BUSINESS SOLUTIONS TO THE FORMALIZATION OF ARTISANAL GOLD MINING

by

Christopher L. Tucker

B.Sc., Simon Fraser University, 2000

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Abstract

Artisanal and Small-scale Mining (ASM) exists in virtually every developing country with accessible mineral deposits. Typically ASM is an informal or in some cases illegal activity with numerous problems associated with it including mercury pollution, non-existent health and safety standards and abusive child labour practices. Furthermore ASM is often regulated to a “subsistence” activity that, along with poor financial management among the miners, keeps participants trapped in a cycle of poverty.

Nonetheless, ASM is remarkably productive and has the potential to be extremely profitable as well as environmentally and socially responsible given guidance and formalization. Efforts to formalize ASM activity thus far have been government-led, top-down, heavy-handed attempts to police an activity that employs an estimated 20-30 million people world-wide, often in remote places and often in situations where they believe they have no economic alternative for survival. Not surprisingly, these efforts have met with limited success.

The productive and potentially very profitable nature of this activity, where there is no shortage of demand for their extremely fungible product, lends itself readily to a business approach. Franchise businesses are effective in markets where consistency in operations and production are required, especially where such operations are attractive to capable local operators.

The franchise model offers access to finance, improved technical capacity for increased recovery, business management expertise, access to banking and personal financial guidance, and a mechanism to reduce environmental and social risk.

Furthermore, investors are increasingly wary of investing in junior mining companies as country-risk, resource nationalism, and social license to operate act as impediments to a project’s timely entry to production. ASM offers high social license with local operators and well-diversified country risk.
Thus, a small-scale gold mining franchise offers an appealing opportunity to manage, as well as diversify against, such risk factors, while remaining in an extremely profitable and hitherto unexplored market. The reality in many places in Latin America is that partnerships with community locals have a much higher success rate than businesses without. Even nationals from other localities experience difficulties such as additional or longer permitting and harassment. This dynamic provides additional advantages to franchise structures.
Preface

The initial idea for this thesis came from an essay by Alan Tidwell of the University of Georgetown as part of an online EduMine course he was taking with my supervisor, Marcello Veiga. Alan and his research assistant, Annie Zhou, contributed freely to the discussions around the development of this idea as my Masters thesis.

Chapter 4 is based upon a case study I undertook with students of UBC’s MINE 581: Environmental Technologies and Issues in Mining.
Table of Contents

Abstract.......................................................................................................................................... ii
Preface........................................................................................................................................... iv
Table of Contents ...........................................................................................................................v
List of Tables ............................................................................................................................... vii
List of Figures ............................................................................................................................. viii
Acknowledgements ...................................................................................................................... ix
Chapter 1: Introduction ................................................................................................................1
  1.1 Statement of the Problem ................................................................................................ 1
  1.2 Objectives ....................................................................................................................... 1
  1.3 Approach of this Thesis .................................................................................................. 2
  1.4 Deliverables .................................................................................................................... 2
  1.5 Structure of the Thesis .................................................................................................... 3
Chapter 2: Artisanal and Small Scale Mining ............................................................................4
  2.1 Artisanal and Small Scale Mining Around the World .................................................... 9
  2.2 Examples of Current Business Models in use by Artisanal and Small Scale Miners... 11
    2.2.1 Shamva Processing Centre, Zimbabwe................................................................. 12
    2.2.2 Caroni River, Venezuela....................................................................................... 14
    2.2.3 Las Cristinas, Venezuela....................................................................................... 16
    2.2.4 Hecla Mining, Venezuela.................................................................................... 19
    2.2.5 Gran Colombia Gold, Colombia.......................................................................... 19
    2.2.6 Piura, Peru........................................................................................................... 20
    2.2.7 Bonanza Gold, Nicaragua .................................................................................. 20
    2.2.8 Tapajos, Brazil .................................................................................................... 21
  2.3 Artisanal and Small Scale Mining in Ecuador .............................................................. 22
  2.4 Mining and Sustainable Economic Development......................................................... 25
Chapter 3: Potential Business Models for Economic Development in Small Scale Mining..27
  3.1 Partnerships .................................................................................................................... 27
  3.2 Franchises ....................................................................................................................... 29
    3.2.1 A History of Franchises ..................................................................................... 30
List of Tables

Table 1. Scale of mining (from Veiga & Angeloci, 2013). ............................................................ 6
Table 2. Preliminary assumptions for a small gold processing plant (values in USD). ............... 39
Table 3. Labour, maintenance and reagents.................................................................................. 48
Table 4. Total labour costs for running the plant......................................................................... 48
Table 5. Operating costs including reagents, labour, maintenance and power............................ 50
Table 6. Continuous cash flows for the three scenarios under option 1. ...................................... 52
Table 7. Continuous cash flows for the three scenarios under option 2. ...................................... 53
Table 8. Small-scale reserve estimation....................................................................................... 55
Table 9. Risks and mitigations..................................................................................................... 61
List of Figures

Figure 1. Tailings ponds that drain directly into the Puyango River. ........................................... 24
Figure 2. A simplified process flow chart.................................................................................... 41
Figure 3. Representing a steady revenue source by an annuity. ................................................... 51
Figure 4. Establishing a mineral reserve from a mineral resource after JORC, 2004. ............... 54
Figure 5. Steps to implement the franchise business model. ...................................................... 59
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Special thanks go to my wife Anita and son Laurence who were tremendously supportive throughout the entire process of researching and writing this thesis.
Chapter 1: Introduction

1.1 Statement of the Problem

While artisanal and small scale mining has the potential to be a significant driver of sustainable community economic development, it is currently plagued with problems due to its informal and sometimes illegal status including the difficulty of eliminating truly problematic sectors such as criminal organizations. This includes health and environmental issues from mercury pollution and poor tailings management, social problems such as drug addiction and the spread of sexually transmitted diseases through prostitution, as well as the instability and lack of accountability of the sector itself.

Artisanal and small scale mining also presents a problem to large-scale mining companies who, without the skills required to properly interact with complex community and political dynamics, are incapable to responding to this situation appropriately. Political, legal and corporate power have been shown inadequate on their own to deal with the issues surrounding formalization and effective delivery of educational and awareness programs have met with limited success. (ILO, 1999)

1.2 Objectives

The research conducted as part of this thesis had the following objectives:

- Review the literature on artisanal and small scale gold mining
- Assess the state of artisanal and small scale gold mining in Portovelo-Zaruma, Ecuador
- Analyze how different business models could affect and contribute to formalization efforts
- Assess the appropriateness of this model in Latin America and beyond, using Ecuador as a model
1.3 Approach of this Thesis

Many approaches have been taken to address problems associated with artisanal or small-scale mining: environmental, health and safety, enforcement, political, legal, technological, etc. The large majority of these approaches have not been generating sustainable solutions. The lens through which this thesis views the problems and solutions associated with this sector is that of a management system. The hypothesis is that by creating an effective management system that incentivizes responsible small-scale mining, miners will be enticed rather than pushed into the formalization process. The motivation for profit has historically been the most significant driver of the world’s economies and well-managed, efficient businesses and industrial operations have historically flourished while erratic and disorganized businesses have withered. Small-scale gold mining is now a massive, global enterprise that is ready to be developed into a systematic and profitable sector. The barriers to this type of organization, especially in many developing countries are significant yet contractual agreements and management systems have the potential to organize behavior in places where rule of law is lacking. Furthermore, the adage that “one must measure that which one would improve” lends insight into how developing a transparent process organizing small-scale mining as a responsible business can help to harmonize the overall formalization process with financial and governance benefits to host countries.

1.4 Deliverables

This thesis was designed to deliver the following results:

- Literature review of all relevant research on global artisanal gold mining
- A survey of artisanal and small scale gold miners in southern Ecuador
- A management model to transform disorganized artisanal gold miners into responsible small-scale miners
- A generic assessment and selection of business models for small scale gold mining
- Assessment of the appropriateness of this model and viability of this solution
- An approach how to implement this novel model in practical way
1.5 Structure of the Thesis

Chapter 1 introduces Artisanal and Small-scale Mining and notes the differences between the two commonly associated activities. It states the problem that this thesis addresses, the objectives of the thesis, a list of deliverables from this work, and identifies the structure the thesis takes.

Chapter 2 looks more deeply at Small-Scale Gold Mining and specifically at the nature of Artisanal and Small-scale Gold Mining. Examples of business models to transform the poor practices of artisanal miners tried in different countries are briefly commented upon. The characteristics of the artisanal miners in Portovelo, Ecuador, as a central part of this study, is also introduced. Then the relationship between Mining and Sustainable Economic Development is explored.

Chapter 3 addresses Franchise Mining by first describing the franchise business model and how it works, second looking at the history of franchises, and third examining how the franchise business model could be applied to the small-scale mining sector.

Chapter 4 presents a feasibility study of a typical small-scale gold processing plant. It includes estimates of capital expenditures and operating expenses for three different scenarios of scale and develops cash-flow models and discounted cash-flow estimates for each using different business models to determine the optimal approach.

Chapter 5 explores the steps necessary to create a mining franchise.

Chapter 6 discussed the subject more freely in the hopes of inspiring a deeper discussion of the overall feasibility of developing a franchise mining operation and of the issues raised. It includes an assessment of the various risks involved and potential mitigation measures.

Chapter 7 presents the conclusions of this thesis.
Chapter 2: Artisanal and Small Scale Mining

Internationally the artisanal and small-scale mining (ASM) community represents a significant opportunity to reduce poverty and increase the wellbeing of communities throughout Latin America, Africa and Asia. Small-scale mining has a huge potential to alleviate poverty in the developing world, and can contribute significantly to national revenues (Hilson, 2002).

ASM directly involves 20–30 million people worldwide, generates up to five times the income of other rural poverty-driven activities in agriculture and forestry, employs 10 times more people than does the large-scale mining sector, and stimulates considerable local economic development (Buxton 2013).

Artisanal mining ostensibly refers to the particular method and technologies used by small groups of people to extract ore from the ground in a primitive manner that has a relatively long history. Ideally this would mean traditional placer mining involving panning and sluicing. In practice the term “ASM” refers to a wide variety of methods of extraction and scales of production from panners to large dredgers working informally.

Legislatively the term “artisanal” often refers to a mining operation that holds no concession, where an individual miner may or may not hold a permit, and allows for mining as a traditional “subsistence” activity (ILO, 1999, Ministry of Non-Renewable Natural Resources of Ecuador 2014). In Colombia, for example, the Mining Code of 1988 defined the type of mine based on the volume of material being extracted, the installed capacity for mining and mineral processing as well as other technical, social and economic aspects. The Decree 2636 of 1994 changed this, and defined another type of miner, “mineros de hecho” (miners de facto) who are the informal miners with no mineral title, i.e. those who undertake mining as a traditional economic (subsistence) activity (Ministerio de Minas y Energia de Colombia, 2014). These categories create additional confusion around the definition of each type of operation, making it even more difficult to formalize the operations and derive tax revenue from them.
Often much greater profits are realized and it may be considered that such legislation is in fact legislating for poverty rather than addressing any of the problems associated with the sector. To escape the poverty trap of artisanal mining as well as the resource curse of large-scale mining, developing countries need more specific legislation that accurately describes the reality on the ground in order to prescribe more effective solutions (Veiga, 2009).

In practice, the term “small scale” can refer to mining operations ranging from a few kilos of ore being mined and processed per day to hundreds or thousands of tonnes per day in operations as sophisticated and nearly as large as many conventional mines. In many countries, such as is the case in the south of Ecuador, limits to production levels under the category of “small scale” are by individual concession and so companies or individuals holding multiple concessions can increase their scale of production simply by holding more concessions (Ministry of Non-Renewable Natural Resources of Ecuador, 2014).

In general, an artisanal mining operation is a small operation, although there are a few large activities using rudimentary methods that should be considered artisanal. In these cases, the term “small-scale mining” does not necessarily refer to mining that is “artisanal” or rudimentary, but only in terms of the mines exploiting small volumes of material (Veiga et al., 2014). But the question is: how small should an operation be in order to be considered a small mine? In Ecuador, for example, the Mining Law of Jan 29, 2009 considers every mine extracting and processing less than 300 tonnes of ore per day as a small operation and which then pay as low as 5% tax. Those mines producing more than 300 tonnes/day are considered large and pay 50% tax (Vergara, 2009). It is clear that the boundary should be more flexible to allow for medium-scale mines, but the approach taken by many larger operations is to have multiple 300 tonne per day mines.

The main point of confusion in terms of the legislation is that the opposite of artisanal mining is not necessarily large-scale mining (LSM), but rather conventional mining, i.e. those formalized operated by organized companies, respecting the laws and highly mechanized. The term LSM is somewhat vague as it defines only the size of the operation, and not the level of sophistication or formalization.
In a practical way, it is possible to select at least three different characteristics that differentiate between conventional and artisanal mining: 1) the legality of the mining operation, 2) the scale of production and 3) the method and technology used.

In regards to legality, conventional mining is almost always in accord with national legislation. However, particularly in developing countries, this can be a contentious issue with a variety of actively engaged stakeholders including different levels of government who may or may not support a project. For example, a municipal government may be more accountable to local artisanal miners, whereas a national government may be further removed and more considerate of obtaining international investment by way of mining concessions.

Depending on jurisdiction, ASM may be regarded as a legal activity, an informal or uncategorized/uncensored activity, or, especially when conventional mining permits are being tendered, outright illegal.

In regard to scale, a more useful analysis is proposed (Veiga & Angeloci-Santos, 2013; Angeloci-Santos, 2013) (Table 1) as follows:

<table>
<thead>
<tr>
<th>Size</th>
<th>Scale (tonnes per day)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>&gt; 1000</td>
<td>covers most multinational operations and many national ones</td>
</tr>
<tr>
<td>Medium</td>
<td>300 – 1000</td>
<td>covers a significant portion of conventional mining</td>
</tr>
<tr>
<td>Small</td>
<td>5-300</td>
<td>covers the range of community miners operating with no permit</td>
</tr>
<tr>
<td>Micro</td>
<td>&lt; 5</td>
<td>covers only quite small operations, solo panners, etc.</td>
</tr>
</tbody>
</table>
It is important to highlight that the organization of mining operations by the amount of material produced per day (Table 1), despite its simplicity, is idealistic and not yet implemented by developing countries.

