SCALES OF RESPONSIBLE GOLD MINING: OVERCOMING BARRIERS TO CLEANER ARTISANAL MINING IN SOUTHERN ECUADOR

A Thesis Presented

by

Sara Beth Lovitz

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Master of Science
Specializing in Natural Resource Planning

May, 2006

Accepted by the Faculty of the Graduate College, The University of Vermont, in partial fulfillment of the requirements for the degree of Master of Science, specializing in Natural Resource Planning

Thesis Examination Committee:

_____ Advisor
Saleem Ali, Ph.D.

_____
Jon D. Erickson, Ph.D.

_____ Chairperson
Jeffrey Sasha Davis, Ph.D.

_____ Vice President for
Frances E. Carr, Ph.D. Research and Dean
of the Graduate College

Date: April 7, 2006

Abstract

Gold mining by itinerant miners is acknowledged by the International Labour Organization (ILO) as the means of livelihood for more than 13 million people in the developing world. Though there are many potential socio-economic benefits of small-scale mining, there are also negative impacts from these small and inefficient operations due to wasteful extraction and processing techniques, often involving mercury amalgamation. Environmental planners are thus confronted with the prospect of regulating this sector to reduce the ecological impact of mining while preventing large scale unemployment in some of the most impoverished areas in the world. This thesis explores some of the barriers to formalizing the artisanal gold mining sector and how to overcome these from a policy perspective. The overarching research question may be stated as follows: What is the range and scale of barriers to cleaner production of artisanal gold mining and why have they not been overcome by existing policy intervention? Various development agencies have recommended that artisanal mining be formalized as a legal enterprise as the primary means of overcoming these barriers to cleaner production. In the early 1990s the government of Ecuador was among the first regimes to legalize all de facto informal mining settlements, an essential component of the formalization process.

This study empirically tests the hypothesis that the process of formalization in Ecuador has led to better mining practices and contributed toward sustainable development in mining communities. The findings first challenge the conventional wisdom about the improved environmental performance of small-scale enterprises. Unskilled artisanal gold miners prefer using mercury for amalgamation because it does not require special skills and is inexpensive, fast and effective. The study used ethnographic methods, observational fieldwork and archival research to ascertain the perspectives of miners, government officials, mining consultants, NGO leaders, and non-mining community members from the mining regions of Bella Rica/Ponce Enriquez and Portovelo-Zaruma. The study finds while progress has been made in reducing environmental impact, there remain numerous challenges to sustainable development in the small-scale gold mining sector. The roles of the government as enforcer of laws and regulations and promoter of mining development need to be better defined. The lack of enforcement and control has allowed environmentally destructive mining practices to persist. Miners also need to take responsibility for the negative impacts from their livelihood; however, they need improved access to financial resources and more incentives for conservation. There are some positive examples where miners have organized themselves and formed cooperation systems with local and regional governments. The future of artisanal and small-scale gold mining in Southern Ecuador remains uncertain as gold deposits become increasingly more difficult to extract and government resources are focused on larger scale investment. Alternative development strategies will thus need to be considered in the long-term and plans for transitioning miners to other livelihoods are important to consider.

Acknowledgements

First, I would like to acknowledge all of the people in Ecuador who took the time to participate in this study. I would like to thank those who facilitated my travel throughout Ecuador and to the many mines, mills, and processing plants I visited. This study would not have been possible without their help. I would also like to thank my advisor Saleem Ali for supporting me in my research endeavors and allowing me to chose a topic I am truly interested in and passionate about. I will like to thank my entire committee, including Jon Erickson and Sasha Davis, for their patience, flexibility, and support as I worked to finish this masters thesis.

I would like to acknowledge both Jeffrey Davidson and Gotthard Walser of the Communities and Small-Scale Mining (CASM) Group at the World Bank who provided me with a summer internship. This internship was integral in developing a background in artisanal and small-scale mining issues worldwide and ultimately in selecting to undertake my field research in Ecuador. This masters thesis would not have been possible without my experiences at CASM.

My family has been an incredible source of support for me throughout my masters program, and I could not have done it without help especially from my sisters, Rebecca and Jessica. Their help in reading over my work, helping with translations, and listening to my ideas has been appreciated greatly. I would also like to thank my friends and housemates who have helped keep me motivated both academically and encouraged me to maintain a balanced life. Lastly, I would like to thank my golden retriever, Osito, for dragging me outside everyday whether rain or shine!

Table of Contents

List of Tables

List of Figures

Introduction

Common perceptions of mining practices tend to exclude artisanal and small-scale mining (ASM). Most people are aware of the conflicts over environmental and social impacts from large scale mining; however, an area that has not been as extensively studied is the impacts from artisanal and small-scale mining in developing countries. This is despite the fact that artisanal and small-scale mining employs a greater number of people than large-scale mining worldwide. There are numerous environmental and social impacts from this sector of the mining industry which are now gaining more interest. For example, the negative impacts from the use of mercury in ASM on human and environmental health have been well documented; mercury contamination makes nearby water resources unsafe for drinking and fish stock unsafe for consuming by local peoples who rely on these resources for their sustenance. Thus, the reduction of mercury pollution is necessary in order for the mining communities themselves and surrounding communities to be more sustainable. There are currently many projects and programs led and conducted in cooperation by international and national aid agencies, governments, private organizations and local, national and international NGOs worldwide to address these issues (UNIDO 2001).

If conducted in an appropriate manner, artisanal and small-scale gold mining can generate significant benefits in developing countries. However, the poor health and safety record and use of environmentally destructive mining and processing practices have drawn much negativity and criticism to the sector (Nöestaller 1997). There are numerous barriers to cleaner and safer production and processing techniques which have

already been well documented (Bermeo 2001; GEF et al. 2003; Hinton et al. 2003). There has also been much research done in the development of technological alternatives or solutions to the environmental problems. It is believed that all the necessary alternatives to the use of mercury exist today; now the difficulty lies in implementing them (Wotruba 2003).

In recent years, a number of international experts have proposed that the introduction of appropriate legislation and policies could contribute to breaking down some of these barriers and enhancing the positive contributions, while reducing the negative impacts of unregulated artisanal and small-scale mining. Formalization of the sector should improve access to the financial, technical and educational resources necessary to remove the barriers to the implementation of these cleaner methods and technologies for small-scale gold mining. The creation of small miners associations or cooperatives will help provide technical assistance and improve economies of scale (Bugnosen et al. 2000). Thus, in the early 1990s the government of Ecuador legalized all de facto ASM settlements, an essential component of the formalization process.

The goal of this study is to evaluate the effectiveness of the formalization of the artisanal and small-scale gold mining sector in Ecuador in achieving cleaner and more sustainable production of gold. The objectives of this study are to identify from the experiences of the mining communities in Ecuador, both positive and negative lessons which can provide input to improve formulation and implementation of policies and programs which work to achieve cleaner production of gold at the artisan and small scale level. It is especially important to gain the miners' perspectives for what practices have been most useful to them in overcoming these barriers and what barriers remain the most

difficult to overcome despite formalization efforts. Previous studies related to this topic have been more quantitative in nature, focusing on the amount of mercury pollution, measuring mercury levels in air, water, fish, sediment, etc. In addition, a significant amount of research into remediation exists; however, fewer studies have been done that focus on the various stakeholder perspectives, though more attention is currently being focused here. The primary question of this study is whether the process of formalization will lead to better mining practices and contribute toward sustainable development in mining communities. This was examined by asking the following research questions:

- Has the use of mercury been reduced and under what conditions?
- What are the environmental management challenges that remain?
- Which of the barriers to cleaner production have been the most difficult to overcome and why?
- A question which emerged during research – What are the roles and responsibilities of stakeholders (miners, government, ngos)?

This thesis will first provide a comprehensive literature review of the topic, and second will present the details and results of this study. The literature review provides an overview of artisan and small-scale mining in general, outlines the numerous impacts of mercury use in ASM gold mining, discusses the alternatives to Hg amalgamation which exist, gives the background on artisan and small-scale gold mining in Ecuador, follows the theory behind formalization efforts, and notes the barriers to cleaner production. In addition, the debate about mining and natural resource extraction as a means of development will be discussed. This lays out the theoretical foundation for discussion

about the future of the gold mining sector in Ecuador and the possibilities of investment for larger scale production or the search for alternative economic opportunities as production becomes increasingly more costly and difficult. The second part presents the methods, results, and conclusions of the field research focusing on stakeholder perspectives of the challenges and responsibilities in achieving cleaner production of gold. It concludes with discussion of a longer term vision for the gold mining sector in Ecuador and the potential transition to alternative livelihoods.

Comprehensive Literature Review

Part 1: ASM Background

Artisanal and Small-Scale Mining (ASM) Overview

There is currently no universal definition of artisanal and small-scale mining (ASM), due to the fact that the definition often varies from country to country (Africa 2002). A number of attempts have been made to define small-scale mining in an international context using criteria such as investment costs, mine output, labor productivity, size of concessions, amount of reserves, annual sales, levels of technology, or some combination of these. A broad definition of small-scale mining characterizes the operations as both labor-intensive and low-tech. This definition is sometimes expanded, placing small-scale mining operations in one of two categories: high value mineral extraction including gold, silver and precious stones; and quarry mining or the mining of industrial minerals and construction materials (Hilson 2002). Most literature tends to provide a specific definition based on the study which was undertaken and provides this definition to the reader (Africa 2002; Hilson 2002). Although there are many different definitions it is generally accepted that, "small-scale or artisanal mining generally encompasses small, medium, informal, legal and illegal miners who use rudimentary methods and processes to extract more than 30 different mineral substances worldwide" (GEF et al. 2003). Usually such mines are individual enterprises or small family-owned companies which are not affiliated with any multinational corporations. Thus studying such small mines also provides a critical analysis of scale in mining.

