are coexisting under the ore buying model, the interest in finding quality resources is shared, if the ASM community gets

resources they will have the ore to sell to the LSM and the company will have more ore to process. In Chapter 3 it was observed that in the event that coexistence is a process of formalization or formalization subcontract, the LSM is interested in the success of the process in terms of ASM complying with the technical requirements that the mining and environmental authorities request in such a way that they can continue to maintain their livelihoods and thus maintain peace in the community. If the community is working and have guaranteed access to a portion of the resource, the Social License to Operate (SLO) can be achieved more easily. For these reasons, it is worth it for companies to offer technical support to ASM.

Access to financial support. When ASM communities are formalized and have ore sale contract agreements with LSM, the companies can support financially the ASM operations with the warranty of the future ore production, or, given that ASM miners are formalized, they can have access to financial support from the banking sector.

Continued access to traditional livelihoods. When coexistence occurs, ASM communities does not need to abandon their territories or their Livelihoods. They can continue to work as ASM, and their livelihood will not be affected. As seen in chapter 4 although their livelihood does not change their economic capacity and access to goods and services improve.

Continue working as independent entrepreneurs. In chapter 4 it was observed that Artisanal miners of La María SAS could continue to manage their own business. Many artisanal miners prefer to work independently, not being required to meet schedules, or have supervision. In this case the coexistence agreement with Gramalote Ltd allow ASMs to continue working independently.

Cessation of mercury use. Coexistence with LSM can allow ASMs to improve their gold recovery processes and replace them with more environmentally friendly ones while increasing the recovery rate. According to Chapter 4, this will improve the quality of life for the ASM community and help to achieve the SDGs.

Reduction in the Resource available for ASM. When a company obtains the right to exploit a subsurface resource, this resource is no longer available to the ASM. Artisanal miners exploit subsoil resources in a more sustainable way, thinking of obtaining what is necessary for their subsistence, and leaving resources for their outcomes, LSM mining, on the contrary, what they seek is to exploit as quickly as possible the greatest amount of resource to have better profits.

Additional costs when entering the legal framework. For companies to have a relationship with the ASM, they require that the ASM be legalized, in the case of the formalization processes the ASM miners become legal, and this implies that they must keep an accounting, use bank accounts, declare, and pay taxes and royalties. This increases the cost of your operations. Other reasons why costs are increased is because they must comply with labor and safety laws. However, the formalized ASM miners of Gramalote stated that after the formalization, they felt more at ease knowing that their income is now legal and that they could invest. The costs increase but equally their lives are calmer.

Livelihood changes or loss. When LSM companies arrive in ASM community areas, they usually pursue the same resources that are exploited by ASM communities, this forces the latter to have to stop their operations or work for the company in different working conditions than those they are used to, this makes the ASMs forced to change their livelihood.

Loss of Territory. LSM mining operations use large areas of land that were previously used for other activities, agricultural, livestock, or ASM. Communities often have to leave these territories to make way for the LSM. However, certain coexistence models such as the purchase of ore, or operation subcontracts model partially mitigate this risk, allowing ASMs to continue working in their territory.

5.4. Recommendations

In order to unlock resources available in countries of the global south were the ASM sector is widespread, mining industry must be innovative to avoid social conflict. In this study

we demonstrate that the investments made to reduce the social risks are as rewarding as the investments made to reduce the technical risks. Investments in social engagement to reduce the social risk should be made from the first stages of the mining project. Several ASM-LSM coexistence strategies had been presented here; these strategies can be applied in a wide variety of resource deposit types. Though, there is no one and only bullet proof strategy to achieve ASM-LSM coexistence since every project is different and every ASM community has its own complexities, the mining industry should consider engaging with communities and build together the coexistence agreement that better fits to both parties. Based on the results of this research, the mining industry can now see that some of these agreements are sustainable and hopefully this can be useful to help to detonate a change of paradigm about ASM sector and work collaborative to obtain the resources needed together. Finally, the presence of ASM miners can be seen as an opportunity to strengthen ties with the community, enabling social license to operate while protecting the livelihood of the people involved in ASM mining and creating value for shareholders and stakeholders and the countries where they operate. This task is usually undertaken once the deposit has achieved a pre-feasibility stage and maybe at this point is too late to obtain a social license to operate.

There are many opportunities to continue doing research on the topic of coexistence. Several cases presented in Chapter 2 are unsuccessful cases of coexistence in which mining companies continue to try to enter and mining communities continue to defend their territories by denying entry. Do these confrontations really need to continue? How can rulers generate solutions in this regard? What can be done to end the conflict between LSM and ASM?

Indigenous and ethnic minority communities that for centuries have been discriminated against and mistreated today have some tools to defend their territories, in Colombia and Peru. However, it takes a lot of understanding of these communities of their knowledge, needs and convictions, to understand them and value their struggle. Governors,

civil authorities and LSM companies must recognize the importance of these cultures, respect and preserve them.

The Gramalote coexistence case examined in chapters 3 and 4 is one of those that has the greatest impact on almost all the SDGs. However, this could be due to the subcontract of operation coexistence model. In this case the LSM company continues to have obligations to the mining authorities. For this reason, the formalized ASMs have received great support from the LSM company to improve their methods. In other coexistence strategies, such as ore purchase, support for ASM may be minimal. It can be said that in this case of coexistence, the companies are not involved in the way ASM miners produce their ore. Instead, they are simply interested in receiving and processing the ore. In this model of coexistence between ASM and LSM, the company only has to worry about proper processing practices. However, it does not pay much attention to the social conditions of the community of ASM miners who sell the mineral to it. The ore purchase strategy of coexistence may not have such an impact on the SDGs since LSM companies do not need to intervene in ASM operations, since they have no responsibility for what happens there.

Research opportunities in this field seem to be quite broad, taking into account a backwards review of the supply chain of the companies that buy ASM ore and evaluating whether these companies are really socially responsible, if these companies verify the origin of the ore or if these companies really care about the social conditions of the artisanal miners who supply the ore. It would also be interesting to review how many SDGs achieve this type of coexistence agreement.

Although this dissertation was made with a lot of effort and dedication, the COVID pandemic strongly affected the possibility of visiting the study areas with much more time. It was difficult to find a space for field visits and to generate the necessary confidence to obtain more field observations. It is difficult to build trust with the communities of ASM Miners, however, everything possible was done in the time available. The field visits were in a very limited space of time and it would have been preferable to have had more time in the field.

APPENDIX A

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Rodríguez-Novoa, F., & Holley, E., 2023. Coexistence between large-scale mining (LSM) and artisanal and small-scale mining (ASM) in Perú and Colombia. Resources Policy, 80, 103162.