Conventional mining, which in the large majority is large-scale, including both underground and open pit operations, typically covers the large and medium categories of scale in Table 1. In some cases, there are small operations that operate in a conventional fashion. In southern Ecuador, in the Portovelo-Zaruma region, there are at least 30 well-established operations that can be characterized as small-conventional mines (Veiga et al., 2014b). ASM typically covers small and micro scales of production. Thus, in the small scale range there can be, and often is, a confusion of the two definitions.

In regards to technical method, conventional mining is fully mechanized, has a relatively high carbon footprint (Buxton, 2013) and uses large volumes of water for extraction.

Traditionally, artisanal mining (AM) has been defined in the legislation of some developing countries (Veiga, 1997) as a manual activity employing hand-tools for extraction, sacks for transporting ore to the surface, and simple mills and sluice boxes for processing. Indeed this is the image that the term “artisanal” conjures today. However, much of what is currently deemed “artisanal mining” is highly mechanized and has similar per tonne carbon footprints and water usage as conventional mining operations (Veiga et al., 2015). Therefore this type of mining would be better described as small- (or even micro-) scale mining while the term artisanal mining might best apply to the subset of small-scale mining that uses rudimentary tools.

Small-scale mining (SSM) has the capacity to access gold deposits that cannot be economically extracted by large-scale mining. It can also rework tailings from old mines and can yield a profit, as well as significantly supply minerals to the global market, in a way that large-scale mining cannot (Andrew, 2003).

However, ASM is not without its problems. Environmental problems range from the use of mercury to process ore to a lack of incentive to reclaim disturbed lands. Health problems include
mercury inhalation and mercury releases into water waterways, transmission of sexually transmitted diseases, drug and alcohol abuse, etc. (Tschakert, 2009; Mwaipopo et al., 2004). There are also considerable social issues associated with the sector such as heightened security risks to neighbouring communities and operations, child and forced labour, and inequitable distribution of benefits (ICMM, 2013). Furthermore, the fatality rates are up to 90 times that of conventional, large-scale mining in developed countries (Hinton, 2007) and much of the revenue generated remains untaxed and often supports illegal or even revolutionary activities (ICMM, 2013). Some of these factors are self-propagating where soil erosion caused by mining disturbs agricultural production, which in turn leads to greater poverty and reliance on outside resources.

ASM activities also are associated with various forms of conflict. Carson et al. (2005) describe what they call “conflict flashpoints,” which center around the distribution of mining revenues, the diversion of revenues intended for local development and problems associated with how revenues that do make it to the local level are ultimately used. These problems illustrate the bigger issue: that the current dysfunction benefits many in power. While numerous solutions have appeared in the literature to mitigate these problems and conflicts including formalization of the sector, fair trade models that currently exist for agricultural products like coffee, bananas and cocoa, and various forms of public-private partnership, these programs up until now have had little if any success. One explanation is that many of the costs and risks associated with ASM are externalized and thus not realized by those who reap the benefits. Therefore, there is no motivation for change. In the current industry there are millions of itinerant independent small-scale miners who earn perhaps a few hundred dollars a year during time taken off from their regular work as subsistence farmers. In contrast, there are hundreds of thousands of employees working for the larger operations previously described who make subsistence wages on the order of a few thousand dollars per year. Finally, there are a few extremely successful entrepreneurs who benefit tremendously from the situation and have a vested interest in seeing that it remains informal and unregulated. All of this operates within an unregulated economic system that includes gold buyers, mercury dealers, and businessmen, often supported by affluent and influential politicians as well as other players outside of the actual mining areas (Tschakert, 2009).
2.1 Artisanal and Small Scale Mining Around the World

Artisanal and small-scale mining represents a significant source of economic activity and provides a subsistence livelihood for over 100 million people in approximately 70 countries. In addition, artisanal mining is a significant producer of minerals, yielding between 380 and 450 tonnes of gold annually (Seccatore et al., 2014). As gold prices have risen through the early part of the 21st century, gold mining offers a unique and powerful opportunity to the world’s poor, generating 3–5 times the income of other occupations (Siegel & Veiga, 2009).

In conventional large-scale mining, production of minerals is dominated by a few very large companies, whereas exploration and discovery of ore deposits involves thousands of junior mining companies who rarely if ever build a producing mine. A mining business is very capital-intensive and very few of the relatively high number of discoveries in the mining world, make it to production (Kruezer & Etheridge, 2010). Those that do bring a very high economic value per hectare of land occupied thereby presenting significant potential as economic drivers. The often lengthy and bureaucratic permitting process presents a significant risk factor for these high capital projects. Significant risks to large-scale mining include capital allocation and access, resource nationalism, and price and currency volatility, among others (Ernst & Young, 2013). Many rural communities in developing countries have artisanal mining as a traditional occupation and are unfamiliar with, and apprehensive about, large-scale mining. As ASM is often perceived as being members of the local community, effective resolution of conflicts with ASM can be the most effective means for reducing social risk through community engagement (Davis & Franks, 2011).

While large scale development of mineral resources significantly aided in the building of developed countries during their growth in the late 19th and early 20th centuries, the developing countries of the late 20th and early 21st century have not been equally aided by their endowments. With the oft-quoted exceptions of Botswana and Chile, developing countries have been described as being “cursed” rather than “blessed” with resources due to problems of inequality associated with civil unrest, corrupt regimes and depredation by stronger nations and companies (Auty, 1993).
Conventional mining can also be characterized as having relatively well-regulated environment, health and safety, and labour standards. While the mining industry as a whole is proud of the gains it has made in the realm of health and safety – evolving from a once highly dangerous profession to a very safe one - and is beginning to attain satisfactory environmental performance in many cases (with notable exceptions), the industry as a whole struggles to understand and manage the inherently complex dynamics involved in engaging with communities (Davis & Franks, 2011). However, this is not due entirely to a lack of awareness or concerns.

“Sharing the benefits” and “Social License to Operate” now make it into Ernst and Young’s annual roster of Risks to the Mining Industry (Ernst & Young, 2013) and companies are increasingly understanding the material risk involved in dealing with communities responsibly. Yet, the problem remains a difficult one to solve: academic literature and corporate social responsibility reports are fraught with examples of well-intentioned community development and engagement plans gone awry.

One area where conventional mining companies can make significant improvements is when dealing with existing ASM operations, in particular when this is occurring on their properties. When large-scale mining permits are issued in developing countries, the concessions typically have pre-existing artisanal mining operations within their boundaries. Often these groups are locals whose activity directly or indirectly supports many community members. Furthermore, many communities view artisanal mining as a traditional occupation, and are thereby more accepting of it than conventional, large-scale mining (Veiga & Tucker, 2015). One well-publicized case of this is when Manhattan Minerals attempted to develop a large deposit at Tambogrande, Peru. The company was effectively pushed out of the community, which was then overrun with small-scale miners who created a tremendous amount of pollution and social problems (Veiga & Tucker, 2015). Nonetheless, the community appeared to be both tolerant and accepting of the small-scale miners because they were not perceived as a threat in the way that a large, multinational company can be, even though in this case the negative impacts were probably much greater (Muradian, 2003).
Sometimes however the miners are extra-local and/or involved in drugs and organized crime, as gold makes an excellent vehicle for money laundering, due to its highly fungible characteristics. However, given the great size of the average concession it is nearly impossible to police or control entirely: hard-line attempts to evict small-scale miners mostly fail as miners will return, often within weeks, to a profitable site (C. Velázquez-Lopez, personal communication, May 12, 2013).

2.2 Examples of Current Business Models in use by Artisanal and Small Scale Miners

There are many different examples of tentative models of businesses that companies and governments have made with artisanal miners worldwide. Some were successful while others failed to sustain themselves. All these models focussed on the formalization of the artisanal miners, as a key objective, which would create incentives for them to increase their gold recovery and to generate taxes for various levels of governments. It is difficult to select what is the most adequate business model based on these examples, as there are site-specific characteristics dependent upon the needs of the miners, their capacity to run the business, and their motivations. In the large majority of the cases, the government or mining companies established relationships with surrounding artisanal miners to avoid further invasions of their mineral claims. Also there are business models carried out by the private sector based on investments in existing artisanal operations and working in partnership.

It is possible to organize the examples of business models in 5 categories:

1. Government or private entrepreneurs establish processing centres where miners pay a nominal fee to process their ores e.g. Shamva Centre, Zimbabwe; Caroni River, Venezuela.
2. Mining company selects an area and gives it to artisanal miners to work alone as they wish e.g. Koffeecamp, Suriname.
3. Mining company gives an area to the miners and the company provides technical assistance and delegates to help manage its operation e.g. Las Cristinas, Venezuela.
4. Mining company buys ores from the miners for a fair value to be processed in a conventional processing plant of the company. Sometimes the company provides technical assistance to improve the mining activities (e.g. Hecla Mining, Venezuela; Gran Colombia Gold, Colombia), or the company simply buys ore from the miners without knowing the source and the operating conditions in which the ore was extracted (e.g. Piura, Peru; Hemco, Nicaragua).

5. Mining company or private investors work in partnership with the artisanal miners sharing the risks and results of the mining and processing activities e.g. Bonanza Gold, Nicaragua; La Poderosa, Peru; Tapajós, Brazil.

2.2.1 Shamva Processing Centre, Zimbabwe

The model of processing centres which extract gold for a nominal fee is the most popular and proliferates in virtually all countries with artisanal gold miners. The miners take their ores to be processed by rudimentary methods, such as amalgamation of the whole ore in copper-plates or in ball mills and the owners of the processing centres retain the tailing to be leached with cyanide. This ineffective extraction usually recovers less than 30% of the gold from the ores (Veiga et al., 2014). This was the model of the Shamva Centre, which was an initiative introduced by a British Non-Governmental Organization (NGO) to reduce mercury use in Zimbabwe.

The Shamva Centre was built in Zimbabwe in 1989 to process ore from 40 gold mines in the region and presents a good example of organized processing centres. This centre began as an initiative by the National Miners Association of Zimbabwe with the UK NGO Intermediate Technology Development Group (ITDG, now called Practical Action).

The Shamva Centre discouraged miners from using mercury in their operations by presenting alternatives for extracting gold and introduced proper tailings storage and management in order to reduce the amount of riverine tailings disposal, the miners’ traditional method. The centre was active for many years, although it failed ultimately to attract a critical mass of miners, as it was located distantly from their operations and lacked an effective method for extracting fine gold. A full analysis of the Shamva Centre can be found in Hilson (2006). The author also illustrated
similar challenges with a processing centre implemented by the United Nations International Development Organization (UNIDO) and the Ghanaian Government in Japa. In that case, it was outlined how the Ghana miners began to use the centre to decompose amalgams in retorts. However, as with the Shamva Centre, the high demand for services forced miners to wait for extended periods and the miners defaulted to the practice of burning their amalgams in open pans in the jungle.

As the Shamva Centre model grew and expanded around the globe, the merit of the idea for the miners was clear: that the processing centres provide, for free or for a token fee, the facilities, equipment and training to, in a short period of time, produce a bar of dore. For governments and funders of these projects, the primary intent was to avoid discharges of mercury into the rivers, the generation of significant amounts of atmospheric mercury, and the exposure of hundreds if not thousands of people employed directly and indirectly to this toxic vapour. The business model was that the miners would then leave behind the tailings from this preliminary processing which the processing centre owners would then further refine to extract the residual gold. Many other such processing centres have been established in Zimbabwe and in other developing countries to provide similar services. However, these new centres rarely use clean or efficient techniques in processing the miners’ ore. The processing centres use a very crude grinding process to liberate fine gold particles before processing, which negatively affects the gold recovery. They use rudimentary methods to concentrate the gold, or they simply amalgamate the whole ore using copper amalgamating plates or they grind the ore with mercury in small ball mills. The amalgamation of the whole ore is the main reason for large mercury losses to the environment. With these inefficient processing techniques, the gold recovery is usually below 30% (Cordy et al., 2011).

Centralized processing centres for artisanal miners began to become an interesting business in which the miners do not need to invest in equipment to process the ore and extract the gold. They spend some time (2 to 3 weeks) mining the ore and take it to these centres where the ore is crushed and ground, the heavy minerals concentrated (or not), the gold amalgamated and the amalgam burned (using retorts or not) by operators. It is not new that centralized processing centres such as these offer their services in order to reduce the costs and risks associated with
mineral processing. The Shamva Centre in Zimbabwe described above was the first attempt to control pollution by providing to miners a place where they could grind, concentrate and amalgamate their ores. It was built in 1989 by a miners association and a British Non-Governmental Organization. The centre provided crushing, grinding, concentration, amalgamation and retorts for the miners to decompose amalgams so that they would not be exposed to the toxic fumes. As well, atmospheric pollution would be minimized and tailings disposal services provided in order to prevent disposal into the river. This centre was active for many years, although it was limited in capacity and located far from the centre of mining activity. Originally designed for 40 miners, the centre drew up to 500 miners who then were forced to wait weeks if they wanted to process their ore (Hilson, 2006). Ultimately, the centre suffered from a lack of planning and scalability.