In 1999, the International Labour Organization (ILO) estimated there were 13 million small-scale miners in 55 countries, with the majority in developing countries (see Appendix A). These numbers suggest that 80 to 100 million people indirectly or directly depend on this activity for their livelihood. In Latin America alone, there are an estimated 1.4-1.6 million miners. Gold is the main metal being extracted due to its easy transport across borders and because it is less vulnerable to the instability of local or national governments (Veiga 2001; Hinton et al. 2003). It has been estimated that one in every 900 Latin Americans are employed in gold and silver artisanal mining (Inter Press Service, 1995 in (Veiga 2001)). Precious metals and gemstones are by far the most economically important minerals mined on a small-scale due to their high value per unit weight. Other minerals and material mined include: clays, tin, tungsten, limestone, sulphur, lithium, bismuth, salt, and uranium. Base metals such as copper, iron ore, lead, manganese, nickel and zinc do not usually lend themselves to small-scale mining because of the need for economies of scale for their production ((ILO) 1999).

The socio-economic contribution of ASM in developing countries is well documented and agreed upon; it has been estimated that small-scale mines account for 20-25% of all non-fuel mineral production (Jennings 1993 in (Hilson 2002; Echavarria 2004). In many countries and for certain minerals, these numbers are much higher. Close to $2 billion in gold and gems have been mined in Africa and more than $200 million in gold has been mined in more than six countries (Echavarria 2004). In South America, specifically Brazil, almost 90% of gold comes from the nearly 200 small sites operated by informal miners called garimpeiros (Veiga and Hinton 2002). ASM provides an economic livelihood to more than six million of the most vulnerable families and

excluded groups, often complimenting agriculture and other seasonal jobs. ASM employs more people in the world than large-scale mining. It serves as a social 'safety net' to people who are unemployed and have no other opportunities, as well as to subsistence farmers who are affected by drought (Bugnosen et al. 2000). It is often seen as the only way to alleviate poverty in many areas, where the population has no other economic opportunities. While some miners are in the sector with the dream of becoming rich, the majority have no other way to provide for their families and are forced to work in the mines (Heemskerk 2002). Veiga and Hinton (2002) agree that, ultimately it is survival which drives most artisanal miners, who work to provide for the needs of their family.

In addition to the direct employment opportunities, ASM contributes to the generation of a substantial number of indirect jobs in other sectors of the economy. ASM creates the demand for production inputs, transportation and other services, as well as benefits due to increased income and consumer spending (Nöetsaller 1997). However, until artisanal and small-scale gold mining is cleaner and safer it can not be an encouraged livelihood and means of development.

Impacts of Mercury Use

Though many in the sector agree that the potential socio-economic benefits of small-scale mining outweigh its negative aspects, the negative environmental and health impacts of ASM undeniably need to be addressed. The impacts from these small and inefficient operations are related to the wasteful and primitive extraction and processing

techniques, often involving mercury amalgamation (Tarras-Walhberg et al. 2000). Gold in the ore sludge is mixed with mercury into an amalgam, which is then separated by heating into mercury vapor and gold. It has been found that an estimated two grams of mercury are released into the environment for each gram of gold recovered (UNIDO 2001; Limbong et al. 2003). The negative impacts of gold mining due to the use of mercury amalgamation have been well documented all over the developing world. The Global Mercury Project, a joint effort of the Global Environment Facility (GEF), United Nations Development Programme (UNDP) and United Nations Industrial Development Organization (UNIDO), began in 2002 to address the environmental and health impacts from the use of mercury in small-scale gold mining. The Project focuses on six countries: Brazil, Sudan, Tanzania, Zimbabwe, Laos and Indonesia and was initiated to help demonstrate ways to overcome the barriers to the introduction of cleaner artisanal gold mining and extraction technologies. Preliminary investigations in these six countries were undertaken to establish the intensity of artisanal mining activities and their impacts on international water bodies (GEF et al. 2003).

Mercury is one of the pollutants that are causing growing concern due to its long-term impacts on ecosystem and human health. Though the use of mercury is illegal in most countries, artisanal and small-scale mining remains a dangerous source of mercury pollution affecting all developing countries in Latin America where gold is produced (Veiga 1997). Mercury is used to separate gold from ore and is leaked to the environment in many ways during the amalgamation process: unintentional spillage, discharge with other wastes into inadequate tailings ponds, direct discharge into rivers and waterways, or vaporization into the atmosphere. The extent of mercury lost depends on which of a

variety of mining and amalgamation methods are used, along with the fate of contaminated tailings and Au-Hg separation methods. When mercury is placed on sluice boxes or spread on the ground to amalgamate the whole ore, losses can be 3 times the amount of gold recovered. When just the gravity concentrates are amalgamated, the mineral portion is separated from the amalgam by panning, forming an amalgamation tailing which is then usually dumped directly into a water stream creating a "hot spot" of mercury contamination (Veiga 1997).

While most mercury released into the environment is in the form of elemental or inorganic mercury, it is organic mercury—in particular, methylmercury—that poses the greatest threat to people and wildlife. A potent neurotoxin, exposure to methylmercury impairs the brain, kidneys, and liver, and causes developmental problems, reproductive disorders, disturbances in sensations, impairment of speech and vision, hearing and walking difficulties, mental disturbances, and death. Methylmercury concentrates in fish tissue, becoming increasingly potent in predatory fish and fish-eating mammals (USGS). A person with methylmercury poisoning or "Minamata disease" has five typical symptoms: visual constriction, numbness of the extremities, and impairment of hearing, speech, and gait (Veiga 1997).

In a number of studies undertaken in artisanal and small-scale mining communities, neurological problems have been found in miners and surrounding communities due to inhalation of vapors when the amalgam is heated, as well as in fish-eating populations who ingest methylmercury which has bioaccumulated in the fish. Thus, mercury affects not only the miners themselves, but surrounding communities and communities downstream from the mining locations as well. Studies in historic mining

districts in the U.S. have been able to trace sources of mercury to a watershed from mining sites more than 30 km away (Hygelund et al. 2001). A study of a Bolivian river system in the Amazon drainage basin looked at mercury contamination measured in water, fish and human hair. The potential health risk from fish consumption was evident in people living 150 km downstream of the gold mining activities, affecting people who are not directly involved in gold extraction (Maurice-Bourgin et al. 1999). Consequently, the use of mercury and resultant contamination of water and food supply can create tension and conflict with non-miners and communities whose water source has been affected.

Once it is in the water, mercury attaches to sediment and is transported downstream. Larger sediment sinks to the bottom but later re-enters the aquatic system when channel or floodplain materials are reworked by erosion (Miller and Lechler 2003). Mercury is also able to persist in surface waters for decades, which means that mercury use today will still impact these communities for years to come. It is widely recognized that cleaner production methods for artisanal and small-scale gold mining are needed to reduce the negative impacts on environment and health and to achieve legitimacy of the sector as a means of poverty alleviation and sustainable development. The technologies that are developed must satisfy certain criteria in order to be viable for the sector: economically beneficial, simple and expedient (Hinton et al. 2003).

Alternatives to Mercury Amalgamation

"Pure gold is relatively soft--it has about the hardness of a penny. It is the most malleable and ductile of metals. The specific gravity or density of pure gold is 19.3 compared to 14.0 for mercury and 11.4 for lead. Impure gold, as it commonly occurs in deposits, has a density of 16 to 18, whereas the associated waste rock (gangue) has a density of about 2.5. The difference in density enables gold to be concentrated by gravity and permits the separation of gold from clay, silt, sand, and gravel by various agitating and collecting devices such as the gold pan, rocker, and sluicebox (Kirkemo 1997)." A variety of mining and amalgamation methods are used in artisanal operations (Table 1), and together with fate of contaminated tailings and Au-Hg separation procedures, will determine the amount of mercury losses from specific site (Veiga 1997).

Table 1. Extraction and Processing Techniques for Alluvial and Primary Deposits

	Extraction Techniques	Processing Techniques
Alluvial Deposits	manually (pics & shovels, wheelbarrows), ground sluicing, monitors/gravel pumps, dredges, heavy equipment (bulldozers, front end loaders, backhoes, trucks)	manually (pans), sluice boxes & strakes, mechanical jigs, direct **amalgamation** of gold bearing ore, **amalgamation** of free gold concentrates (manually), "burning of **amalgam**", dry panning and windsorting
Primary Deposits	manually (hammers & chisels, crowbars) manual or mechanized drilling, use of explosives, open pit mining, underground mining	manually (pans, stone mills, rocking crushers, sluices, hand jigs) mechanized: jaw crusher, mills, sluices and strakes, jigs, **amalgamating** plates, centrifuges, direct **amalgamation** of gold bearing ore, **amalgamation** of concentrates, "burning of **amalgam**"cyanide leaching, flotation (rare)

(Source: Wotruba 2003)

The amount of mercury released during amalgamation greatly depends on the type of method used. Amalgamation of the whole ore releases three times as much

mercury as gold produced. This ratio drops to 1:1 when only the concentrates are amalgamated, and when a retort is used during amalgamation of concentrates only, the ratio is reduced to 0.001 mercury lost to gold produced (Veiga and Hinton 2002). A retort is a simple device which is used to recover or capture the volatized mercury during the burning stage, condensing it with recovery rates higher than 95%. There are a variety of retorts available, from those made of stainless steel, inexpensive iron, or home-made retorts out of plumbing water-pipes (Veiga 1995). Thus it is shown that mercury contamination can be drastically reduced without using alternatives which are costly or require high level technical skills. However, the use of retorts by miners has had limited success overall. Though retorts have been promoted in Ecuador, they are not accepted for cultural reasons (Bermeo 2001). There are, however, some examples of success.