2.2.2 Caroni River, Venezuela

In Bolivar State, Venezuela, the Caroni River, a 640 km long tributary of the Orinoco River, has been subjected to mining operations since the end of the last century. Until 1989, about 200 dredges were operating to extract gold and diamonds from sediments in the Lower Caroni River. Before 1991, amalgamation was performed on the dredges using cheap copper plates or simply by adding mercury to riffled sluices. Contaminated tailings were returned to the riverbed. Considering that the maximum production of the Lower Caroni before 1991 was 700 kg annually and mining activities had intensified after 1985, it is estimated that approximately 5 tonnes of mercury were discharged into the Lower Caroni before 1991. In 1991, through two decrees, the Venezuelan Government prohibited all amalgamation activities on dredging barges or on shore. A direct consequence of this legal measure was the creation of three Amalgamation Centers and two Gold Processing Centers where gold is extracted from gravity concentrates produced on barges on the Caroni River. The first Amalgamation Center, in Playa Blanca, was created and administrated by the state-owned company, CVG. Four technicians and one engineer operated the center that amalgamated concentrates from over 70 barges. Each miner would usually take 15 to 20 kg of gravity concentrate to be amalgamated with 250 g of mercury in rolling barrels. After amalgamation, a mechanical spiral was used to separate heavy minerals from amalgam. The excess mercury was removed by hand squeezing using a piece of fabric. Amalgam was retorted
in a separate building under miners’ supervision. Operators would process 200 to 300 kg of concentrates daily to produce about 1 kg of gold. The Center did not charge the miners and all amalgamation steps are visible. The owner of the concentrate was the only person allowed to be present with the operators inside the Center. This creative idea was copied and even improved by private companies.

The Amalgamation Center of Carhuachi demonstrates that it is possible to handle mercury safely with a negligible level of mercury emission. In Carhuachi, all heating steps (retorting and melting) were carried out in an isolated room with a large fan in the roof. To avoid occupational exposure, a small fume hood was placed on top of all retorts to remove any mercury vapor that occasionally escapes. The fumes were conducted through a series of scrubbers containing iodine solution and finally through activated charcoal filters. The melting furnace had a water condenser to remove mercury from vapor and various small scrubbers with potassium iodide solution to guarantee that no mercury was emitted to the atmosphere. A mass balance of the Carhuachi Center indicated that more than 99% of mercury added is recovered (Veiga & Beinhoff, 1997). The majority of mercury recovery (70 to 82%) occurred when excess mercury was removed from amalgam by an innovative technique using a centrifuge instead of hand-squeezing. No mercury vapor was lost and 17 to 25% of mercury added was recovered by condensation in the retorting operation and 2 to 4% in the melting step. The main mercury loss, around 1%, occurred with the amalgamation of the tailing. However, this tailing still contained 300 ppm mercury and 50 ppm gold. However, it is important to point out that the tailings are not dumped into the rivers but sold to a cyanidation plant in El Callao, which paid 50% of the gold content value (Veiga & Beinhoff, 1997).

While these centres were operating, they attracted considerable attention from the development and environmental communities and a significant reduction in mercury discharge into the river was noted. The centres were closed in 2002 by the Venezuelan Government, when two new hydroelectric reservoirs were built.

Both initiatives, Shamva and Caroni, started with the valid ambition of reducing mercury use in the field and rivers. However, thousands of processing centres are operating currently to exploit
miners who do not have sufficient financial capacity to install a processing facility for crushing, grinding, concentration and amalgamation. This has become common practice in all developing countries with artisanal gold miners. The centres provide services to extract only a small portion of the gold from the ores and then the centres use cyanidation to extract the residual gold from the tailings. The services are typically free or charge the miners a nominal fee provided they leave their tailings with the processing centre facilities. This business model is predatory to the miners and highly polluting as most of tailings contaminated with mercury and cyanide are improperly disposed and end up in the local waterways (Veiga et al., 2014).

2.2.3 Las Cristinas, Venezuela

Another well-cited example is of the supposed mutually beneficial relationship developed at Las Cristinas. In the 1990s, Placer Dome sought to develop a 40000 tonne per day open-pit gold and copper mine in Venezuela. The mine was located in the centre of Venezuela's Kilometre 88 mining district, which had seen a tremendous amount of artisanal mining activity in the 1980s with over 10,000 artisanal and small scale miners operating in the area. During this period, responsibility for exploration and development in the region was transferred from the Ministry of Energy and Mines to the state-owned Corporacion Venezolana de Guayana (CVG) (Davidson & Wotruba, 2004).

CVG developed a plan to promote large-scale mining in the Kilometre 88 district while retaining some areas for organized small-scale mining. Placer Dome created a joint venture with CVG (70% PD, 30% CVG) called Minera Las Cristinas (MINCA) which was awarded the Las Cristinas concession. At this time (1991-92), approximately 4000 people, who were living and working on the concession, were displaced by CVG, 2800 of which were resettled into two sites 5 km east of the concession. This led to approximately 500 miners invading and working illegally on the nearby concessions, including Las Cristinas. As the relocation did not consider the workers livelihoods, it resulted in significant frustration and led to road blocks, threats, violence against people and property, public protests and invasions of neighbouring mining concessions.
The rising tension in the community concerned the company enough to fund an independent assessment of the risks posed to the project. This assessment showed that economic opportunities for the community were directly linked to the security of the Las Cristinas project and so a “co-habitation” scenario with the artisanal miners was developed.

About 50% of the artisanal miners working on the Las Cristinas concession would typically be found in an area known as Los Rojas. This area was set aside for the miners as a legally-organized, technically-assisted, small-scale mine and mill. Technical assistance on the mine included mechanized overburden removal followed by selective hand extraction of ore. Technical assistance on the mill involved eliminating the release of mercury into the environment and improving the gold yield.

Initially, MINCA management saw the Los Rojas project as a short-term, stop-gap measure that would provide basic livelihood to the miners until the large mine could be built which would then be a source of jobs and business opportunities for the local people. The company believed that consensual co-habitation would reduce risks on the main property and the need for armed security. Furthermore, the very act of engaging with the community miners would reduce tensions and stabilize the relationship between ASM and MINCA, which were interested in opening a large operation. They also saw in this project the opportunity to build an organized, disciplined work force that would be a good source of labour for the large mine and that the project would ensure that safety and environmental standards were met by the artisanal miners working in the area (Davidson & Wotruba, 2004).

The feedback on how the artisanal miners perceived this opportunity only comes from MINCA. Unfortunately the company says that they did not document the miners’ perceptions with surveys, formal conversations, etc. The company only provided a conventional mining perspective on ASM (access to capital, clean mining techniques, etc.) which it is doubtful that the miners fully endorse. The potential perceptions of the miners themselves about the opportunities associated with this co-project, bearing in mind that they were negotiating from a weak position - having been previously relocated and declared illegal - include the opportunity to
create a legal, secure working area for themselves, access to technical assistance, and an opportunity to improve their mineral processing and profitability.

Under Venezuelan mining law, independent mining undertaken by individuals is illegal and artisanal mining is allowed only as an organized group activity. Therefore, the first step was to organize the local miners into either civil associations or cooperatives. While the project received favourable attention, even winning awards for industry best practices from the World Bank and Conservation International, the Las Cristinas gold reserve, which Hugo Chavez described as one of the “best in the world” remains, decades later, undeveloped. It has passed through numerous corporate hands: from Placer Dome, who was acquired by Barrick Gold, to Canadian junior Crystalllex, who had the project held up by environmental permitting and finally expropriated by the Venezuelan government, to now options to develop with the China International Trust and Investment Corporation and Rusoro, a Russian development company. It is unclear whether the Venezuelan government genuinely wishes to develop a gold mine here. However, this example illustrates the fact that relationships between corporations, communities and governments exist within a complex network of relationships (De Brooks & Waymer, 2009).

A senior engineer on the project compared the effort of organizing the miners into civil associations and cooperatives to “herding cats” in order to characterize what a challenge this presented (J. Thomas, personal communication, Oct 4, 2013). He also compared this effort, which consisted of 10 years and close to $150 million of investment money, to a similar project in Venezuela where resident miners were simply paid less than $2 million to vacate the concession, which they ultimately did. This latter solution, albeit temporary, cleared the area sufficiently long enough for the project in question to become established and resulted in the same outcome, with less work and financial output on the part of the company.

Clearly, sophisticated working relationships with communities and especially small-scale miners require not only goodwill on behalf of the company and the community members but also local governments. Without this support it is difficult to imagine how such a project could be successful.
MINCA’s initiative of establishing a small mine and processing centre was apparently based on the experience of the Venezuelan government from 1991 onwards in introducing legislation to establish processing centres in the Caroni River region in which miners would bring their concentrates from the dredges to be amalgamated by professional operators. The five centres established processed concentrates from 70 barges which eliminated the use of mercury on board and recovered 99% of the mercury that had been previously used. However, the owners and managers of the processing centres determined that the amalgamation was not efficient and removed less than half of the mercury from the concentrates (Veiga & Beinhoff, 1997).

2.2.4 Hecla Mining, Venezuela

In 2002, Hecla Mining acquired a 1,800 hectare property from CVG Minerven, the previously mentioned Venezuelan state-owned Corporacion Venezolana de Guayana. This property had been worked for many years by artisanal gold miners and at the time of acquisition approximately 250 artisanal miners were working a number of deep (up to 80m) shafts in the area with explosives and transporting the ore to 28 local processing centres. Overall production was estimated at approximately 2 tonnes annually. Hecla then established an agreement to purchase ore from the miners and take it for processing at the mill at their Camorra mine (Veiga et al., 2005).

2.2.5 Gran Colombia Gold, Colombia

The small town of Segovia in Antioquia Department, Colombia is the largest gold producing region of Colombia, due to the presence of Gran Colombia Gold, a Canadian gold mining company. Since the company acquired the Frontino Mine in Segovia, Gran Colombia Gold has been working with over 4,000 artisanal and small-scale gold miners. Under contract, the artisanal miners work the company’s mines and take the ore for processing at the company mill. This helps formalize the artisanal miners and provides the miners with health and pension benefits, health and safety training and a safer work environment (Gran Colombia Gold, 2015). Previously the miners primarily used mercury to process their ores and by 2013, mercury losses had been
reduced by 63%, resulting in 46 to 70 tonnes/a less mercury entering the environment than in 2010 (Garcia et al., 2015).

2.2.6 Piura, Peru

In the Peruvian region of Piura nearly 10,000 artisanal and small-scale miners have traditionally processed their ore in 160 rudimentary plants dispersed over 158,000 hectares. However, oxidized ore, which is porous and easy to leach, is becoming scarce, and recovery by amalgamation is producing poor recoveries, often as low as 10%. As a result three companies now operate in the area (Veiga et al., 2015) which buy ore from the miners and then transport it a distance of 1,100 km to more sophisticated plants in southern Peru. Before transporting the ore, the buyers assay the gold in the ore and pay the miners 50% of the value of the gold content. Upon purchase, the companies process the ore by fine grinding, followed by concentrating copper minerals with gold by flotation and eventual cyanidation.

2.2.7 Bonanza Gold, Nicaragua

According to Nicaragua’s Ministry of Energy and Mines, official gold production for 2011 was 7.46 tonnes which includes 1.24 tonnes produced by approximately 20,000 to 30,000 artisanal miners locally known as “güiriseros.” The miners take their ores to processing centres that charge US$70 per day for the use of a “rastra” (a grinding process using three rocks over a flat bottom tank) which grinds two tonnes of ore per day, and US$22 to US$35 for rastras with a capacity of half-tonne to one tonne per day, respectively. In 2012, 160 rastras were in operation in the country, releasing approximately four to five tonnes of mercury per year. The owners of the processing centres sell the mercury-contaminated tailings to other companies or processing centres, which use cyanidation to extract residual gold from the tailings. Analyses of rastra tailings indicated grades of 7.17 g Au/t and 10.3 g Hg/t (Veiga et al., 2014). With feed grades around 9 g Au/t gold recovery is less than 20% resulting in part of the mercury in the tailings being converted into mercury-cyanide complexes in the reprocessing of the tailings.
Under Nicaraguan Mining Law, mining companies must dedicate 1% of their concession to artisanal gold miners. Entering this situation in 1995 with a successful bid for the Bonanza Gold concession, Hemco began purchasing ore from artisanal and small-scale miners. First performing an assay to determine the grade, they would pay the miners 50% of the recoverable gold (typically 85% on ore with a cut-off grade of 2 grams per tonne). As this relationship progressed, Hemco provided training for 3000 miners in two cooperatives on mining methods, explosives, geology, safety, etc. and built two 60 tonnes/day, mercury-free processing plants for the miners to operate, through an overall investment of US$1,000,000 (Veiga et al., 2014). The Bonanza Mine was recently sold to the Colombian company Mineros S.A.

2.2.8 Tapajos, Brazil

The Tapajos River Basin in the Brazilian Amazon is the location of one of the largest concentrations of artisanal and small-scale miners in the world. Approximately 40,000 miners produce close to 8 tonnes of gold per year, releasing at least twice this amount of mercury into the environment (Nevado et al., 2010).

In the 1990s, this area witnessed the world’s largest gold rush when over one million miners produced around 100 tonnes of gold per year from over 2000 mines. Tapajos still has one of the world’s largest concentrations of mines in an area that extends for 98 000 km². In 2010, the population of miners was estimated at close to 200,000 (Sousa et al., 2010).

A common business model in the Tapajós is a partnership of five artisanal miners with one investor. They share the profits equally but the investor, who pays all the operating costs, deducts expenses including food, fuel, tools, transport, etc., before splitting the profit with his partners. This method became a standard in the region and most investors observed in the area are pilots of small planes that originally made their money transporting artisanal miners to the sites and now invest in the operations. Currently there are many organized processing plants in the Tapajós region using more sophisticated processing methods such as cyanidation, with some of them still using the well-accepted 50-50% model. (Sousa et al., 2011).
2.3 Artisanal and Small Scale Mining in Ecuador

In the early 1990s Ecuador was one of the first countries to legalize all informal mining communities, which represents an essential step in the formalization process (Bugnosen & Twigg, 2000). In Ecuador, artisanal mining employs approximately 130,000 people directly and indirectly. Portovelo-Zaruma is the oldest and most important gold mining area in Ecuador (Tarras-Wahlberg et al., 2002). The small mountain village of San Antonio de Zaruma has been described as “the longest-running hard-rock gold camp in the Western Hemisphere” (Lane, 2004), although it is virtually unknown in the rest of the world. However, with high gold prices over the last decade, the region has experienced a surge in both artisanal and conventional gold mining (Veiga et al., 2002; Velázquez-Lopez et al., 2010; Velasquez-Lopez et al., 2011) and is once more a place of interest for foreign investors.

Artisanal miners in Portovelo typically process their ore in small scale processing centers owned by those with knowledge of mineral processing and financial capital. Truckloads of ore that range from 40 to 90 tonnes, are delivered to the processing plants lining the Puyango River in an area of Portovelo known as “El Pache.” Typically, the ore is first shovelled by hand into a jaw crushe that then feeds into a Chilean wheel mill. In these mills two or three large wheels approximately one metre in diameter each travel a circular path within a large drum some 2.5 metres wide while a small but steady supply of water is added. There are many anecdotal accounts of miners becoming trapped within the mill and crushed to death or suffering permanent injury. As the crushed ore becomes sufficiently fine, a slurry of material passes through a fine screen leading onto the surface of a sluice box. The sluice box is a ramp averaging seven metres in length and half a metre in width. It declines at between five and ten degrees and often is lined with wool carpets or sack cloth in order to trap the heavier minerals and gold particles as the relatively light tailings and water flows along. This process recovers relatively coarse gold (>0.1 mm) estimated at approximately 30% of total gold in the ore (Velásquez-López, et al., 2010). This figure is dependent on the mineralogy of ore being processed and can vary considerably. In this scenario, the remaining 70% goes into the tailings or waste material which is typically recovered further by cyanidation either by the plant owner, or at significantly greater cost by the miner. Many miners believe that they recover much more gold, even all the
gold, through the sluicing method. They will pan at each stage of the process until they don’t see any more gold. The concentrates removed from the sluices are panned and amalgamated. In the panning process the miners lose gold and the rich panning tailings are mixed with the primary tailings to be leached with cyanide.

In Portovelo-Zaruma, 87 such processing centres line the banks of the Amarillo River that flows from Ecuador into Peru. While many of the plants have small tailings ponds, the majority end up draining directly into the river. While once a fish-bearing river, the Amarillo now contains virtually no fish and no longer supports any fishing activity. The Puyango ultimately flows into Peru on its way to the Pacific Ocean. This brings a significant amount of mercury pollution into Peru (Adler-Miserendino, 2012) and is the subject of considerable political conflict between the two countries. As a result, a massive tailings facility (El Tablon) has been constructed several kilometers away and uphill from the Puyango basin. The Ecuadorian government has stated its intention to move all 87 processing plants closer to this tailings facility within the next 5 years. This activity, if at all feasible, is sure to disrupt the businesses currently operating and potentially represents an opportune time to introduce and/or establish a new way of doing business in the region. Until the processing centres can be moved closer to the tailings facilities, the plan, stated at public meetings, is to construct a pipeline to carry the tailings to the facility. As tailings are notoriously difficult to transport via pipeline and extremely abrasive the options presented were to either spend a very large amount of money (approximately $1 million USD per kilometer) on a long-term pipeline, or build a temporary pipeline for the next five years, or to truck the tailings to “El Tablon”. The political changes in the region have brought dramatic changes and currently many miners are transporting their tailings by truck to “El Tablon.” Furthermore, very few people in the region continue to believe that the pipeline will become a reality.

These are among the factors that have defined Ecuador as an extremely suitable location to conduct a study of this nature, considering the potential impact of different business models on the small scale mining sector. Other factors include strong working relationships between the Mining Department at the University of British Columbia and Ecuador’s Mineralogical service, INIGEMM (Instituto Nacional de Investigación Geológico Minero Metalúrgico), with ten years of experience working together to reduce mercury pollution among small-scale miners. Other
factors include a positive working relationship with a well-organized collective of local miners in Portovelo, APROPLASMIN. Furthermore, the fact that such a large number of processing plants are located in close proximity makes an ideal setting for such a study, especially in a country that remains relatively untouched by large scale mining investment as of 2014.

Figure 1. Tailings ponds that drain directly into the Puyango River.

Large-scale, conventional mining is virtually unknown in Ecuador despite national government’s expressed desire to build this industry. The largest deposit known in Ecuador at Fruta del Norte recently failed to be developed by Kinross, due to a breakdown in negotiations with the national government (Koven, 2013). The Ecuadorean government imposed a 70% windfall profits tax that
would cut out most of the benefits Kinross’ shareholders might gain from rising gold prices, benefits required to offset the social and political risks associated with operating in a jurisdiction like Ecuador. Currently, one of the largest operations is Canadian Dynasty Metals operating in Ecuador as Elipe S.A. Elipe has five concessions in the Portovelo-Zaruma region mining less than 300 tonnes of ore per day and in 2012 built a 2000 tonne per day processing plant where cyanide and water are recycled. This plant is current operating well below its capacity (J. C. Andrade, personal communication, May 7, 2013). The company declares they are processing approximately 800 tonnes per day as four of the five concessions await permitting. However, the incentive exists for Elipe to officially remain below capacity as it keeps their production at the level of small-scale mining (five concessions held times Ecuador’s 300 tonne per day limit per concession for small scale mining yields a maximum of 1,500 tonnes per day). As small-scale mining is taxed at a lower rate (5%) than large scale mining (50%), this situation is convenient for Elipe’s shareholders.

2.4 Mining and Sustainable Economic Development

Artisanal mining is a significant source of income and employment and can help to alleviate poverty in rural communities in the world (Hilson, 2012). With appropriate organization and management, artisanal and small scale mining has the potential to significantly impact community economic development around the world. In Portovelo-Zaruma, mining is the most significant economic activity employing directly or indirectly 10,000 people or 35% of the total population (Tarras-Wahlberg, et al., 2001; Betancourt et al., 2005).

Historically, from the late eighteenth century, Portovelo, Zaruma and the southern highlands of Ecuador had generally developed export-based industries of textile manufacturing, quinine bark collection, and tobacco cultivation. During that time, Guayaquil was a significant cacao and tobacco producer and exporter, which helped to strengthen the region’s agricultural economy (Lane, 2004).

Artisanal and small-scale miners in the Portovelo-Zaruma district are predominantly people from the local community. As such, they have social and familial ties with the local people and the
local economy. Thus, ASM, though often informal, generates revenue that stays in the local economy through direct and indirect support of local businesses and individuals. Sandoval (2001) reports that 80% of small scale gold mining profits stay in Ecuador, while the remaining 20% enters the international market to purchase machinery, spare parts, and consumer goods. The perception of artisanal miners being part of the local community and economy means that the community typically tolerates the pollution that is generated, even when it is more significant than that of a large, conventional mining operation. This perception can change as an area gains prominence and attracts miners from outside of the area.

This type of mining is in contrast with large-scale mining, where significant profits earned by international or multinational companies are repatriated or otherwise removed from the local and national economy.

A case in point is Chile, which is often touted as a success story for mineral resource development. One significant reason for Chile’s success has been the existence of a relatively stable mining law, Decree Law 600, which governs foreign investment in Chile and provides rules for the repatriation of profits. This makes for a very favourable environment for companies to reinvest in Chilean operations, knowing that their investment is safe (Craze, 2002).

This is in stark contrast to the situation in Ecuador where the recent installation of a 70% “windfall tax” led, amongst other factors, to the abandonment of a $1.4 billion international project (Koven, 2013).

Nonetheless, small-scale mining remains an attractive prospect for many of the world’s poor precisely because it is so lucrative and offers the most viable livelihood available (Siegel & Veiga, 2010). In an increasingly connected world, these developing markets would be available to global investors were it not for the various risks outlined in Chapter 5. Indeed, economic development at the “base of the pyramid” has been identified by economists as a crucial market for investors, not only to alleviate global poverty and its associated impacts but also to help stabilize the global economy after the instability experienced in the early part of the 21st century (Hart, 2005).
Chapter 3: Potential Business Models for Economic Development in Small Scale Mining

A key objective in this study was to develop an entrepreneurial business model which effectively allows artisanal gold miners to implement effective economic, environmental, health and safety management systems. This would help reduce mercury pollution as well as health problems associated with chronic and acute mercury poisoning, which is endemic in this sector. It would also help to build and diversify an economy estimated to be almost entirely dependent on small-scale gold production, a concern expressed by local miners at a workshop held in Portovelo in December 2013. The ultimate target of the proposed model is to transform artisanal miners into profitable and responsible small-scale miners.

3.1 Partnerships

It is increasingly recognized worldwide that obtaining a “social license to operate” is necessary for doing business, irrespective of whether you are operating in Canada, Africa, or Latin America. Significant resistance is realized in many places where foreign companies are operating in host countries. In particular, many countries in Latin America have seen rising resistance to foreign companies operating within their borders. Nonetheless, there is considerable merit to foreign companies who have significant experience running sophisticated, safe and reliable operations expanding their expertise to foreign operations (Prno & Slocombe, 2012). However, these operations also must recognize the source of local frustrations and work towards addressing the “resource curse” whereby host countries fail to realize the benefits associated with mineral resource developments at the national or local level. Thus, an optimal business solution for working in foreign countries is through partnership.

Economic development programs increasingly recognize the value of stimulating in-situ entrepreneurial activity (Naudé, 2008). Rather than applying top-down solutions that rarely outlast their funding cycle, small-scale entrepreneurs have the motivation and aptitude for learning that makes them ideal drivers of local community economic development.
Many different types of business partnerships allow parties with different skills and resources to develop projects and initiatives that would be unfeasible for either party to perform independently. These can include general partnerships, limited partnerships and limited liability partnerships (Lowndes & Skelcher, 1998). However, the ideal solution is context-dependent on the countries, entities and people involved. One strong option that is beyond the scope of this thesis is the public-private partnership where one or more governments participate in the partnership representing significant buy-in and interest in the success of the project.

Another specific type of partnership that can be appropriate in this field is the joint venture. A joint venture is created when two business entities, e.g. a Canadian company and a local Latin American company, agree to form a partnership sharing control over the enterprise as well as revenues, expenses and assets. The exact breakdown of this sharing is elaborated in the specific joint venture agreement. A joint venture is ideally suited to accomplishing a goal that neither entity could perform independently. For our model, a group of miners could form an association as a first step in formalization. This association would then legally be able to enter into a partnership with an international organization (e.g. a corporation, a non-governmental organization, etc.).

Partnerships between organized mining companies and artisanal miners would be ideal to improve the mining and processing practices and increase gold production, thereby eliminating the need for processing centres. However, international investors, in particular those from North America, are suspicious of this type of partnership as artisanal miners are frequently characterized in developed countries as illegal and disorganized. In spite of the clear organization of some artisanal miners in Ecuador, many entrepreneurs from Vancouver, Canada have refused to invest in partnerships with these miners, as they believe the miners will steal the gold that is produced. In fact, the presence of investors’ representatives at sites is a crucial factor. However, developing an appropriate business structure is the main element required in order to create foundations of credibility and trust that will ultimately protect both investors and miners.
The following chapter discusses the core idea of this study in which a business model is suggested that considers the example of the franchise in order to establish cleaner and safer processing facilities.

### 3.2 Franchises

A franchise represents a readily replicable form of joint venture where the franchisor provides the necessary management systems and expertise to the running of the enterprise. In this regard, the franchise model is a strong candidate for the long-term transformation and formalization of the small-scale mining sector as it lends itself well to situations where local operators have little business or technical training (Falbe & Dandridge, 1992).

The word “franchise” comes from the Old French word “franche” meaning “free” and is similar to the English word “frank” meaning “open” or “honest.” Traditionally the word has meant a right or privilege granted by a government or company to operate a business, typically within a specified territory. Modern-day franchising refers to a legal, business relationship that supports systematisation and replication of successful enterprises (Fairbourne et al., 2008). While modern-day franchising began in the United States, it can now be found across the globe. This systematised relationship consists of a franchisor, which sells the rights to the business model, and a franchisee, which purchases the rights. In order for the model to be effective and sustainable it must benefit both parties. The appeal to the franchisee is the relative ease of implementation and relatively high success rate of the franchise business, compared to other business models. The appeal to the franchisor is the ability to expand rapidly in new markets and diversify investment across a large geographical area (Sireau, 2011).

Franchising is a globally established business model that creates consistency, reliability and efficiency in business operations, service and product. In the context of small-scale mining, this model has the potential to create an economic incentive for responsible behaviour. Rather than attempting to punish individuals who operate outside of the model of responsible small-scale mining, the objective is to promote this responsible behaviour through access to financing and better business operations, resulting in higher profits and more stable economic development.
3.2.1 A History of Franchises

The first recorded franchise was in China circa 200 B.C. (Sireau, 2011). A businessman named Los Kas created a branded food product. Little is known about this early franchise apart from its existence. Franchises did not remerge in the historical record until medieval times in England when British royals rewarded loyal soldiers with a “franchise” to collect taxes (Ekelund & Herbert, 1981). A small percentage of the taxes collected was in turn paid to the royal family. Hence, the term “royalty payment” which continues to persist today.

In the mid-1850s “tied houses” emerged as public houses directly owned by breweries. While these businesses shared much in common with contemporary franchises, they were wholly owned by the breweries, with their proprietors little more than managers of the business and ultimately this model did not survive (Mutch, 2006). As will be discussed later, individual ownership is the most important motivator for the franchisee.

By the end of the industrial revolution in the 1850s, mechanical technology had developed to the point that production greatly outpaced local demand. In response, the Singer Sewing Machine Company developed a sophisticated network of franchise dealers in the United States who provided not only the machines, but also the necessary user training and local technical support (Sireau, 2011).