What is "cleaner production"? It has been defined as "a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies" (USAID nd). Cleaner production includes substituting different materials, modifying processes, upgrading equipment and redesigning products. This can provide great benefits for small mining cooperatives and enterprises while reducing environmental impacts and worker accidents. While organizations such as UNIDO are currently promoting mercury retorts rather than alternatives, in the long-run, mercury free alternatives are undeniably necessary to improve the environmental, public, and economic health in these areas. However, until viable cleaner alternatives are available, UNIDO believes it is important to work to reduce the amount of mercury being used and increase the recycling of this mercury.

According to Wotruba (2003), there are acceptable tested alternatives to the use of mercury amalgamation that currently exist (Table 2). There are simple and more advanced methods, but each has its limitations and may not be possible to implement in all situations. Wotruba (2003) has concluded that the proposed "cleaner" technologies need to be low-cost, easy to handle and highly effective, and must fit within the social/cultural background of the area. They must combine both ecology and economy in the solution. Because these solutions already exist, there does not need to be further investigation and/or study. What is now needed are campaigns to disseminate knowledge and to help introduce and implement cleaner technologies (Wotruba 2003). The difficulty lies in that many of the alternative processes to simple gravity concentration followed by amalgamation, such as cyanide leaching or centrifuging are more complicated and more costly. In many cases, they are neither effective, efficient nor technically sustainable (Hennig nd).

Table 2. Alternatives to the Amalgamation of Gold Bearing Concentrates

Simple Processes	**Limitations of Process**
Panning	Only usable for coarse gold
Magnetic separation & panning	Only applicable for magnetic materials
Blowing	small quantities
friction-separation on inclined rough surface	small quantities of flaky gold
More Advanced Process	
direct smelting	need highly enriched concentrates
cyanide leaching	health, safety & envtl problems.; slow process
leaching w/other reagents (Cl, Br, etc)	technical complexity; high cost; health, safety & envtl problems.; slow process
gold/oil agglomeration	need highly enriched concentrates; technical complexity; high costs; health, safety & envtl problems

(Source: Wotruba 2003)

One alternative which has been successful at replacing or complementing the use of mercury in some areas has been the use of cyanide; however, amalgamation and

cyanidation should not be combined (Table 3). Cyanide leaching of amalgamated material produces dissolved mercury. In addition, because cyanide is a highly toxic, deadly reagent, maximum attention needs to be given to the proper handling and use of cyanide, for protection of environment and health (Wotruba 2003). Cyanide is less persistent than mercury and does not bioaccumulate up the food chain, thus the long-term implications of its use are less than with the use of mercury. Other "…alternative complexing agents for gold, such as chloride, bromide, thiourea, and thiosulfate form less stable complexes and thus require more aggressive conditions and oxidants to dissolve the gold. These reagents present risks to health and the environment, and are more expensive. This explains the dominance of cyanide as the primary reagent for the leaching of gold from ores since its introduction in the later part of the 19th century (Institute 2006)." In Ecuador, contamination of water resources and aquatic biota with mercury, cyanide and other toxics remains a fundamental preoccupation for the ASM sector (Bermeo 2001).

Table 3. Advantages & Disadvantages of Cyanide Leaching Methods in S-S Gold Mining

Advantages	Disadvantages
good recovery of Au	mercury and heavy metals in the material are partially dissolved and emitted in water and tailings
usable for gravity concentration tailings	emissions of cyanide and its components
relatively simple process	safety problems
	rarely correct residue water treatment and tailings deposition are found

(Source: Wotruba 2003)

Education is highlighted as the main durable measure to reduce mercury emissions, and processing centers also provide a concrete and viable solution to reduce

mercury use or possibly eliminate it (Veiga 1997). Even when educated, some believe the probability of eliminating the use of Hg in artisanal gold mining is low; therefore strategies should focus on reducing Hg losses through lowering Hg inputs in the process and creating "closed circuit" operations and recovery of mercury. There are five general approaches: reduction of specific mercury input per unit of gold produced; separating comminution (grinding) stage from the amalgamation stage; minimizing the volumes of material which are loaded with mercury; introducing and implementing "closed circuits" where possible; and recovery of mercury (from tailings). A combination of these five approaches would be most successful because it would keep the greatest amount of mercury from being released into the environment (Hennig nd).

Artisanal and Small-Scale Gold Mining in Ecuador

In Latin America, Ecuador is in the top four for both estimated gold production and number of artisanal and small-scale gold miners (Veiga 1997b). Gold is the major mineral being mined on a small-scale; it accounts for 60,000 of the 92,000 total artisan and small-scale miners in Ecuador. ASM activities began in the late 70's in the Portovelo-Zaruma region as a result of the closure of the large mine operating there. The ex-workers from the South American Development Company (SADCO) began illegally mining these deposits. In the 1980s, two new mining regions emerged – Ponce Enriquez and Nambija in the Amazon, driven by an increase in international gold prices and agricultural crisis due to El Niño events. These areas are centers of banana and shrimp

production, both important sources of foreign income for the country of Ecuador (Sandoval 2001). Therefore it is essential to manage mining activities in these regions.

At an international roundtable, convened by the World Bank to discuss the problems and potential of the ASM sector, a key conclusion was that no real solutions to these problems were possible unless informal miners are given full legal and transferable mining titles to their claims. Though the legalization or formalization of artisanal mining is necessary, it is only the first step (1996). During the decade of the 80's small mining had no clear mechanism for legalization in Ecuador. The Mining Law of 1991 legalized all de facto mining in Ecuador and encouraged the grouping of miners together to decrease the time for granting of titles. However, little or no organizational assistance or technical advice was provided by the State. The reinforcing of ASM took place throughout the decade of the 90s and continues today. With assistance from primarily international cooperation and state institutions, small mining began to incorporate more planning and technical criteria, more modern equipment and machinery, and improved environmental management (Sandoval 2001). Technical underground production has improved in efficiency and safety while increasing profits. However, there are no public or private financing mechanisms for small-scale mining in Ecuador (Sandoval 2001).

One major project, the COSUDE project to minimize Hg-emissions from small gold mines in southern Ecuador, was run in cooperation between the Ecuadorian NGO "Fundacion CENDA" and the Swiss Technical Cooperation COTESU, represented by Projekt-Consult GmbH and was supervised by these three organizations along with the State Secretary of the Environment in the Ministry of Energy and Mines (Hruschka 1993). Part of this larger project, Plan ECO+, is based on a collective environmental

impact assessment study that forges a partnership between a government agency, an NGO, and a group of artisanal miners. The program is aimed to reduce the environmental impact of mining activities, raising environmental consciousness among the population at all levels, and promoting the production and use of equipment that protects the environment. The Plan provides technical assistance and also includes a host of social programs that contribute to the well-being of the mining community. They provide meals for miners' children, improve potable water sources, arrange for garbage collection and disposal, and promote small industries as alternative sources of work (2002).

In 1995, the Ecuadorian Ministry of Energy and Mines, with funding from the World Bank, British DFID, and Swedish International Development Agency (SIDA), began administering the Mineral Development and Environmental Control Project (PRODEMINCA) (Sánchez Delgado 2001). The PRODEMINCA project carried out a sustained support program for small-scale mining which included the following aspects: improved gold recovery in concentration process, promotion of alternatives to mercury amalgamation including small cyaniding plants, improvement of work safety conditions, and other technical initiatives to improve small-scale mining operations, as well as support for organized mining associations (Sandoval 2001). In addition to international cooperative projects, government projects have focused on technical training programs while private projects run by civil organizations, professionals, and academics have focused on socio-environmental themes (Sandoval 2001).

One of the most significant technological advances as a result of these projects and programs from the late 90's, was replacing mercury amalgamation with cyanidation

processes, relegating amalgamation to second place. This has led to more efficient recovery and reduced environmental contamination. Small modern cyaniding plants for gravity concentrates are operating in nearly all the mining districts; however recovery by amalgamation still persists. In many cases, mercury is still burnt in the open air, while in other cases, retorts are used to recover the mercury. Actions to improve the open air burning have been met with limited success. At present, only one of these is still in operation in the Ponce Enriquez mining centre (Sandoval 2001).

In the early 1990s, the amount of mercury emitted by approximately 100,000 miners was estimated to be 50 tons annually and increasing (Hruschka 1993). More recent studies have found that small-scale mining in southern Ecuador continues to cause considerable environmental impacts. The impacts on aquatic ecosystems have been especially harsh in the areas of Portovelo-Zaruma (P/Z) and Ponce Enríquez. In these mining areas, there exist only two important pathways for the contamination of the rivers: direct and indirect discharge of tailings; and the precipitation of airborne mercury vapor (Tarras-Walhberg et al. 2000). These discharges are caused by inadequate management of waste products and a failure of policy and supervision to achieve good environmental performance among the miners.

In Ecuador, the gold is mainly extracted from sulfide rich ores using hard-rock methods of crushing and grinding, followed by gravity concentration. Then amalgamation with mercury is used to recuperate gold from the heavy mineral concentrates. In addition, the gravity tailings have been treated by cyanidation since the 1990s (Tarras-Walhberg et al. 2000). Obviously, the environmental impacts from these processes are severe. In Portovelo-Zaruma the principal environmental problems in the

region were found by the PRODEMINCA-SGAB study to be: “discharge of heavy metals, mercury, cyanide, and suspended solids into the rivers due to bad management of tailings; absence of information about mineral reserves and inefficient exploitation of mineral reserves; poor planning of the use of the ground/soil; deforestation and loss of vegetative cover, causing soil erosion; loss of water and chemicals in gold processing methods; indiscriminate discharge of used waters with high content of organics, nutrients, and bacterias; and inadequate disposal of domestic and municipal solid wastes” ((SGAB) 2000). To improve environmental quality of the affected rivers the usage of mercury in gold processing needs to be discontinued or at least drastically reduced. In addition the management of tailings and wastes need to be addressed as high levels of cyanide, lead, cadmium, copper, arsenic, and mercury have been found in waterways (Tarras-Walhberg et al. 2000).