By the late 1940s, fast-food restaurants had become so popular in America that it became challenging for traditional restaurateurs to expand in response. Their rapid growth attracted a new investor in the restaurant industry, one without restaurant experience but with significant financial acumen. Further developments in radio and later television would bring increased brand awareness to the public enhancing the popularity of these food chains. These pioneers of the franchise model developed the first “business format franchise” where turn-key operations were sold for an initial start-up cost and a management fee extracted. This would prove to be the model that ultimately flourished throughout the United States and continues to grow around the world. As of 2011, franchises account for over half of consumer sales in the U.S., amounting to over $880 billion dollars per year and employing more than 21 million people (Sireau, 2011).
3.2.2 Franchise Model Applied to the Small Scale Mining Sector

Transforming artisanal miners into responsible business units as part of a mineral processing franchise will create greater possibilities for education and accountability. By creating a legally binding structure that can enter into contractual agreements with both large-scale mining companies and national governments, responsible behaviour will be encouraged. This structure will also allow for greater lobbying power as well as access to capital and support with bulk equipment purchases.

Successful franchises are traditional outgrowths of successful independent businesses. With many types of businesses, economies of scale make it much more effective to expand in an organized manner. However, this requires management skills and networking that not all start-up entrepreneurs possess. The majority of processing centre owners and managers interviewed in Portovelo-Zaruma had significant experience as small scale miners, but very little, if any, in business management.

The first step in the development of the successful small scale mining franchise is to establish an efficient and well-run, legal processing plant. An economic feasibility study of such a plant is to be found in Chapter 4.

The second step is to develop the management framework and legal structure of the franchisor, or overseeing commercial body that will act on behalf of the local processing plants at the national and international level.

Peru has recently led the way towards a responsible Artisanal and Small-scale Gold Mining (ASGM) sector by mandating in law that all small-scale and artisanal mining become formalized. This has created an opportunity for progressive companies to offer formalized and responsible mineral processing to small scale miners. Currently, several TSX-listed companies are operating in the mineral processing sector in Peru such as Standard Tolling Corp (formerly Orovero Resources), Inca One, Dynacor and Anthem United (Keech, 2015).
Benefit Corporations (B-corps) fill the gap between corporations and not-for-profit organizations by working social benefit into their corporate charter. Existing corporate law prevents board of directors from considering social or environmental impacts that have no clearly demonstrated effect on corporate profitability. Benefit Corporations are required to consider the impact of their decisions on specified stakeholders, communities and on the environment (Clark & Babson, 2012). By incorporating the franchisor as a B-corp with the expressed purpose of promoting environmental and social responsibility in the ASGM community, three significant advantages can be attained:

1. Establish a higher profile and competitive edge against companies such as Inca One and Dynacor
2. Formalize an informal (but strong) relationship with the academic/NGO community
3. Ensure that as a publicly traded B-corp the model can thrive with reduced risk of contrary takeover or shareholder action.

In their classic study of franchising research, Elango and Fried (1997) wrote that:
“For any party to subject itself to the transactions costs and contractual limitations caused by being part of a franchising system, the arrangement must provide a means of gaining resources that may be difficult to acquire in traditional factor markets.”

Therefore, the appropriateness of introducing a franchise model to any particular market depends on the relative availability of resources. Typical ASGM operations in Latin America are characterized by low-cost start-up capital due to the lucrative nature of the industry and the absence of viable investment alternatives and engineering feasibility studies. It also provides low-cost, reasonably skilled labour and local knowledge. The proposed franchise management structure can supply:

1. financing for expansion
2. managerial assistance
3. bulk equipment purchasing
4. lobbying power
1. **Financing for expansion** – Artisanal and small scale mining being, as it is, often relegated to an illegal and/or subsistence activity, rarely has the ability to scale according to opportunity. Yet this is one of ASM’s greatest strengths. The small-scale approach potentially allows operators to expand or contract their operation depending on its profitability which in turn is dependent on a host of other factors including gold price, labour supply, uncertainty in mining operations, changes in legal and regulatory environments, etc. However, this ability is largely predicated on the operator’s ability to have, or generate, sufficient capital to realize expansion during commodity upswings.

2. **Managerial assistance** – Typically, artisanal and small-scale miners are miners or other types of labourers who have been attracted to ASM because of its relative profitability. It is rare to find miners of this kind who have business management experience or aptitude. By developing a formalized business and operations management approach, the miners themselves will be able to focus on the aspects of the operation they know best and professional business and operational management experience can support the running of the business.

3. **Bulk equipment purchasing** – It is well-known that operations that have the ability to purchase larger volumes of products such as equipment or reagents can leverage better rates. This is an important advantage of the franchise mining model, whereby economies of scale and bulk-buying opportunities can be established for the individual mineral processing operations.

4. **Lobbying power** – Finally, and perhaps most importantly, is uniting the concerns and interests of artisanal and small scale miners so that the franchise model will have greater power in dealing with various levels of government and advancing collective interests. As mining operations become legalized in many jurisdictions, more opportunities will emerge for engaging with governments at all levels. This last point goes beyond traditional industrial lobbying efforts, as in developing countries artisanal miners normally are powerless. Therefore, this effort to formalize their activities will be immensely attractive to host governments looking to reduce environmental and social risk, as well as boost tax revenues.
3.2.3 Marketing Strategy

The objective of the marketing and sales strategy is to attract artisanal and small scale miners to endorse the franchise model. A mining franchise can distinguish itself by offering:

1. flat-rate tolling with transparent operations and high gold recovery
2. fast turnaround times
3. responsible mine waste treatment
4. increasing productivity

By creating a strong brand presence across Latin America, this Mining Franchise model could be well-positioned to enter African and Asian markets. By promoting responsible small scale mining with governments of developing countries and documenting environmental rehabilitation and community economic enhancement, this kind of initiative can serve to make the Mining Franchise welcome in new national markets.

Field and laboratory assays of ASGM ore regularly demonstrate an average of 10 grams of gold per tonne of ore and field surveys with processors and miners indicate a going-rate of 5 grams per tonne charge for mineral processing, giving a 50/50 split on 10 g/t ore. Any additional benefit associated with higher grade ore would be received by the miner. Similar existing partnerships currently favour the foreign partner as the provider of capital. This study proposes a 50/50 split such as proposed by Rakai Resources in Uganda (Kirschke, 2015) which represents an equitable split between the partners. This kind of position promotes the necessary acceptance and trust within the community of miners.

As trust is a significant issue among artisanal miners, having a clear and established brand is the most significant factor in dominating the mineral processing markets. This can be achieved through transparent, sustainable business practices and educational outreach campaigns.

A key component of the marketing strategy for the proposed clean gold solution will be an effective environmental, health and safety management system (EHSMS). In general, this
EHSMS would consist of safe and responsible operating procedures for the entire operation. In particular, it would contain environmental standards for the appropriate management of tailings.

Appropriate management of tailings depends on many factors such as local geography and geology, climate and hydrology (Davies & Rice, 2001). Increasingly various filtered tailings solutions including dry stacked tailings have been seen, in certain situations, to create less environmental impact due to improved stability and reduced footprint. In many cases they also reduce capital cost and long-term operating costs (Stockman et al., 2014). This approach requires dewatering tailings to a very low moisture content and then placing, spreading and compacting to form an unsaturated, dense and stable tailings stack (a "dry stack"), requiring no dam for retention. Davies and Rice (2001) identify small-scale milling operations as ideal for a dry stack approach and estimate a cost of $1.50-3 per tonne to filter, transport, place and compact tailings.

Cyanide destruction is a crucial component of both cyanide management and overall water and waste management. Numerous solutions exist for treatment of cyanide including the INCO process which uses SO₂ and air in the presence of a soluble copper catalyst to oxidize cyanide to the less toxic cyanate (OCN⁻), Caro’s acid (Peroxymonsulfuric acid, H₂SO₅), and hydrogen peroxide (H₂O₂) (Botz, 2001). These processes are inexpensive and, although no study has been performed on the cost comparability in a small-scale application, comparisons to large-scale operations indicate that cyanide destruction costs less than $1 per tonne of processed ore (Detour Gold, 2014).

3.2.4 Franchise Agreement

Typical franchise agreements include an upfront, initial franchise fee, which can include operations procedures, branding and marketing, training, as well as infrastructure and hardware. The franchisor offers these services to assist the franchisee with the creation of the business, as the latter often does not have significant experience in business management. Nonetheless, both franchisor and franchisee are wise to perform due diligence when entering into such a contract, in order to ensure that the potential franchise is successful. The risk to the franchisor comes with
damage to their brand’s reputation, while for the franchisee there is the risk of significant financial losses.

Ongoing operations are coordinated by management systems involving a steady stream of key performance indicators (KPIs) relevant to the particular business. Franchisees receive ongoing technical support and franchisors receive ongoing updates regarding employment, production, finance, and waste and energy management. These management systems are maintained by a royalty payment of typically 5% of gross profits.

3.3 Financing the Formalization of Small Scale Mining and Mineral Processing

One of the most significant incentives in developing a business model that is more formal than currently exists in small-scale mining and mineral processing is the attraction of outside capital investment. The current situation is economically unsustainable as the miners are trapped in a cycle of poverty, unable to invest in either superior, cleaner production or in themselves and their communities. As discussed previously, the typical situation is where owners of processing centres take advantage of miners by offering cheap and rudimentary processing methods in which less than 30% of the gold is extracted. The remaining 70% in the tailings stays with the owners.

Even though there is high yield potential, foreign investors have been wary of the small-scale mining sector due to its high degree of informality. Even in countries where small-scale mining is not illegal, it remains informal and poorly regulated in countries with weak rule of law, especially regarding foreign property owners (Siegel & Veiga, 2009).

3.3.1 Private Company Option

As Chapter 4 will elaborate, this franchise for artisanal and small-scale mining model distinguishes itself by offering extremely high profitability, by providing a rapid return on investment, and by its replicable, scalable nature. All these factors make it extremely attractive to the private capital market which currently is extremely cautious of current mining investments,
including small-scale, large-scale, and junior mining and exploration enterprises. In conversations with private investors, there has been strong interest for investing the capital required to validate this model following the breakdown given in Chapter 4. Once the model has been proven and replicated, it could then ultimately represent the strongest option in the formalization of small-scale mining business solutions.

3.3.2 Public Company Option

The Toronto Stock Exchange (TSX) is the global leader in mining investment. Incorporating an umbrella company in Canada and listing on the TSX would allow Canadian and international investors a convenient and risk-managed vehicle to invest in small-scale mineral production. Public financing of this sort offers a much greater pool of capital from which to develop a global enterprise, once the model has been proven.

3.3.3 Stream Financing

A stream financing company is a type of public company that focuses exclusively on bringing mines into production by providing upfront capital investment. Once the mine goes into production, the streaming company recovers its investment plus profits by means of an option to purchase the commodity (typically gold or silver) at favorable rates up to a certain limit. Silver Wheaton and Sandstorm Gold are Canadian public companies offering such services. They focus on large scale, conventional miners that are typically already listed on the TSX. Stream finance companies attract investors looking to diversify the risks associated with one project across a broad portfolio of producing assets.

In spite of its productivity, the small-scale sector currently does not attract stream financing. This is largely because of the lack of understanding of the various risks involved in small-scale mining. The traditional mining investor community typically regards artisanal and small scale mining as impossible to manage and unlikely to honour any contracts.
Many TSX-listed junior gold mining companies hold properties in areas with active small-scale miners. A junior mining company’s business model typically involves obtaining a permit and exploring the property in order to make it attractive enough for purchase by a larger company, earning value for its shareholders. The larger company then typically has the resources to bring the property into production. Rarely do junior companies find world-class deposits with reserves of more than 2 million ounces of gold that would be of interest to large corporations. These small companies, with little or no revenue, struggle to survive as they hope to be purchased by a major mining company with the resources to bring a mine into development. Frequently these companies abandon areas in developing countries that are occupied by artisanal miners. However, junior mining companies could be producing revenue using a small mine and plant, with adequate relationships established with the local community and small-scale miners. This could present an opportunity for a company with a solid understanding of the relationships required to finance these smaller properties into small-scale production. The due diligence required for such an investment would be as much social as geological, and yet would be analogous to that done by existing large-scale stream financiers.
Chapter 4: Feasibility Study for a Typical Small-scale Plant

Typically, under a franchise model, a business should establish itself as a stand-alone enterprise before expanding into a franchise network. In this case, a joint venture with a resourceful, in-country partner would pursue the construction and operation of a cleaner, more efficient plant to ensure greater profitability thereby demonstrating adequate success.

4.1 Pilot Plant Feasibility Study

This feasibility study includes an assessment of the construction and operation of a small gold processing plant with three production scenarios for comparison purposes: 25 tonnes per day, 50 tonnes per day and 100 tonnes per day. A list of assumptions for the inputs can be found in Table 2 below.

Table 2. Preliminary assumptions for a small gold processing plant (values in USD).

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<tr>
<th>Item</th>
<th>Name</th>
<th>Value</th>
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<td>Currency exchange rate</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>Gold Concentrate Price</td>
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</tr>
<tr>
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</tr>
<tr>
<td>4</td>
<td>Hours per shift</td>
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</tr>
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<td>Mining Rate - Scenario II</td>
<td>tpd</td>
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<td>10</td>
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<td>tpd</td>
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<td>Payment Factor</td>
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<td>95%</td>
</tr>
</tbody>
</table>

Engineers from Sepro Mineral Systems (A Gillis, personal communication, October 21, 2013) have kindly provided quotes for all the processing equipment for each scenario. All estimates provided are in U.S. dollars. The equipment costs can be substantially reduced if one uses locally made or used equipment.
This study is based on an assumed feed grade of 10 grams gold per tonne (see Table 2) of non-refractory ore and total processing gold recovery of 90% when grinding 80% below 150 mesh (0.104 mm). It is assumed that no copper or other type of valuable mineral is recovered in the concentration process, thereby the income is exclusively based on gold recovery.

A description of common processing equipment (Capex Parameters) planned for all three scenarios will be provided: jaw crusher, protection screen, mill discharge pump-box, cyclone feed pump-box, cyclone, and shaking table. Each scenario’s specific processing equipment is then described, including the non-processing equipment and other miscellaneous items.

Reagents, maintenance and power supply costs have been estimated based on other similar operations in South America. Labour costs are based on existing wages at small-scale mines in Ecuador. Wage burdens have not been included in operating costs and government taxes or royalties have not been discounted from the EBTIDA (Earnings Before Taxes Interest, Depreciation and Amortization) profit. However, if this information is provided, the financials could be updated with these additional inputs.

4.1.1 Capital Costs

Sepro Systems Ltd. was identified as a suitable source for conservative estimates of small-scale mineral processing equipment. All prices here are quoted in U.S. dollars. The intent is to demonstrate the feasibility of this plan based on estimates from Sepro (A Gillis, personal communication, October 21, 2013). Less expensive options exist, especially in Latin America and would only improve the profitability of such an operation. However, depending on the local situation, equipment quality could be compromised. Figure 2 shows a high-level flow chart of the process described in this chapter.
The specific crusher chosen for the three potential plants is a 7.7 ton YJC-3020 model. The opening feed for this model is 750mm x 500mm and can crush the material down to anywhere between 42mm to 138mm using 45kW to 55kW to operate. This machine costs approximately $80,000 and is capable of crushing 42-138 tonnes per hour.
The screen suitable for all three scenarios is the Sepro 0.9m by 2.4m Sizetec Step Deck Screen. This screen requires 1.9kW of power and provides efficient wet sizing for material prior to going into the gravity concentrator ranging from 10mm to 0.4mm. The cost of this equipment is $35,000.

Two pump-boxes will be needed in each of the three potential plants, including a mill discharge pump-box and a cyclone feed pump-box. These two items come from Sepro and have identical specifications and price. Each is equipped with a 4 x 3 pump (HD80) that is powered by a 7.5kW motor, making the total power required for both of these pump-boxes 15kW. The cost of each pump-box is $8,500.

Cyclone costs and specifications for the three scenarios could not be obtained from Sepro. However, they did refer our inquiries to the partner firm Multotec. Multotec is known for their cyclones’ ability to provide maximum separation efficiency and minimal operating costs. The screen suitable for our ore needs to be 100mm in diameter which would cost $1,500.

The last processing equipment that remains constant for each of the processing plants is a Hollman 2000 shaking table. Hollman’s gravity table products are recognized globally for their fine mineral separation and close density mineral separation. The Hollman 2000 model is 4m by 2m in size and requires 2kW of energy in order to operate at a processing rate of 0.06 to 0.45 tons per hour. This table costs around $15,000.

Sepro’s smallest cyanidation unit is their SNL1000 applicable for all three scenarios at $270,000. However, smaller cyanidation capacity can be developed appropriate for these scenarios following a methodology described by Veiga et al. (2015) for approximately $20,000 and is included in the scenarios below.

The processing equipment that remains the same for each of the three cases has been covered, which included the jaw crusher, screen, pump-boxes, cyclone and shaking table. Variations in processing equipment became apparent on a case-to-case basis, particularly the size and cost of different ball mills, gravity concentrators and flotation cells. The following section discusses the
variations of processing equipment in each of the three scenarios, along with structural equipment and any additional capital-related information.

**Scenario I - 25 tonnes per day**

Ball mill, gravity concentrator, rougher, scavenger, cleaner, steel, screening, electrical drives, electrical cables, piping and valves, control and instrumentation, engineering, and freight.

Sepro suggested a 1.5m diameter by 3.0m sized grinding mill for the 25 tonnes per day plant. In fact, the mill can handle twice this throughput. This mill is suited to take ball, rod and pebble charges, and has low installation costs due to no heavy foundation requirements, unlike trunnion supported mills. The mill comes with heavy-duty commercial tires mounted on the unit, known as the Pneumatic Tyre Drive System (PTD). Exclusion of mechanical parts such as ring gears, chain drive, steel wheels or trunnion bearings allow for this machine to be efficiently maintained in practically any area of operation. This unit operates with a standard high efficiency 75kW electrical motor and is capable of turning a feed F80 of 6cm - 10cm down to 100um. This model costs $300,000.

A Falcon concentrator from Sepro is used in this scenario to recover liberated gold by gravity. The model most suitable for 25 tonnes per day is the Falcon i350, which has the same specifications as the SB400 model but costs a third less. The i350 has manual valves, lacks auto controls and a self-reliant rinse cycle, and the feed can potentially be slower compared to the SB400 model. However, the unit uses less water (3 to 5 cubic meters per hour), has the highest gravity force in the mineral processing industry (100-150 G) which increases the recovery of very fine material, and has a long life span with low maintenance costs. It requires 3.7kW of power and can handle 1 to 15 tons per hour of solids. The machine best operates at a solid feed of 60%, and the feed particle size should not exceed 2mm. The maximum slurry capacity for the i350 is 30 cubic meters per hour. As the i350 costs $19,000 and the SB400 $33,000, the i350 is ideal for this scenario.
One flotation option for the 25 tonnes per day scenario would be to use Metso Denver flotation machines. Here, the model most suitable for the Rougher and Scavenger is the DR #15, which is .28 meters cubed or 10 cubic feet. The rougher will require two units of the DR #15 and the Scavenger just one of these units. For the cleaner, a single DR#8 model is used which is .09 meters cubed or 3.17 cubic feet. The price of the DR#15s is $20,000. The price of the rougher cells with power included add up to $40,000. The scavenger requires one DR#15, and costs $20,000. Finally, the cleaner cell costs $10,000.

DPSMS of Brazil also provides compact and efficient flotation columns. For the 25 tonnes per day scenario their size small DPFlot column would be sufficient (capable of 30 tonnes per day) and costs $50,000.

Other factors that need to be considered for each scenario are the structural equipment, engineering and shipping costs. Structural steel required for this scenario is about seven tons. On average a ton of steel costs $4,000, therefore a total of $28,000 worth of steel would be required.

Grating requires about 10 m², assuming that $50 is paid per square meter. Therefore, a total of $500 needs to be spent on grating. Seven small drives are also needed as well as one large drive for the ball mill. The small drives cost about $1,000 a piece, and the drive for the ball mill is an estimated $3,000. Therefore, the total cost for electrical drives is $10,000. For each of the small drives 50m of electrical cable is needed, totalling 350m. Assuming that it costs $20 for every meter, the price of the small cables would be $7,000. For the ball mill, 50m of a thicker cable is needed at a price of $25 per meter, which is $1,250. Total cable costs are $8,250.

Piping and valve costs were determined by adding up the total of the processing equipment used, which was $557,500 for a 25 tonnes per day plant (not considering contingency), then taking 12% of this for a total of $66,900. For control and instrumentation, a determined allowance is set by the owner. This scenario used $10,000 as the set allowance. We estimated engineering and project management to be $30,000 for a junior engineer in this field. Freight costs are roughly $4,000 for one container. A plant of this size requires around three containers. The total capital spent on freight is $12,000. The total capital costs for scenario I (25 tonnes per day) is $976,360.
Scenario II - 50 tonnes per day

The ball mill used for the 50 tonnes per day scenario is the same model as the 25 tonnes per day scenario, which allows the smaller plant to be readily scalable without significant additional cost. Part of the appeal of this type of models is that the entire operation can readily scale up upon demand/market conditions. This ball mill costs $300,000 and requires 75kW of power.

The centrifuge chosen for this scenario is the Falcon SB400, which is the more expensive version of the i350 which was recommended for the 25 tonnes per day scenario. All the specifications are the same for the two models, although the SB400 has auto controls and its own rinse cycle. Considering that more tonnage needs to be processed in this scenario, the SB400 assures that a constant feed is maintained, in contrast to the i350 potentially slower feed due to manual valves. The SB400 costs $33,000.

Metso Denver again provides options for flotation in this scenario using Denver’s DR#15 .28 cubic meter / 10 cubic feet models for rougher and scavenger, and the DR#8 model for the cleaner. The differences between the scenario I and II are in the quantity of units and the total price. A 50 tonnes per day plant needs six units of the DR#15 model for the rougher, and two units of DR#15 for the scavenger. The cleaner uses the DR#8 model, but an extra unit is needed. The DR#15 model costs $20,000 per unit, and DR#8 $10,000 per unit. The total cost of the roughers would be $120,000; scavengers $40,000, and; cleaners $20,000 - totalling $180,000.

Once again DPSMS provides a less expensive alternative with their medium size DPFlot column that costs US$ 80,000 and has a capacity of up to 90 tonnes per day.

Structural steel needed for scenario II is about 10 tonnes. Considering our assumption that each tonne costs $4,000, the total cost of steel would be $40,000. Grating costs are estimated to be five square meters more than the 25 tonnes per day plant, which is 15 square meters. At $50 for every square meter, the total cost for grating is $750. Electrical drives remain the same as scenario I, with seven small drives priced at $1,000 per unit and one big drive for $3,000 – adding up to $10,000. Electrical cables increase in thickness for each of the drives, raising the
price by roughly $5 per meter. Therefore, 350m of the seven small drives is multiplied by $25 to reach a total of $8,750, and 50m of cable for the big drive is multiplied by $30 for a total of $1,500. The total capital needed for electrical cables adds up to $10,250. Piping and valves for the 50 tonnes per day plant follow the previous scenario, and is 12% of the total price of the processing equipment. The processing equipment for this scenario is $681,500 therefore 12% would be $81,780.

Control and instrumentation costs remain consistent with the 25 tonnes per day scenario and a set allowance of $10,000 is allocated. Engineering costs remain the same at $30,000. Freight costs increase due to another container needed, thereby reaching a total of $16,000. Total capital cost for Scenario II (50 tonnes per day) is $1,045,600.

**Scenario III - 100 tonnes per day**

The ball mill required for the 100 tonnes per day plant is Sepro’s 2.1m x 4.0m. The installed power on this model is 220kW and contains all the same features as the smaller version from the previous two scenarios. The Sepro’s price of this ball mill is $573,220.

The gravity concentrator in this scenario is Sepro’s Falcon SB750 model. This model is the next size up from the SB400 and retains all the same features, but with different specifications. The SB750 can handle a solids capacity of 10 to 80 tons per hour and a maximum slurry capacity of 100 m³ per hour. The concentrator consumes 8 to 12 m³ of water per hour, and has a G-force range from 50 to 200. The power required for this unit is 7.5kW and costs $86,000.

Flotation cells increase in size with the 100 tonnes per day scenario for the rougher and scavenger. Denver’s DR#18 requires 5kW to operate and holds 0.71 cubic meter / 25 cubic feet. The rougher requires 4 units of the DR#18, with each unit priced at $25,000. The power consumption adds up to 20kW with a cost of $100,000.

DPSMS’s standard size flotation system DPFlot costs $150,000 and has a capacity of 210 tonnes per day.
The scavenger circuit uses two DR#18 mechanical flotation cells for a total cost of $50,000. The cleaner circuit uses the same model from the previous scenarios. Two of the DR#8 models are used and add up to $20,000.

Structural steel required is roughly 15 t at a price of $4,000, which results in a capital cost of $60,000. Grating cost for 100 tonnes per day can be estimated at 20 square meters required, priced at $50 per square meter for a total cost of $1,000. Electrical drives increase in price by roughly 25% from the original for a total of $12,500. Electrical cables for scenario III can be estimated by raising the price per meter to $30 for the seven small drives (350m) for a total of $10,500. For the 50m of cable required for the big drive the price per square meter goes up to $35, yielding $1,750. The combination of the two makes up the total cost of $12,250.

Piping and valve costs are estimated to be 12% of the processing equipment cost. The processing equipment for the 100 tonnes per day plant adds up to $997,500, 12% of which equals $119,700. Control and instrumentation is determined by the owner, and remains the same as the other scenarios at $10,000. Engineering also remains the same as the previous cases at $30,000. However, the freight costs increase, as 6 containers are needed at a price of $4,000 per unit - resulting in $24,000. Total capital costs for Scenario III / 100 tonnes per day are $1,525,086.

Scenario analysis

For all three scenarios we see an economy of scale developing. Capital costs per tonne drop as the scale of the processing plant increases: $39,054 $/t at 25 tonnes per day, $20,912 $/t at 50 tonnes per day, and $15,250 $/t at 100 tonnes per day. For this reason it is proposed that 100 tonnes per day is the preferred option. These costs include cyanidation, elution and electrowinning.

4.1.2 Operation Costs

Labour, maintenance and reagent estimates are given in Table 3 below:
Table 3. Labour, maintenance and reagents.

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<table>
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</tbody>
</table>

Estimates for the number of personnel needed to run a plant and their costs are given in Table 4:

Table 4. Total labour costs for running the plant.

<table>
<thead>
<tr>
<th>POSITION</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>1.</td>
</tr>
<tr>
<td>Plant Supervisor</td>
<td>2.</td>
</tr>
<tr>
<td>Plant Operator</td>
<td>6.</td>
</tr>
<tr>
<td>Plant Assistant</td>
<td>6.</td>
</tr>
</tbody>
</table>

Subtotal | # | 17. |

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>$14,400.00</td>
</tr>
<tr>
<td>Plant Supervisor</td>
<td>$28,800.00</td>
</tr>
<tr>
<td>Plant Operator</td>
<td>$86,400.00</td>
</tr>
<tr>
<td>Plant Assistant</td>
<td>$86,400.00</td>
</tr>
</tbody>
</table>

Subtotal | $216,000.00 |

LABOR TOTAL | $231,120.00 |
Operating costs are constant for each year of operation, and have been estimated per tonne of ore mined for each of the three scenarios: 25 tonnes per day; 50 tonnes per day; and 100 tonnes per day, as in Table 5.

Operating costs at 25 tonnes per day are $397,913/year or $44.21/tonne of ore processed. A 50 tonnes per day plant costs $424,560 to run per year or $23.59/tonne. A 100 tonnes per day plant costs $592,484 to run or $16.46/tonne of ore processed.