It will not only be important to look at the effect that formalization of the ASM sector in Ecuador has had on the use of mercury, but also on the overall level of environmental and health impacts from mining operations. The use of cyanidation to rework tailings or as a replacement for mercury amalgamation comes with its own hazards as well. It is also significant to note that the improvements that have been made are found more often in the mining of primary deposits rather than the working of gold placers or secondary deposits. The miners working these secondary deposits use mercury amalgamation to recover the gold (Sandoval 2001).

Formalization

Because most ASM operations develop haphazardly, are poorly equipped and lack resources, they often result in wasteful productive practices, hazardous working conditions and a disregard for health, safety and environmental protection. These operations are often unregulated and illegal because they are cut off from mainstream economic and industrial development opportunities. These informal operations cannot be effectively controlled by the authorities who are responsible for health, safety and environmental enforcement. In Sub-Saharan Africa, Nöetstaller found that, "legalizing artisanal mining, therefore is an essential precondition for sub-sector control and the eventual elimination of harmful environmental practices, including the liberal use of mercury in gold processing. It is also a prerequisite for the efficient transfer of technical and financial assistance necessary to improve sub-sector performance" (1997, 11). Thus, in recent years a number of international expert meetings have concluded that the introduction of appropriate legislation and policies could work to enhance the positive contribution, while reducing the negative impacts of, unregulated artisanal and small-scale mining (Bugnosen et al. 2000).

To successfully legalize artisanal miners will require various complementary components. According to Nöetstaller (1997), these include: making allowance for the needs and constraints of artisanal and small-scale miners; the formation of ASM organizations that can be held accountable; and encouraging miners to legalize their operations thru the use of awareness, incentives and deterrence. Overall, the sustainable development of artisanal mining is constrained by three key factors: Lack of appropriate legal, regulatory and institutional framework to support and monitor the activity;

inefficient methods and equipment; and environmental, health and safety problems arising from the practice of haphazard mining (2002). The formalization efforts of the ASM sector should work to address each of these three factors. Quiroga (2002) believes that the most effective way to tackle these interrelated issues is to simultaneously build capacity for both small-scale mining and local government authorities. Successful formalization should benefit current miners by improving access to resources, mineral recovery, and working conditions, and benefit the government through the recovery of taxes from these legal operations. Formalization provides miners with the rights to land thus they cannot be displaced by the government to allow for larger scale mining operations.

While formalization has been proposed to help overcome barriers to reduce impacts from mercury use in small-scale gold mining, not everyone believes this is the answer. Heemskerk (2002) disagrees with this theory in the case of the Maroon miners in the Suriname Amazon:

> Consequently, I do not expect that campaigns aimed at increasing the ecological awareness of miners will reduce participation in gold mining or mining's environmental impacts. Educational measures might convince dedicated miners to use mercury more wisely (Veiga 1997a; Veiga et al. 1995). However, they will not address the multitude of mining problems, nor the root causes underlying mining. Alternatively, development organizations have advocated stricter law enforcement as a mechanism to reduce the impacts of small-scale gold mining (Barry 1996; Monsels-Thompson 1998; United Nations 1996; Veiga 1997a). The World Bank, for example, speculates that ``if governments take basic steps to regularize their informal mining sectors, they should at least prevent [environmental degradation] from worsening and in favorable circumstances artisanal miners could begin to make a positive contribution to national wealth'' (Barry 1996, 14). While such measures might offer temporary relief, they are not likely to produce lasting

> results due to the mobility of miners, the difficulty of policing a vast area, and the lack of trained inspectors (Cleary 1990; Veiga et al. 1995).

Barriers to Cleaner Production

Heemskerk's reservations about formalization are due to the difficulty in overcoming the barriers to mercury elimination from small-scale mining. Unskilled artisanal gold miners prefer using mercury for amalgamation because it does not require special skills and is inexpensive, fast and effective. The environmental costs of mercury (Hg) are not included in the raw material price, thus it is cheap for the miners to acquire (Hylander and Meili 2003); miners can buy 1 kg of mercury for 1 g of gold (UNIDO 2001; Veiga and Bernaudat 2003; Veiga 2004). Mercury has become more expensive in recent years as there is pressure on the European Union to stop trading mercury. Though trading will officially come to an end in 2011, increases in the price of mercury have already occurred. From 2004 to 2005 the price rose from $4.6/kg to $12/kg so it will become more important for miners to recycle Hg when it is used (Veiga 2005).

Lack of education is a barrier to cleaner production since many miners do not know of the environmental and health effects of mercury, while others do not believe or do not seem to understand the severity of these effects. An extreme example of this was provided by Veiga and Bernaudat (2003) in Brazil, "'you environmentalist should go to the school . . . this mercury we use is inoffensive,' an ASM leader in Brazil commented, when he was drinking a glass of metallic mercury in front of the TV cameras." This episode demonstrates some of the misperceptions of mercury. Mercury is poorly absorbed by the gastrointestinal tract thus the majority of the mercury was flushed out of

the body. However, the inhalation of mercury vapor can cause severe health problems so the use of mercury is not benign as the miner believed and suggested (Veiga 1997b).

In Venezuela, UNIDO workers found that there is a huge gap between fact and fantasy about mercury, and that the only effective way to obtain long-term results is "with clear, sincere and direct information about the hazards of mercury compounds and ways to avoid contamination" (Veiga 1997b). In many mining communities distillation retorts have been distributed; however, in developing countries it has been found that ecologically motivated measures will be accepted only if the changes in the production process have positive economic benefits for the miners themselves (Maurice-Bourgin et al. 1999). In certain cases gold obtained through amalgamation is recognizable by the buyer for its texture so can be marketed and sold easily, whereas gold obtained by another process may face reluctance by buyers in the field (Hennig nd).

There have been a variety of attempts to deal with the mercury problem including armed, legal, ecological, and educational approaches, yet all have largely failed. The legal approach only has a temporary effect of dispersing miners who eventually return to their activities. Mercury use has also been made illegal in many countries; however, enforcement is limited and the legislation is often ambiguous. The ecological approach has involved warnings and pronouncements made by environmentalists and research groups who investigate mercury pollution to raise awareness. However, few real solutions to stop mercury pollution have been generated and miners often do not have access to this knowledge. The education of miners is certainly necessary in the move toward cleaner production and reduction of Hg-emissions by miners, yet it has not always been successful. The miners must be convinced that limiting Hg use is in their personal

and their families' best interests. Though all approaches to this problem are important, technical solutions need to be included in an integrated approach (Veiga 1997b)

Successful introduction of cleaner technologies needs process-oriented approaches and depends as much on socio-cultural as on techno-economic factors. Wotruba (2003) believes that it is important to understand the organization of the miners, "as well as the socio-economic dependencies between miners, mine owners, equipment owners, mill owners, mineral buyers, equipment and consumables suppliers, local communities, as well as religion, superstitions, habits and traditions of the miners." These factors are generally stronger obstacles to overcome than technical aspects.

While the measures needed to improve the environmental situation are technically straightforward, in Ecuador there are other barriers which exist. According to Tarras-Wahlberg et al (2000) artisanal and small-scale miners "do not have the financial resources available to construct tailings dams or to invest in more efficient methods of gold retrieval, such as cyanidation; and the authorities have the almost impossible task of ensuring compliance to environmental regulations for a large number of small enterprises, many of which do not have legal status."

The two examples of acceptable environmental performance are operations which in the context of Ecuador are much larger than average operations, thus suggesting that the impacts of small-scale mining are due to their small size operations. Thus PRODEMINCA focused on: the reorganization of small-scale miners into formal companies or cooperatives to move toward bigger more mechanized operations. These larger cooperatives will be more likely to overcome the barriers to cleaner production discussed above (Tarras-Walhberg et al. 2000). However, a move toward large and mechanized

labor means a reduction in the needed labor force, ie loss of jobs. Thus, new economic opportunities must be made available to replace the lost positions.

Part 2 – Large Scale Mining and Sustainable Development

The Debate

There are numerous theories on promoting growth that have been applied in the developing world, often heralded as panaceas by development institutions. Yet they have largely failed to produce the desired economic results because of the linear reasoning by which they are applied (Easterly 2002). Recently, there has been much debate on the role of mining and other extractive industries in achieving development. According to Davis and Tilton (2002), conventional or traditional wisdom suggests that countries with large mineral deposits are fortunate because they contain this natural capital which when mined directly contributes to economic development. However, a new view of mining has emerged which questions the positive relationship between mineral extraction and economic development due to disappointments in the growth of mineral producing countries. Often developing countries with rich mineral deposits open themselves to foreign investment in order to increase development and growth; however, the success of this policy remains heavily debated.

In general, large scale gold mining operations often find themselves as a source of controversy and conflict in the communities where they exist. These multinational companies, country governments, and certain development agencies highlight the positive impacts that these mines can have on local, regional and national development by bringing in jobs, revenue, etc (Griffin 2000; (IFC) 2001). However, many

international NGOs, mining communities, and others believe that the negative impacts outweigh the positives; it is the mostly foreign companies and stockholders who reap the benefits while local communities are faced and often left with environmental destruction and loss of traditional livelihoods (BBC News2002; (FOEI) 2003). In 2001, the World Bank Group (WBG) initiated the Extractive Industries Review (EIR) to determine if the WBG's involvement in oil, gas, and mining projects was consistent with its objective of achieving poverty alleviation through sustainable development (Salim 2003).

In the long run is large-scale, industrial mining a sustainable form of development or will the communities fail upon mine closure? This is being debated all over the world by development agencies, mining companies, lending institutions, and local and international NGOs. The mining sector is aware of the criticisms of extractive projects with regard to sustainability, thus it is working to tackle these issues. The Mining, Minerals, and Sustainable Development project is one effort to hold the sector to higher performance standards with regard to sustainable development. The report states that, "Realizing the potential for mining to contribute to development in all countries where it takes place is arguably one of the greatest priorities facing the mining and minerals sector" (International Institute for Environment and Development 2002). When mining is managed well, it can bring significant benefits and can be an engine for economic growth. Thus, the World Bank/IFC is working to better manage the environmental, social, and economic, and governance risks and challenged associated with large scale mining (Strongman 2001).

It is important to take a look at the arguments for and against the role of mining in development to determine the appropriate policy recommendations. According to

Davis and Tilton (2002), conventional or traditional wisdom suggests that countries with large mineral deposits are fortunate because they contain this natural capital which when mined directly contributes to economic development. The first assumption of this view is that the extraction costs for gold (or other minerals) are less than its market price, therefore generating profit or economic rent. (Davis and Tilton 2002)

The conventional view is based largely on neo-classical economic concepts, specifically the production function: Quantity output reflects quantity inputs, which include: labor, capital, energy, materials, etc. Therefore, if a country has more capital it should also have increased output and increased per capita income. Mineral deposits contribute to natural capital only when extracted. If output is consumed immediately it will increase current welfare, and if it is invested in other capital it will increase future welfare by contributing to economic growth when invested wisely. Thus, mining provides a country with an opportunity to increase economic growth and it is the government's fault if it fails to take advantage of these opportunities (Davis and Tilton 2002)

Another assumption that supporters of mining development make is that foreign direct investment (FDI) leads to growth. FDI is investment by a foreign or multinational company in a host country. It was believed that profits from the extractive sector would help build local infrastructure and eventually be re-invested in industries that could process and add value to the minerals before export. This would lead to a more "diversified" pattern of growth (Ross 2001). According to Easterly (Easterly 2002), investment doesn't really matter and was just another failed panacea for growth. He

found that without technical innovation and education investment was not enough to foster growth.

Formal mining operations offer both direct and indirect employment opportunities even though they are not labor intensive. Gold mining has multiplier effects providing additional jobs, wages, and government taxes which facilitate growth of legal, physical, and financial infrastructure. Mining can help diversify a country's exports and production, which is a critical stage in the development process, by facilitating a shift from agrarian weakness to industrial strength. Mining helps diversification from one or two traditional agrarian exports because it is less demanding to develop a mining sector than manufacturing or tourism sectors which require more significant infrastructure investments (Plowden 1999).

Economists and activists today are beginning to question economic models that base development on the extraction of non-renewable resources, highlighting many cases in the developing world where countries with great oil and mineral wealth continue to suffer from devastating poverty (Ross 2001). One study finds that the overall living standards of mineral dependent countries are exceptionally low, much lower than they should be compared to their per capita incomes; higher levels of mineral dependence are strongly correlated with higher poverty rates and income inequality; and mineral dependent states tend to suffer from high rates of corruption, authoritarian government, government ineffectiveness, military spending, and civil war (Ross 2001).

Recent publications which discourage mineral development as a means to achieve growth highlight studies done by Harvard economists Jeffrey Sachs and Andrew Warner. In their study of 95 developing countries they found that countries with high ratios of

natural resource exports relative to GDP had slower per capita growth (Earthworks 2004). Since it has been determined that "growth is good for the poor," and mineral dependent countries have a lower overall rate of growth, one can conclude that mining is bad for the poor (Ross 2001).

Some of the more recent explanations highlighted in research suggesting that mining development may hinder economic development include: the falling prices of primary products in relation to manufactured goods; volatility of primary commodity markets which make planning in developing countries difficult due to fluctuations in revenues from minerals; the flow of labor and other resources out of agriculture and manufacturing into the minerals sector during mining booms; mining as an enclave industry providing few benefits other than tax revenues; revenues from mining may be misused and promote corruption, civil strife, and wars (Davis and Tilton 2002).

It is believed that the World Bank supports investments in extractive sectors because they generate high rates of return and raise government revenues and exports in the host country. Relative to the size of many developing country economies, even a small output of gold is very important. Much of the conflict and discussion about large scale mining is due to this distribution of the rewards and the burdens from capitalism. Though the profitability of mining may be high, NGOs highlight the inequality of the distribution of these profits. The assumption that mining revenues will reach all sectors of the economy is not always a correct one. The nature of mining itself provides several reasons for why mining does not contribute to economic development. Local communities bear the majority of the social and environmental costs associated with mining operations, while the benefits go to the central government and foreign

companies. Mining is also considered an enclave activity where supplies are imported and minerals are exported for processing abroad. In addition, mining employs few workers because of the high level of mechanization. The employees that are needed are often highly skilled workers who come from abroad. Thus, local and regional communities benefit little from large-scale mining operations except for the little they receive from their share of profits (Davis and Tilton 2002).

In addition, concentration of profits and economic rents can lead to profits seeking activities which essentially help the rich get richer, rather than the increase the overall amount of profit and redistribution of wealth. This concentration of the wealth can also lead to corruption, civil war, military spending, and lead to authoritarian regimes. The assumption is that mining causes these problems, but which comes first? This plays a role in determining whether mining leads to an increase in poverty or not; however, in the Congo, Sierra Leone, and Liberia it can be argued that mining has undoubtedly contributed to poverty, civil war, corruption.

The short term rather than long term nature of mining operations is cited as another reason mining should not be encouraged as a sustainable means of development. Large mines usually include social amenities and improved infrastructure such as schools, workshops, health clinics, roads, offices, etc.; however, when the mine closes the amenities go along with it. This usually leaves the workers in more distress and with no other means of alternative employment (Quiroga 2002). Thus, though large mines may be more efficient and profitable than small or medium scale mines, in the long run they may not be as beneficial to the community. Large mines are also not without severe environmental impacts, due to their sheer size alone where entire mountains are

completely altered. There are few large mines in the developing world today which are completely free from controversy and conflict.

Around Valentine's Day 2004 Earthworks/Oxfam International (along with twelve other activist groups around the world) began publicizing their "No Dirty Gold" campaign to raise consumer awareness about the destructive practices of gold mining (Earthworks 2004). Though the campaign highlights the destructive environmental practices, the campaign also discusses social and economic impacts. In large scale mining, cyanide is the most common chemical used to extract gold from ore, despite the fact that it is an extremely toxic to animals, plant life and humans. Some of the many negative impacts from large scale gold mining include: acid mine drainage, chemical spills and accidents, damage to landscapes, changing of the hydrologic cycle, and forced relocation of communities (Hilson 2002). The EIR calls for the WBG to minimize support for any mining projects which use cyanide and mercury, working to utilize safer substitutes (Salim 2003).

Another general problem with mining's role in development is that economic growth does not always equal development. Economic growth is measured in Gross Domestic Product (GDP); however, GDP can be misleading because it measures the overall productivity of the economy. An increase in GDP could be due to growth from a war, for example. Thus economic growth alone is not a panacea in poverty reduction itself. In Mozambique large increases in GDP coexist with extraordinary levels of poverty for most of the population (Fauvet 2004). Is growth in GDP what we should really be striving for?

One of the reasons that the two views of mining are contradictory in their conclusions regarding the benefits of mining for economic development is that they focus on different aspects of economic development. The traditional view concentrates primarily on level indicators such as per capita income, literacy rates, and infant mortality, while the new view focuses on growth indicators, such as the changes in these three indicators over time (Davis and Tilton 2002).

Davis and Tilton (2002) also directly refute some of the results determined by those supporting the new view of mining. They question the results of supporters' studies due to a number of factors – one being that an association between two variables does not necessarily imply cause and effect. They debate whether the Sachs and Warner results, which are often cited as evidence of the negative correlation between mining and development, are methodologically sound, and whether slower economic growth reflects diminished economic welfare. They also question the conclusions of the Oxfam America report by Michael Ross (2001). They find that there may be other factors besides mineral development that contribute to the high levels of poverty. For example, these countries often have more corruption, civil war, and military spending and are more authoritarian.

Davis and Tilton (2002) also highlight the statistical shortcomings of Ross's study, including the use of the Human Development Index (HDI) as an indicator of poverty as well as his empirical methodology. They discuss in detail the problems with the assertion of causality from the regressions Ross conducted, thus undermining his conclusions about the links between mining and poverty. They conclude that "the evidence presented in the Oxfam report is unreliable and does not in fact support the

conclusion that mining was detrimental to the development of mineral economies over the 1990s" (2002).

Davis and Tilton (2002) determine that the economic experiences of mineral dependent countries are too varied and development economics too complex to make any pronouncements about resource and development linkages. Because of this they do not advise making any broad policy recommendations regarding mineral development. They argue that the appropriate policy question is not whether or not to promote mining in developing countries, but where mining development should be encouraged and how it can be ensured to contribute as greatly as possible to economic development and poverty alleviation.

With both sides of the argument refuting research studies and conclusions by the other, the debate of the efficacy of mining development continues. Meanwhile, both sides seem to be in agreement that there are both winners and losers where mining development occurs. All of the recommendations made to the WBG in the EIR are aimed at "the need to strike a better balance of life and development in this world" (Salim 2003, xiii). Ultimately the goal is to give civil society an equal playing field in the triangle of partnership between governments, business, and civil society; to place greater importance on social and environmental considerations so that they are at the same level as economic considerations in efforts to achieve sustainable development and poverty alleviation; and to "strive for a human-rights based development that balances the material and the spiritual goals of life" (Salim 2003). These same recommendations provided to the WBG for investment in extractive industries should be given to all private and public stakeholders working to promote mining in developing countries.