Reagents include the purchase and shipping of collector, frother, and lime for the flotation process and consumables such as balls for the ball mills. Water is assumed to be available at no charge.

Labour costs are based on three shifts per day, eight hours per shift, with 360 operating days (5 holidays) per year. One team of operators is placed at each shift plus an additional team to account for retention, holidays and other miscellaneous labour related events. This rotation system does not apply to the Manager. As noted previously, this study does not include costs for mining the ore, i.e. no labour is included for mining and/or trucking of the ore to the processing facility.

The plant is expected to run at 90% efficiency. The maintenance costs of the plant for each scenario were estimated using 3.0% of the capital cost of its plant. Energy supply unit cost has been estimated at $0.10/kWh without tax.

Labour and operating contingency were applied to the estimation at 7% and 5% respectively. A discount factor of 15% has been applied to the Project. This rate is relatively high compared to other projects, and has been used because of the limited information available for the project.

Included in operating costs is a $300,000/year management team cost to cover salaries for a light and nimble team of financiers and entrepreneurs to oversee the enterprise. In addition to these are various site level costs include access to land, a basic structure to house the plant, facilities for the workers, etc. that will vary from project to project. This model assumes that much of these
costs will be provided by the local miners as part of their negotiated contribution to the agreement.

Table 5. Operating costs including reagents, labour, maintenance and power.

<table>
<thead>
<tr>
<th>OPEX - SCENARIO I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 24,570.00</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 231,120.00</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 29,290.80</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 121,032.00</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>USD</td>
</tr>
<tr>
<td><strong>USD 397,912.80</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPEX - SCENARIO II</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 49,140.00</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 231,120.00</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 31,368.00</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 121,032.00</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>USD</td>
</tr>
<tr>
<td><strong>USD 424,560.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPEX - SCENARIO III</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 98,280.00</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 231,120.00</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 45,752.58</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 225,432.00</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>USD</td>
</tr>
<tr>
<td><strong>USD 592,484.58</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>costs per tonne</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 2.73</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 25.68</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 2.35</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 13.45</td>
<td></td>
</tr>
<tr>
<td><strong>OPEX-TOTAL SCENARIO I</strong></td>
<td>USD/t</td>
</tr>
<tr>
<td><strong>USD 44.21</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>cost per tonne</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 2.73</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 12.84</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 1.05</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 6.26</td>
<td></td>
</tr>
<tr>
<td><strong>OPEX-TOTAL SCENARIO II</strong></td>
<td>USD/t</td>
</tr>
<tr>
<td><strong>USD 23.59</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>costs per tonne</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagents</td>
<td>USD</td>
</tr>
<tr>
<td>USD 2.73</td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>USD</td>
</tr>
<tr>
<td>USD 6.42</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>USD</td>
</tr>
<tr>
<td>USD 1.05</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>USD</td>
</tr>
<tr>
<td>USD 6.26</td>
<td></td>
</tr>
<tr>
<td><strong>OPEX-TOTAL SCENARIO III</strong></td>
<td>USD/t</td>
</tr>
<tr>
<td><strong>USD 16.46</strong></td>
<td></td>
</tr>
</tbody>
</table>
4.1.3 Financial Summaries

A new model for business and investment attempting to establish itself within developing economies will be subject to many of the risks and uncertainties previous described such as the changeable political environment in Latin American countries, high levels of corruption, competing interests between different levels of government within host countries. Furthermore, while observation and history suggest that a steady source of ore will be available from artisanal mining communities, this assumption is not risk-free. Similarly, supplies of reagents and equipment assumed to be readily available to large-scale mining models, may experience shortages due to unstable economies and transportation within these countries. A common, if imperfect, approach to addressing these risks would be using a conservative discount rate. Using a discount rate of 15%, at 25 tonnes per day, the Net Present Value (NPV) a 5 year project of this nature is calculated to be approximately US$5,213,246. At 50 tonnes per day, the NPV is US$13,724,828 and at 100 tonnes per day, the NPV is calculated at US$29,101,033. These financial summaries and NPVs are calculated based on the assumptions as provided in Table 2, where mining costs (excavation and transport of the ore), taxes, labour burden and other miscellaneous expenses are not included. Furthermore, this model incurs the risks associated with owning and operating a small-scale mine, such as the potential of having the mine exhausted or expropriated. Payback times on the initial capital investments are thus 146 days, 67 days and 53 days respectively for each of the three scenarios, once constructed and operational.

Continuous cash flows such as these can be represented by an annuity following the diagram and equation in Figure 3 below:

$$\frac{1}{r}(e^{-ra} - e^{-rb}) = [P/A, r, a, b]$$

**Figure 3.** Representing a steady revenue source by an annuity.
Continuous cash flows for the three scenarios are provided in Table 6 below.

| mine life $t$ = | 5 years |
| discount rate $r$ = | 15% |

<table>
<thead>
<tr>
<th>25 tonnes per day</th>
<th>50 tonnes per day</th>
<th>100 tonnes per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>2,466,794</td>
<td>4,933,588</td>
</tr>
<tr>
<td>Capital Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>706,360</td>
<td>775,600</td>
</tr>
<tr>
<td>Management</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>Operating costs</td>
<td>698,633</td>
<td>726,000</td>
</tr>
<tr>
<td>Net revenue</td>
<td>1,768,161</td>
<td>4,207,588</td>
</tr>
<tr>
<td>PV(Net revenue)</td>
<td>6,219,606</td>
<td>14,800,428</td>
</tr>
<tr>
<td>$NPV$</td>
<td>5,213,246</td>
<td>13,724,828</td>
</tr>
</tbody>
</table>

A less risky and simpler model is the flat-rate mineral processing option such as currently exists in many countries yet fails to incorporate effective environmental health and safety management systems (EHSMS). This approach is similarly profitable with 5 year NPVs at US$3,659,211, $10,616,757 and $22,884,895 respectively. For this model, payback times here are calculated to be approximately 194 days, 85 days, and 66 days respectively, for each of the three scenarios. Continuous cash flows for the three scenarios under this flat-rate mineral processing option are provided in Table 7.
Table 7. Continuous cash flows for the three scenarios under option 2.

| mine life t = | 5 | years |
| discount rate r = | 15% |

<table>
<thead>
<tr>
<th>25 tonnes per day</th>
<th>50 tonnes per day</th>
<th>100 tonnes per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>2,025,000</td>
<td>4,050,000</td>
</tr>
<tr>
<td>Capital Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>706,360</td>
<td>775,600</td>
</tr>
<tr>
<td>Management</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>Operating costs</td>
<td>698,633</td>
<td>726,000</td>
</tr>
<tr>
<td>Net revenue</td>
<td>1,326,367</td>
<td>3,324,000</td>
</tr>
<tr>
<td>PV(Net revenue)</td>
<td>4,665,571</td>
<td>11,692,357</td>
</tr>
<tr>
<td>NPV</td>
<td><strong>3,659,211</strong></td>
<td><strong>10,616,757</strong></td>
</tr>
</tbody>
</table>

4.1.4 Small Scale Reserve Estimation

The preceding two sections show that the less risky flat-rate mineral processing option is also, unsurprisingly, less profitable. A key prerequisite to securing foreign investment in a mineral deposit is reserve estimation. With large scale deposits this involves preliminary geological assessment followed by more intensive drilling programs to determine if a mineral reserve is economically recoverable. A mineral resource can only be described as a mineral reserve if it can be recovered economically and legally. Figure 4 shows the general process of establishing a mineral reserve from a mineral resource.
Figure 4. Establishing a mineral reserve from a mineral resource after JORC, 2004.

In conventional, large-scale mining this process requires large-scale capital that small-scale miners do not have access to. Instead, small-scale miners skip this important step and, taking on all of the associated mining, metallurgical and other risks, simply mine the deposit as best they can leading to unpredictable and haphazard results.

A better method is proposed by Seccatore et al. (2013) that involves establishing a minimum reserve to be proved in order to mine and process economically and then replicating this minimum reserve required estimation as many times as is feasible with the deposit.

Equation 1 below, adapted from Seccatore et al. (2013), calculates the volume of reserve needed to be established as a minimum in order for a small scale deposit to be economical.

Equation 1. Small-scale mineral reserve estimation.

\[ V_{R_{\text{min}}} = \frac{M + S + P + V + E + MO + MD + PROFIT}{\eta_M \left( \frac{g_N}{\eta_D} \cdot \eta_R \cdot p - C_M - C_P - C_A \right) - C_E \cdot OF} \]
where:

Table 8. Small-scale reserve estimation.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Factor</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>equipment</td>
<td>$500,000.00</td>
</tr>
<tr>
<td>S</td>
<td>infrastructure</td>
<td>$47,000.00</td>
</tr>
<tr>
<td>P</td>
<td>plant</td>
<td>$1,000,000.00</td>
</tr>
<tr>
<td>V</td>
<td>services</td>
<td>$35,000.00</td>
</tr>
<tr>
<td>E</td>
<td>engineering</td>
<td>$86,000.00</td>
</tr>
<tr>
<td>MO</td>
<td>mine opening</td>
<td>$25,000.00</td>
</tr>
<tr>
<td>MD</td>
<td>mine development</td>
<td>$20,000.00</td>
</tr>
<tr>
<td>PROFIT</td>
<td>profit</td>
<td>$2,000,000.00</td>
</tr>
<tr>
<td>ηM</td>
<td>mining recovery</td>
<td>0.8</td>
</tr>
<tr>
<td>gN</td>
<td>in situ ore grade</td>
<td>10</td>
</tr>
<tr>
<td>ηD</td>
<td>mining dilution</td>
<td>1.2</td>
</tr>
<tr>
<td>ηR</td>
<td>processing recovery</td>
<td>0.9</td>
</tr>
<tr>
<td>p</td>
<td>product price ($/g)</td>
<td>40</td>
</tr>
<tr>
<td>C_M</td>
<td>unit cost of mining ($/m3)</td>
<td>40</td>
</tr>
<tr>
<td>C_P</td>
<td>unit cost of processing ($/m3)</td>
<td>40</td>
</tr>
<tr>
<td>C_A</td>
<td>unit additional costs ($/m3)</td>
<td>10</td>
</tr>
<tr>
<td>C_E</td>
<td>unit cost of exploration ($/m3)</td>
<td>0.23</td>
</tr>
<tr>
<td>OF</td>
<td>ore factor (1 – 100s)</td>
<td>30</td>
</tr>
</tbody>
</table>

In the above example, the minimum reserve needed to be established is 23,047 m³. While this is a very rough estimate, the order of magnitude of the reserve needed is still very low.
Chapter 5: Steps to Creating a Mining Franchise

Only after careful consideration of the literature on artisanal and small-scale mining and first-hand observation and discussion with miners in Ecuador did the idea of a Mining Franchise seem reasonable. Indeed, the model is based on simple, yet established forms of self-organization that can be seen within pockets of the community. For example, the mining collectives of Bolivia or APROPLASMIN, the processing centre owners collective in Portovelo-Zaruma, Ecuador use this kind of model.

The idea of the franchise is that the franchisor provides all technological and financial support to the owners of the mineral title. The franchisor is a facilitator of the process to put miners in contact with investors. The franchisor is also the implementer of the technological changes in the mines and plants and the operator of the mine-mill for certain period of time. It is assumed that the franchisor has a roster of investors interested in investing up to 2 million USD in this kind of business. The franchise method will eliminate the exploitation of miners by the processing centres once the miners have their own efficient, mercury-free plant operating in a profitable manner. The plan includes on-going education of the miners who will process their own ores. The ownership of the mineral titles continues with the miners, and the franchisor is a temporary manager of the mine and processing plant.

Possibly the most significant challenge to creating a sustainable small-scale mining sector is the attractiveness of this sector for outside capital investment. Even given the extremely high potential profitability of such operations, the high-risk nature of small-scale mining is sufficient to discourage potential investors. In particular, investors from the mining community are accustomed to reading drill reports as well as financial data and sophisticated feasibility studies such as those provided under Canada’s National Instrument 43-101.

Furthermore, as mining and exploration worldwide comes into contact with significantly greater social risk, mineral development at all scales is finding it difficult to secure the requisite financial start-up capital. Thus, an opportunity emerges for a methodology for small-scale mining to assess small, economical deposits for extraction. Seccatore et al. (2013) describe such a
methodology that establishes a minimum reserve needed to be proven in order to initiate investment that is then replicated as needed until the end of mine life.

Sepro Systems provide many of the equipment quotes in Chapter 4’s Feasibility Study, and have expressed their interest in making use of their own technologies in gold producing regions. A proposed partnership between Sepro and a legitimate resource owner in South America could be a mutually beneficial relationship and an extremely profitable one.

The following steps must be considered to initiate the economic model herein suggested:

1. Establishment of a Canadian company that will be the franchisor of the technology, provider of pieces of equipment, builder of the plant and provisory manager of the gold extraction (mine and mill) operation.

2. Franchisor identifies artisanal miners currently using processing centres to extract their gold and who are interested in expanding in order to have their own mine-mill operation with high gold recovery.

3. Assuming that the artisanal miner has little capital or none, although is the owner of the mineral title, negotiations are conducted with the miner to establish a profitable business scheme. This can range from 60% to 40% for a possible investor and 40% to 60% for the miner (franchisee) who keeps the mineral titles in good shape as well as the security of the mining site. The franchisor is an implementer and a facilitator of the business between franchisee (miner) and investor. The franchisor receives 10-15% of the profit for the engineering work, equipment procurement and royalties during operation. As observed in the example in Chapter 4, an investment of nearly 1.5 million USD can be paid back in less than one year. The miner must have an agreement with the investor to first pay back the investment in the mine-plant. Then, the profits are shared between investor and miner (franchisee). The franchisor keeps only the royalties.