The No Dirty Gold campaign calls on companies to follow reasonable guidelines that would make mining less destructive to the environment and surrounding communities (Earthworks and Oxfam America 2004). Overall, the movement against gold mining due to environmental and social responsibility has been gaining momentum in the past couple years (Ali 2006). The mining industry itself is aware of the many criticisms and the need for the industry to move toward more environmentally, socially and culturally "sustainable" mining (International Institute for Environment and Development 2002). The Yanacocha gold mine in the Cajamarca region of Peru provides an example of some of the many challenges of large scale mining operations. It is being presented in this thesis to contrast with the small-scale mining that was the empirical focus of my study.

Yanacocha Case Study

The public reports from the Newmont Mining Corp. touting community development programs, social and environmental responsibility contrast greatly with NGO interviews of local residents claiming destruction of their livelihoods due to environmental contamination and other negative impacts of mining. Can the world's second largest open pit gold mine overcome the environmental impacts inherent in the extractive industry and serve as a vehicle for economic growth and sustainable development on the local and regional levels? With IFC support and funding, the project is supposed to help alleviate poverty in one of Peru's poorest regions in the Andes Mountains 360 miles northwest of Lima.

Background

The Yanacocha Mining Company (Minera Yanacocha, S.A. (MYSA)) operates in northeastern Peru 20 kilometers north of the city of Cajamarca (Pascó-Font et al 2001). The Yanacocha Mining Company, owned by Newmont Mining Corp. of the U.S. (51.35%), Minas Buenaventure (43.65%), and the World Bank's International Finance Corporation (5%) (IFC reportedly about to sell its shares), currently operates four open pit mines which produce 70% gold and 30% silver, while two new deposits are currently being implemented (Minera Yanacocha 2005). The first deposit began in 1993 with the support of financing from the International Finance Corporation (Langdon 2000). The two processing plants process approximately 8 million tonnes per year, making Yanacocha the largest and most profitable gold mine in Latin America (Pascó-Font et al 2001). It is not only one of the largest, but also one of the lowest-cost gold mines on the planet.

The Yanacocha project is the first foreign investment in Peruvian mining since 1976 (Harris et al 1996). According to the IFC, the success of Yanacocha was a stimulus to Peruvian reforms, including privatization of the sector, which led to a mining boom that contributed billions of US dollars in new investment, created thousands of jobs, and elevated Peruvian industry standards of technology, environmental protection, and social responsibility. Yanacocha has become one of Peru's most important firms and one of the largest taxpayers (Strongman 2001).

Environmental Safeguards

Initially, many locals were supportive of Newmont's arrival hoping that the operation would bring jobs and prosperity to their region. While the operation does contribute significantly to the city of Cajamarca in the form of 6,000 jobs and an annual boost to the economy of approximately $60 million, many community members are unhappy (Griffin 2000) According to a local farmer who leads a grassroots opposition group, "We didn't know the huge problems that mines create. Soon we began to see the truth. The mine contaminated four important river basins that drain into Cajamarca. Our trout and other fish dies, and our native plants began to suffer. Lakes have dried up of been dammed. They are destroying our natural resources" (Griffin 2000, 5). The use of cyanide to extract gold has contaminated streams that are used for drinking and irrigation, and the June 2000 mercury spill sickened 400 people and contaminated 80 homes (Griffin 2000).

It is undeniable that open pit gold mining using cyanide leaching has numerous environmental impacts. The Newmont Corp. takes great pains to make the distinction between inevitable environmental impacts and the charges of environmental contamination from the local communities and international NGOs. Thus it is imperative that the company puts in place environmental safeguards to mitigate the use of large amounts of water and the toxic residues left by mining. MYSA promotes the presence of the IMF and World Bank as a means to ensure the highest standards of safety, environmental care, and social responsibility. However, it is common knowledge that not all World Bank projects uphold these written standards in practice.

The environmental planning process consisted of an environmental impact study carried out before mining operations commenced. These studies were approved by the Peruvian Ministry of Mines and contain guidelines and recommendations to ensure the mine operates in an environmentally responsible manner (Harris et al 1996). "Foolproof" contamination control systems and other environmental safety measures were extensively undertaken for on-site areas to prevent costly recovery and attenuation actions in the event of an accident. Some of these measures include: lining of effluent ponds, transport canals, and storm water ponds to prevent contamination from leakage; water treatment plant for excess water to destroy cyanide and other toxic elements; surface and groundwater monitoring programs; and mitigation, restoration, and inspection programs (Harris et al 1996). Despite these safeguards many believe that because cyanide is sprayed straight into the rocks resulting in groundwater pollution and since Yanacocha sits on the continental divide on a watershed, its groundwater pollutes the irrigation and drinking water throughout the region (FOEI 2003).

There is also controversy about whether the mine is causing high acidity levels as locals contest. Studies undertaken found that water in the region has naturally high acidity levels, thus Newmont claims the water is no more acidic than baseline conditions. However this is contested by environmental experts who believe that acid levels as high as those recorded in streams flowing from Yanacocha are extremely rare in nature and almost always indicate a disturbance such as mining (Griffin 2000). Locals say that the water is contaminated with proof as the number of aquatic species which have declined (Langdon 2000). It is also important to note that people act according to perception not necessarily to facts, thus it does not matter that Yanacocha had currently been found not

to contaminate the area. Locals may be justified in the long run as it is also difficult to determine what the outcome will be in 10 to 15 years, which is the time it may necessitate to determine if contamination is occurring (Pascó-Font et al 2001).

In 1999, when IFC granted funding for the La Quinua deposit, IFC reported that the MYSA was in compliance with Peruvian environmental regulations and IFC environmental and social requirements. Environmental and social documentation including an Environmental Impact Study, EIS addendum, and the company's Environmental Action Plan have been released to the Bank's InfoShop. Specific mitigation measures that were undertaken by MYSA include: dust suppression measures, minimization of water uptake, leachate collection and recovery systems with intensive monitoring program, reclamation of areas directly affected by mining operations, adequate Occupational Health and Safety and Emergency Response programs, an ongoing Community Development Plan, etc. In addition, MYSA built serpentines, or parallel water canals, which collect runoff to monitor and regulate sediment loads to waterways. The company also conducts voluntary water quality monitoring at 97 surface and groundwater locations, though they are only required to report results for one site to the Peruvian government (Griffin 2000). Due to these extensive measures, the IFC predicted no significant impacts on natural habitats (IFC 1999). The project was approved in June 1999 and almost exactly one year later a mercury spill occurred.

Mercury Spill

After three years of operation, the company's accident statistics were declining while there was a growth in the trend of accidents by contractors (Harris et al 1996). Due

to failure of adequate safety measures and contingency planning with contracting organizations and the lack of a mercury spill response plan, a mercury spill on June 2, 2000, caused damage to the environment, public health, and the company's image.

The spill occurred during the transport of elemental mercury from the mine facility to Lima. It occurred along the road between Cajamarca and the Pan American highway when a cyanide cylinder became dislodged and disrupted mercury containers. The spill occurred on the road between and in the towns of San Juan, Choropampa, and Magdalena. (Environmental Media Services 2001) The driver of the truck, which was working for a contractor, did not inform residents of the dangers of mercury and continued driving to Lima. The company was not aware of the spill until the following morning. Initial response efforts included identifying the spill locations and working with local officials to inform the public of the hazards of handling the mercury. It was estimated that 151 kg of mercury were spilt, with 6-9 kg unaccounted for after cleanup efforts. Some is believed to be in the hands of residents who collected the mercury believing it to be a valuable metal (Shepherd Miller 2002). This is an example of how communication and education by MYSA had failed. Local communities should have been educated about the potential disasters as a result of processes involved in gold mining.

The Compliance Advisor/Ombudsman (CAO), an evaluative unit of the IFC, also investigated the mercury spill and produced a report in cooperation with the Peruvian government, the people of Cajamarca, the staff of the Yanacocha Mine, Centers for Disease Control and Prevention (CDC), and the National Center for Environmental Health (NCEH) (Environmental Media Services 2001) The commission's report found

that: the mine did not follow safety procedures for loading and transport of mercury; Newmont did not apply global standards to handling and transport of hazardous materials at the mine; the mine had no emergency response plan for mercury spills outside its property; and both the mine companies and government agencies involved in the clean up, recovery, and public reporting efforts initially downplayed both the amount of mercury spilled and the danger mercury poses to human and environmental health (Environmental Media Services 2001).

An independent risk assessment carried out and completed in 2002, determined that there are no unacceptable risks to human health or to terrestrial or aquatic ecological reserves from the mercury spill (Shepherd Miller 2002). However, some question the scope and the methodology of the assessment. They argue that the environmental studies do not assess direct human health impacts from contamination levels inside people's houses, describing only the quality of the health of plants and insects (FOEI 2003). According to government estimates more than 900 people were poisoned with symptoms ranging from skin irritation, headaches, diminished eye sight, kidney problems, etc., due to the spill. Despite reports from citizens such as Juana Martinez that children have been born missing fingers and toes, miscarriages are occurring at a higher rate, children suffer from frequent nosebleeds, respiratory infections, etc., the company has still failed to acknowledge the problems and work to provide adequate medical care (FOEI 2003).

So, were the clean up efforts successful as Newmont claims or are there health impacts on the communities as citizens and NGOs contend? This is still being contested today. Regardless, there were other consequences of the mercury spill – the local community had lost confidence in the company. This has led to strained relationship

between the communities and the mines. MYSA is concerned with how to win back the public support and is developing a long-term strategy to do so (IFC 2001). Since the spill, extensive education campaigns to prevent future accidents have been implemented in the communities. The company has also been working to decrease their impacts on water quality and is in the process of building dams to reduce the amount of sediment transported from the mine into local waterways. With the assistance of MWH, MYSA prepared a 5-year, $50 million Site-Wide Surface Water Management Plan that addresses the most critical aspects of surface water sediment and chemistry related to mine operations (MWHglobal.com).