4. The franchise company has a list of private investors interested in specific projects.

5. The franchisor establishes an agreement with an investor to provide to the franchisee (miner) the investment for a specific mine.
6. Due diligence: the franchisor assesses the conditions of the mineral title (legality), existing mining and processing methods, environmental issues, labour issues, etc. However, the franchisor does not have any right to the mineral title. All mineral titles remain with the miner (franchisee). This brings more credibility to the business, as it addresses the concern that the franchisor seeks to speculate in the stock exchange.

7. Eventually the franchisor can also be in charge of the improvement of the technology and designs for the mining methods.

8. The franchisor (in partnership with investors) invests in the assessment of a minimum reserve of gold (e.g. 1 tonne = USD 40 million) with some drill holes. This will guarantee the return of the capital invested in improvements of mine and mill.

9. Franchisor collects representative samples from the mine for a lab study of the processing routes to extract gold.

10. A business plan is established that includes conceptual and basic engineering for a plant to process up to 100 tonnes per day of ore (this can be higher depending on the investment and site specific conditions), capital, operating costs, net present value, labor, environmental management, scheme of the management of the mine and plant, costs to establish a minimum geological reserve and expansion, etc.

11. The franchisor provides all engineering and management support to improve the existing mine and to build new processing plant. Local engineers are hired.

12. The franchisor is in charge of the management of the whole operation. Franchisor trains a group of local engineers and operators to start and operate the mine and processing plant for a certain period of time (e.g. 12 months).

13. The franchisor establishes the management group to run the business (mine, plant, gold refining and sales). This is important to provide confidence to the investors who usually do not trust artisanal miners.

14. After a certain period of time, the franchisor leaves the business operation with the franchisee (miners or other investors) and collects only royalties up to the end of the mine or for some pre-determined period of time. The royalty will help facilitate technical support from the franchisor in case of problems.

15. The franchisor suggests additional drilling to increase gold reserves.

16. The franchisor suggests to the investors other areas for business.
A schematic idea of the steps to implement the franchise model is shown in Figure 5. All these steps should be conducted after identification of areas with active artisanal and small-scale mining activity that are either poorly processing their ore or transporting their ore significant distances for processing. Then, in discussion with the ASGM community, a form of social due diligence could be practiced in order to understand if the people are open to a form of partnership. This would allow more exact numbers to be included in the financial models presented to help determine the overall profitability of the operation. Once this is known, then a discussion with the owners of the mineral title with the intent of negotiating a joint venture could be established. This would involve contractually agreeing on the various inputs and activities each party would provide and help to determine the final arrangement for profit-splitting including community development reinvestment. Once a business plan has been completed and a pilot project implemented, there will be confidence in the validity of the project. At this point, the franchisor can establish further opportunities to develop the model. Social and environmental programs must also be included once the operation starts to produce revenue.

Figure 5. Steps to implement the franchise business model.
Chapter 6: Discussion

The research for this dissertation has provoked many important questions from mining engineers and mineral processors, while at the same time stimulating genuine interest from investors. Addressing all the issues from both communities is beyond the scope of this study, although it is important to recognize that all groups see huge potential from a market perspective with regards to the formalization of small-scale mining. The following points are key in future investigations, both academic and entrepreneurial:

- Formalization of small scale mineral processing in developing countries has hitherto relied on the ineffective strategy of attempting to penalize many of the world’s poor
- Small scale mineral processing offers high profitability
- A model is proposed that incentivizes formalization through improving profitability
- This model will then attract outside investors that can help bring technology and training
- Threats from significant, powerful players challenged by a new, more equitable model
- The inevitability of information parity and equality will lead to a more level playing field with small-scale miners
- Competition from other models
- Ultimately providing “turn-key” solutions of equipment systems and training will encourage expansion of this sustainable model to regions with low capacity

Overall, one of the most significant risks to the global mining and mineral production industry is that bigger is consistently seen as better in terms of economies of scale. Massive scale projects have become the norm, and yet with a steady decline in gold price over the last three years, the largest miners (Barrick, Newmont, AngloGold Ashanti) struggle to make a profit (Létourneau 2014). Small-scale mining is endemic all over the developing world, often to the detriment of host countries. Efficient, clean mineral processing could help to significantly remedy not only the environmental challenges associated with this industry, but also many of the social ones as well. Franchise operations increasingly offer the ability to export the requisite technical and managerial know-how to enable this transformation.
### 6.1 Risk Analysis

The following table attempts to summarize some of the specific risks a Franchise Mining operation will potentially encounter. Mitigation measures for each risk are also outlined.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Mitigation Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>National political risk</td>
<td>Working closely with Canadian Embassy</td>
</tr>
<tr>
<td>Resource Nationalism</td>
<td>Encouraging investment from Host Government</td>
</tr>
<tr>
<td>Local political risk</td>
<td>Franchise Model/Partnership with Local Miners</td>
</tr>
<tr>
<td>Gold price fluctuations</td>
<td>Model comparatively insensitive to gold price</td>
</tr>
<tr>
<td>Absence of rule of law in host country</td>
<td>Franchise model creates contractual law</td>
</tr>
</tbody>
</table>

One of the basic premises of this study is that national political risks and especially resource nationalism in developing countries (particularly in Latin America) presents one of the most significant challenges to large-scale gold mining. For example, there have been massive investments in Corporate Social Responsibility (CSR) programs by all of the major gold mining companies (Barrick, Goldcorp, Yamana, etc.). Governments in developing countries function under considerable stress both by international factors (such as securing foreign direct investment), as well as by local internal dynamics (such as rising resistance to development projects that have questionable benefit for local communities). In examining the literature regarding artisanal and small scale mining, as well as observations of operations in Ecuador, it is clear that host communities favour and trust the activities of local miners over that of foreigners, even when the environmental impacts are greater. Thus, by bringing in foreign investment, along with technical expertise, and retaining the social license of the local miner, we suggest a superior hybrid model than what currently exists. The fundamental challenge to an agreement of this nature is trust. Built into the franchising model are many controls and due diligence procedures required of both parties to address this, which is of significant potential particularly in the developing world, noted for its lack of rule of law and recognition of property rights.

One of the most significant (and uncontrollable) risks to gold mining operations everywhere is gold price. Gold price is a complicated and unpredictable factor. In large-scale mining, where
projects often take decades to progress from initial exploration and discovery to construction and development, as well as hundreds of millions, if not billions of dollars in advanced exploration and construction, timing of development to ensure profitability is a major challenge. Even when gold price is high and a decision to go forward and invest is achieved, there is no guarantee that after three years of construction a property will still be economically viable. This is exactly where the small-scale model is most advantageous. Smaller operations are much quicker to start up or scale up and much cheaper to put on hold. Furthermore, gold as a commodity is still in demand not only from investors, but also from jewelers and for some industrial applications. Therefore, gold price retains buoyancy at the lower levels. The only certainty in this situation is that operations are safest where their costs are lowest and high-grades favoured by small-scale miners prove to be economical, even at relatively low gold prices.

### 6.1.1 General Risk Factors

Any small scale mining and mineral processing company’s ability to generate revenues and profits is subject to a number of risks and uncertainties including work stoppages, damage to producing facilities, damage to life and property, environmental damage and possible legal liability for such damages.

Operating costs are affected by the cost of commodities and goods such as steel, cement, fuel, electrical power and supplies, and reagents. This study has prepared cost and production guidance and other forecasts based on a review of current and estimated future costs, assuming that the materials and supplies required for operations will be available for purchase.

What this study has shown is that costs to small or intermediate scale mineral processing can be competitive with, or superior to, large scale mining operations. While this study does not explicitly analyse mining costs, the survey of operations shows that artisanal and small-scale mining can be extremely cost competitive. However, there are considerable health and safety challenges, along with important environmental safeguards that must be addressed.
6.1.2 Political and Country Risks

It can be especially challenging to determine the impact of potential political, social, economic or other risks on the future financial position of an operation in any given country, which include:

- Cancellation or renegotiation of contracts;
- Changes in foreign laws or regulations;
- Changes in tax laws;
- Royalty and tax increases or claims by governmental entities;
- Retroactive tax or royalty claims;
- Expropriation or nationalization of property;
- Restrictions on the remittance of dividend and interest payments offshore;
- Environmental controls and permitting;
- Opposition from local community members or non-governmental organizations;
- Civil strife, acts of war, guerrilla activities, insurrection and terrorism

6.2 Risks in Context

The purpose of this approach has been to propose that formal mining operations and people with knowledge and experience of mining and mineral processing management systems begin to work with informal miners both to reduce environmental, health and safety risks, as well as to develop a profitable business model that takes into consideration the needs of both parties. In this manner, a truly sustainable mining “ecosystem” is sought, whereby small-scale mining and mineral exploration in developing countries can work closely with mineral exploration (and the social due diligence required in the 21st century), as well as with large-scale mining operations working to maintain their social license to operate in host countries. By intervening first with the mineral process, the issue of greatest global importance: rampant mercury poisoning of the earth’s atmosphere and waterways, is addressed. It is hoped that future partnerships can begin to address further the deeply impacted social and occupational health and safety risks endemic to many artisanal and small-scale mining operations.
Globally, the mining sector is ready for change. Financial drivers, socioeconomic factors, increasing environmental concerns and massive developments in global communications have created an incredibly dynamic situation. In addition to the major challenges faced by all of the world’s major gold producers to operate in, not only developing countries, but also in Canada, the United States and Europe, the junior mining sector, which has fuelled new discoveries for decades, has failed to find a viable way to survive the current slump in gold price. The response has been that many of the major companies are currently undertaking more of their own exploration, although typically junior miners could provide this service more economically. With that relationship now challenged, stronger ties between exploration and local small-scale operators could revitalize the sector, bringing a retention of intellectual as well as financial capital to where it is most needed for the industry.

This kind of new model may appear threatening to established businesses accustomed to a conventional way of extracting, processing and valuating minerals. However, within crisis and flux exist the seeds for opportunity, growth and transformation. A new business model could meet the needs of a growing constituency of the world’s poor, as well as continuing to supply the industrial world’s appetite for minerals.

A particularly valuable strategy for implementation would be for a Canadian junior mining company operating in Latin American to establish a flat-rate mineral processing operation in conjunction with local small-scale miners. The company would benefit from increased revenue and better cooperation with local miners, which could include strategic information about important deposits. The local miners would benefit from improved processing operational efficiency. Such a beneficial relationship could then be the platform on which to build a stronger partnership around exploiting a more significant ore body. In a similar manner to which Seccatore et al. (2013) propose an iterative strategy to ore body assessment, partnerships could grow with miners and deposits in other regions and even other countries. One financing model for this expansion is the franchise model.

This dissertation provides a framework of options for potential partnerships, including a franchise model for longer-term, scalable relationships, as well as various levels of production
capacity. This latter factor has been shown to have appeal to junior mining companies operating with limited resources and exploring novel niches within the mining sector (R. Woo, personal communication, Jan 30, 2015). Furthermore, economies of scale are demonstrated, both in capital expenditures as well as operating expenditures, as we move from 25 to 50 to 100 tonnes of ore processed per day. This is significant for small-scale miners, mineral processors and junior mining companies alike, as it shows value even in facilitating relatively simple cooperation between competitors.

This scalability is also consonant with the spirit of this study, which largely emerged from the writings of E. F. Schumacher. In his works (Schumacher, 1973; Schumacher and Gillingham, 1979), Schumacher’s suggestion that “small is beautiful” referred to the idea that even operations of a small size could be very worthwhile, if well-conceived and managed. His suggestion was that contemporary technologies have departed from the human scale. Instead, he suggested the use of “intermediate technologies” that facilitated human development on all levels, including providing sustainable and satisfying work to people all over the world. As artisanal and small-scale mining provides a significant livelihood to many of the world’s poor, and at the same time presents serious environmental and social problems, the solution is to work with the people involved to develop solutions accessible to them, which empower them in their communities. This empowerment, with a transfer of knowledge and resources, will help facilitate a transition to, not only cleaner production in the mineral sector, but also socially responsible and sustainable economic development across sectors of the world’s developing economies.
Chapter 7: Conclusions

The main findings and original ideas of this thesis are as follows:

- A business model for transforming artisanal miners into responsible-legal small miners is suggested.
- The problems with formalization of artisanal miners worldwide is discussed, including a lack of incentive for miners to formalize. In particular, the bureaucratic obstacles presented by inherently risk-averse governments, fail to consider the deeply complicated social, economic and cultural challenges for the legalization of artisanal and small-scale mining.
- This dynamic is further complicated by the predatory nature of many of the existing processing centres: miners are in the hands of the centre owners to extract gold from their ores, as they do not have capital or knowledge to establish their own facilities. As a result, miners are exploited by the processing centers and less than 30% of gold is extracted by amalgamation. Then, the owners of the processing centres extract residual gold from the tailings using cyanide. This, in turn, creates more pollution as well as continuing a vicious cycle of poverty that few miners can ever escape.
- Small-scale mining has the potential to be a very profitable business. However, the results from this study of a hypothetical processing plant extracting gold from ores with 10g Au/t confirms that $10,000 to $20,000 USD of capital per tonne of ore processed per day is needed for this transformation.
- A franchise model is suggested where the franchisor is the provider of technology to design, build and operate the plant for an initial period of time depending on financial factors, as well as the capacity of the miners to absorb the business and technical processes.
- A sequence of actions to implement this type of business is suggested, where the critical phases are at the beginning of the process. Trust between the franchisor and the miners is critical for the success of the business.
• Investors can be brought by the franchisor, but rarely will they invest directly with the miners as the conditions are not trustworthy. The role of the franchisor is to build the relationship between investors and miners (franchisee).
• The franchisor must have a plan to pass the mine-mill operation to the miner (franchisee) or investor, retaining only the royalties.
• The franchise model can serve to stabilize and formalize investment (financial, social, and technical) in the artisanal and small-scale mining sector, which offers significant potential to bring innovation to the established models of mining, mineral processing, and community development.
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