Despite these pronouncements of environmental awareness and integrity and transparency, many NGOs site the fact that Newmont does not provide information regarding the release of toxic chemicals from its Yanacocha mine. Though they promote the Toxics Release Inventory in the Corporate Responsibility section of their website, the company fails to uphold this policy in Peru. Due in part to the OECD Guidelines for Multinational Enterprises that include only voluntary disclosure provisions, thus Yanacocha remains shrouded in controversy over environmental contamination from its mine (FOEI 2003) in addition to the mercury spill. It is not only the mine's affect on the environment that community leaders are worried about.

Conclusion

Despite the tax revenues paid to the region, Cajamarca has become the second poorest district in Peru since the start of mining operations in 1993 (FONCODES in FOEI 2003). While Cajamarca's rural poverty is increasing, a few individuals in the city

are benefiting tremendously. Because of poor communication early on in the project, these perceived discrepancies along with unequal distribution of the mine's costs and benefits, have led to conflict and an atmosphere of suspicion among the community members (FOEI 2003). Newmont claims that they have created more than 1600 jobs in the area, but locals report that most of these jobs are menial. In addition, much of the 6,000 contractor staff, many who come from outside the region, have negatively transformed the community. What was once a secluded agricultural city with strong rural character now has strip bars and increased prostitution, crime, alcoholism, and domestic violence (BBC News 2006). While the public believes that Yanacocha has brought economic growth to the city of Cajamarca, this development has been viewed ambivalently due to the rising cost of living, arrival of outsiders, deterioration of customs, and an increase in crime (Pascó-Font et al 2001).

In the fall of 2004 another conflict arose over Newmont's plans to expand Yanacocha operations to a nearby mountain called Cerro Quilish. For two weeks thousands of local people laid siege to the mine, and clashes with local police left women and children arrested and hospitalization for the wounded. In 2000 the local government had passed an ordinance which declared Quilish and its watershed a protected natural reserve; however, the Peruvian courts agreed with Newmont that they had acquired the rights to mine the concession years earlier (Perlez and Bergman 2005). The protests have been successful at least for now. On September 7, 2005, Newmont decided to indefinitely suspend all its exploration activities on Cerro Quilish (Minera Yanacocha 2005) In addition the Ministry of Mines has withdrawn their permit. It is not only

enough today to obtain the necessary legal license to mine, but the social license from the local communities as well.

Table 4: Schematic comparison between the conditions of small-scale/artisanal mining and typical large-scale, industrial mining

	Small-scale mining	Large-scale, industrial mining
Effective use of natural mineral resources:		
Small deposits	Good	Poor
Big deposits	Poor	Good
Approach to exploitation	Chance & opportunity	Systematic
Prospecting/exploration	Little to none	Extensive
Commitment	Short-term	Long-term
Requirement for public supervision	High	Modest-high
Payment of taxes	Minimal	Yes
Compliance with legislation	Unsatisfactory	Satisfactory
Rate of employment	High	Relatively low
Social development and professional improvements	Poor	Good
Concern for health and safety	Low-very low	High

(Source: Tarras-Wahlber et al 2004)

The Yanacocha mine serves as an excellent example for the debate about large scale mining operations and their contribution to sustainable development. It shows that larger in scale does not automatically mean without negative impacts and controversy. There are both positives and negatives for mining operations at all scales (Table 4). It is important to determine how and where mining can best contribute socio-economically with respect for the environment at local, regional, and national levels. There are many challenges with an inherently unsustainable extractive industry such as gold mining, to ensure the most efficient use of minerals while looking ahead for a smooth transition to a future when mining ceases to be possible. These challenges are especially difficult to

overcome in developing countries that don't always have the extensive financial, technical, and educational resources necessary.

Literature Cited

(1996). Regularizing Informal Mining: A Summary of the Proceedings of the International Roundtable on Artisanal Mining. International Roundtable on Artisanal Mining, World Bank, Washington D.C., The World Bank, Industry and Energy Department.

(2002). Aid Case Study: Peru's Yanacocha Mine. BBC News.

(2002). First Session: Environmental, Health, and Safety Issues. Regularizing Informal Mining, World Bank.

(2004). Q&A with environmental foot soldiers: Radhika Sarin, Earthworks. 2004.

(FOEI), F. o. t. E. I. (2003). Case Study Six: Dividing and Polluting: Yanacocha Gold Mine in Peru. Hands Off! Why International Financial Insitutions Must Stop Drilling, Piping and Mining. Amsterdam, FOEI.

(IFC), I. F. C. (2001). Minera Yanacocha (Peru) Project Brief. Washington DC, International Finance Corporation.

(ILO), I. L. O. (1999). Social and Labour Issues in Small-Scale Mines. Geneva, International Labour Organization (ILO).

(SGAB), P. a. S. G. A. (2000). Plan Maestro Ambiental: Ambientales Emergentes y el Establecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango. Quito, Swedish Geological AB: 83.

Africa, E. C. f. (2002). Compendium on Best Practices in Small-Scale Mining in Africa. Addis Abba, Ethiopia, Economic Commission for Africa: 101.

Ali

Bermeo, A. (2001). Confianza y enfoque integral para mejorar la minería aurífera de pequeña escala: lecciones aprendidas en Prodeminca. Jornada Internacional sobre el impacto ambiental del mercurio utilizado en la minería aurífera artesanal, Lima, Perú: 17.

Bugnosen, E., J. Twigg, et al. (2000). "Small-scale mining legislation and regulatory frameworks." Industry and Environment: Mining and Sustainable Development II: Challenges and Perspectives 23: 50-53.

Davis, G. A. a. J. E. T. (2002). Should Developing Countries Renounce Mining? A Perspective on the Debate, Colorado School of Mines: 61.

Earthworks, O. A. (2004). Dirty Metals: Mining, Communities and the Environment. Boston, No Dirty Gold Campaign: 34.

Easterly, W. (2002). The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics. Cambridge, MA; London, England, The MIT Press.

Echavarria, C. (2004). Formalization of Artisan and Small Scale MIning: Harnessing opportunities for private sector development, Mining Policy Research Initiative.

Fauvet, P. (2004). Mozambique: growth with poverty. afrol News. Maputo: 9.

GEF, UNDP, et al. (2003). "Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies." GMP News(1).

Griffin, G. (2000). Newmont;s Peru gold mine a mixed blessing. Denver Post Business News. Denver.

Heemskerk, M. (2002). "Livelihood Decision Making and Environmental Degradation: Small-Scale Gold Mining in the Suriname Amazon." Society and Natural Resources 15: 327-344.

Hennig, W. Strategic Considerations for Reduction of Mercury Emissions in Artisanal Gold Mining. Hannover, BGR.

Hilson, G. (2002). "Small-scale mining and its socio-economic impact in developing countries." Natural Resources Forum 26: 3-13.

Hinton, J. J., M. M. Veiga, et al. (2003). "Clean artisanal gold mining: a utopian approach?" Journal of Cleaner Production 11: 99-115.

Hruschka, F. (1993). Concepts for the design of the project: Environment-Protection in Ecuadorian Gold Mining: 2.

Hygelund, B. N., R. K. R. Ambers, et al. (2001). "Tracing the Source of Mercury Contamination in the Dorena Lake Watershed, Western Oregon." Environmental Geology 40: 853-859.

Hylander, L. and M. Meili (2003). 500 years of mercury production: global annual inventory by region until 2000 and associated emissions. Communities and Small-Scale Mining (CASM) Annual General Meeting and Learning Event in Elmina, Ghana.

Institute, I. C. M. (2006). International Cyanide Management Code for the Gold Mining Industry. 2006.

International Institute for Environment and Development, W. B. C. f. S. D. (2002). Breaking New Ground: Mining, Minerals, and Sustainable Development. Sterling, VA, Earthscan Publications Ltd.

Kirkemo, H., Newman, William L., and Roger P. Ashley (1997). Gold, USGS. 2004.

Maurice-Bourgin, L., I. Quiroga, et al. (1999). "Mercury Pollution in the Upper Beni River, Amazonian Basin: Bolivia." Ambio 28: 302-306.

Miller, J. R. and P. J. Lechler (2003). "Importance of Temporal and Spatial Scale in the Analysis of Mercury Transport and Fate: An Example from the Carson River System, Nevada." Environmental Geology 43: 315-325.

Ministerio de Energia y Minas, E. M. P. d. D. M. y. C. A. P. (2000). Plan Maestro Ambiental: Medidas Ambientales Emergentes y el Establiecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango, PRODEMINCA, Swedish Geological AB (SGAB): 94.

News, B. (2006). Protests hit Ecuador oil exports. BBC News Online.

Nöetstaller, R. (1997). Socio-economic potential of artisanal and small-scale gold mining. Vienna: 17.

Plowden, P. a. G. W. (1999). A Glittering Future? Gold mining's importance to sub-Saharan Africa and Heavily Indebted Poor Countries. London, World Gold Council: 74.

Quiroga, E. R. (2002). "The case of artisanal mining in Bolivia: Local participatory development and mining investment opportunities." Natural Resources Forum 26: 127-139.

Ross, M. (2001). Extractive Sectors and the Poor. Boston, Oxfam America.

Salim, E. (2003). Striking A Better Balance: The Extractive Industries Review. Jakarta, The World Bank Group: 92.

Sánchez Delgado, A. B. N., Antonio (2001). Elementos para una Descripcion del Proceso de Desarrollo de la Mineria de Pequena Escala en la Region Sur del Ecuador desde 1983 al 2000. Quito, Ministerio de Energia y Minas: 9.

Sandoval, F. (2001). Small-scale mining in Ecuador, Mining, Minerals and Sustainable Development: 28.

Tarras-Walhberg, N. H., A. Flachier, et al. (2000). "Environmental Impact of Small-scale and Artisanal Gold Mining in Southern Ecuador: Implications for the Setting of Environmental Standards and for the Management of Small-scale Mining Operations." Ambio 29(8): 484-491.

Tarras-Walhberg, N. H. B. L. A. B. a. R. H. (2004). How Beautiful is Small-Scale Mining? Evidence from Small-Scale and Artisanal Gold Mining in Ecuador. Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries. G. Hilson. Netherlands, Aa Balkema: 701-715.

UNIDO (2001). Artisanal Gold Mining Without Mercury Pollution.

USAID Small-Scale Mining: Cleaner Production Fact Sheet and Resource Guide, USAID.

USGS Mercury in the Environment Fact Sheet. 2004.

Veiga, M. M. (1997). Introducing New Technologies for Abatement of Global Mercury Pollution in Latin America. Rio de Janeiro, UNIDO, UBC, CETEM.

Veiga, M. M. (1997b). Mercury in Artisanal Gold Mining in Latin America: Facts, Fantasies and Solutions: 23.

Veiga, M. M. (2001). "Mining with Communities." Natural Resources Forum 25: 191-202.

Veiga, M. M. (2004). Mercury in small-scale gold mining.

Veiga, M. M. and L. Bernaudat (2003). The Global Mercury Project. CASM Annual General Meeting, Elmina, Ghana.

Veiga, M. M. and J. J. Hinton (2002). "Abandoned Artisanal Gold Mines in the Brazilian Amazon: A Legacy of Mercury Pollution." Natural Resources Forum 26: 15-26.

Wotruba, H. (2003). Technologies for Small Scale Mining. Examples of traditional and alternative mining and processing methods. Elmina, Ghana.

Scales of Responsible Gold Mining:
Overcoming Barriers to Cleaner Artisanal Mining in Southern Ecuador

Introduction

The gold mining sector in Ecuador has a long history, since Spanish colonialists began mining in the Portovelo-Zaruma region of Southern Ecuador in the mid-1500s (Zhapan, J.C. 2001 in (Tarras-Walhberg 2004)). While larger scale mining activities existed until the mid-1900s, since the late 1970s all gold mining activities can be categorized as either artisanal or small-scale. There is currently no universal definition of artisanal and small-scale mining (ASM), due to the fact that the definition often varies from country to country (Africa 2002). A broad definition of small-scale mining characterizes the operations as both labor intensive and low-tech. While ASM has been acknowledged as a necessary livelihood for some of the most poverty stricken members of society worldwide, there are numerous environmental and social impacts caused by these activities which are not acceptable. The negative impact of mining activities on the environment and health, in particular due to the use of mercury and cyanide in processing, have been well documented (Appleton 1996; Veiga 1997; Malm 1998; Maurice-Bourgin et al. 1999; Tarras-Walhberg et al. 2000; UNIDO 2001; Limbong et al. 2003). In order to address the impacts and encourage a more sustainable means of development, the legalization and formalization of the ASM sector were promoted in the 1990s.

The philosophy of formalization is that legal oversight provides a means of achieving financial efficiency that ensures sound environmental management practices in small-scale mining. According to Tarras-Wahlberg et al (2000, 490) artisanal and small-

scale miners "do not have the financial resources available to construct tailings dams or to invest in more efficient methods of gold retrieval, such as cyanidation; and the authorities have the almost impossible task of ensuring compliance to environmental regulations for a large number of small enterprises." Though these problems have garnered the focus of those involved in mining activities, they often remain without successful implementation of solutions due to lack of programs and personnel. In Ecuador, oil sales account for about a quarter of gross domestic product (GDP) (BBC News 2006), consequently it appears more government resources and attention from within the Ministry of Energy and Mines are focused on petroleum than on mining.

This paper reports the results of a study in artisan and small-scale gold mining regions in Southern Ecuador. The aim of the study was to identify the progress that has been made and the challenges which remain in achieving cleaner and more sustainable small-scale gold mining production after legalization and formalization of the ASM sector in the early 90's. A qualitative research design was utilized during a five week field study consisting of structured, open-ended interviews with members of Ecuadorian government, miners, third party consultants or NGO workers, and non-mining members of the community. The study focused on two mining regions in Southern Ecuador: Ponce Enriquez/Bella Rica in the province of Azuay and Portovelo-Zaruma in the province of El Oro. Formal and informal interviews as well as field visits to mine tunnels, mills, and processing plants were conducted in these regions. In Ponce Enriquez, the study was focused on the mining concession of the Bella Rica Cooperative. In Portovelo-Zaruma, many different mining concessions, mills, and processing plants were visited to get a broad perspective on the similarities and differences in operations of various sizes and

mechanization levels. While all mining in Ecuador is considered to be either artisanal or small-scale with regard to production levels, there exist great differences among the small-scale operators in the Portovelo-Zaruma region.

In addition, information from a study conducted by the Centro Ecuatoriano de Derecho Ambiental (CEDA), of the small-scale mining production cooperative Bella Rica, exploiting Bella Rica, Guananche and Tres de Mayo in the Azuay province in Ecuador (Cárdenas 2005), provides an excellent opportunity within which to further evaluate the results of my study. The CEDA study focused on the experiences in Bella Rica but also consulted with government mining officials and leaders, who are experts in the gold mining sector (Cárdenas 2005). For an additional perspective, my study focuses on many of the challenges of the Portovelo-Zaruma region and the work being done by miners in this region to ensure a more sustainable mining presence remains in the region for years to come. These two studies allow for strong conclusions to be drawn and results to be extrapolated to the broader small-scale gold mining sector in Ecuador.

Methodology

Qualitative Research Approach

This study empirically tested the hypothesis that the process of formalization in Ecuador has led to better mining practices and contributed toward sustainable development in mining communities. Because the focus of the study was on peoples' perceptions of the effectiveness of formalization in overcoming barriers to cleaner production, it was ideal for qualitative research. A qualitative research design was also chosen due to the need for flexibility and the emergent nature of this type of research. The research design falls between the applied research and summative evaluation. The evaluative approach taken, as Patton states (2002, 220), "aims to discover general principles of effective practice rather than render judgment about the merit or worth of a specific intervention" and thus "falls roughly within the category 'applied research' in a theory-to-action continuum."

Pilot interviews with contacts in Ecuador indicated that open-ended questions would yield more usable results than a survey approach. The open-ended interviews were preferable to me so as not to seem like an outsider who perceived myself to be an expert with my own predetermined notions of mining and the miners' experiences. This style of questioning allowed me to gain a broader range of perspectives and allowed the miners to speak for themselves. Additionally, a qualitative research design was preferable due to the uncertainty that the number of participants in the study would generate an adequate sample size to generate quantitative or statistically significant

results. I used triangulation of data sources including interviews, observations, and documents to demonstrate reliability in the study (Patton 2002).

Data Acquisition

The study used ethnographic methods, observational fieldwork and archival research to ascertain the perspectives of miners, government officials, mining consultants, NGO leaders, and non-mining community members from the mining regions of Bella Rica/Ponce Enriquez and Portovelo-Zaruma. While the primary form of data used in this study was interviews, personal observations and document analysis were also integral to overall results and conclusions. I selected three broad stakeholder groups whose perspectives I felt were important to obtain in this study: miners (included those working in mine tunnels, mills, processing plants and owners of mines, mills, and plants; leaders of small miner organizations – at national, regional, and local level), government (members of the Ministry of Energy and Mines national and regional levels, local municipal government officials), and third party (including environmental consultants, NGO personnel involved in the mining sector, and non-mining members of the local communities) (Table 1). There was some overlap between the groups as one of the 3rd party sample used to be President of one of the regional Chambers for Small Miners, and one of the local government officials is also a miner. In some of the local municipalities where mining is the primary economic driver, they are working to get miners into local office, thus some of the perspectives overlap. These participants were placed in the category they most identified with but they were referred to by both titles in discussion of the results.

Table 5. Interview Sampling Strategy

	Miners	Government	3rd Party
Number Interviewed (formal)	9	9	12
Number Interviewed (informal)	11	0	4
Total Number Interviewed	20	9	16

* additionally there were informal conversations with miners and non-mining community members

The initial study participants were identified due to their various roles in the gold mining sector as government employees, former project workers and leaders of miner organizations. After the initial identification of participants a snowball sampling strategy was utilized to identify further study participants. In addition, in order to gain the largest sample size possible and the broadest range of perspectives mine tunnels, mills and processing plants were randomly visited and workers were asked to participate in the study. Thus formal interviews were most often done in offices, cafes, or restaurants while informal interviews were conducted outside tunnels, at mills and processing plants, and in offices. Additionally, a number of informal conversations provided further information which contributed context to observations and overall understanding.

The data collection activities were primarily undertaken during a five week field visit in Ecuador from December 2004 to January 2005. However, numerous participants provided their contact information if further discussion was necessary. The interviews ranged from 20 minutes to 2.5 hours, with most interviews approximately one hour long. The format of the interviews consisted of structured open-ended questions (Appendices A, B). With the consent of the study participants, each interview was tape recorded and later transcribed. The interviews conducted in Spanish were transcribed by native

Spanish speakers and translated into English. This was done to ensure accuracy in the results. Informal interviews were often conducted with one or more people present who served as guides into the mines, mills, and processing plants. All participants were given the opportunity not to participate in the study.

Data Analysis

All interviews were coded to identify comments related to a list of important themes created from the literature (major barriers to cleaner production) and research goals (use of Hg in processing, responsibilities, leadership). These themes were assigned preliminary codes and then were later refined throughout the analysis from emergent data. Sub-categories were also assigned to certain categories to separate different responses such as the types of barriers to cleaner production.

Respondents were provided code numbers in order to maintain confidentiality. Those participants who were interviewed formally were numbered 1 through 30, while participants who were interviewed informally were numbered 101 to 115. These numbered codes are used throughout this paper when attributing quotes or perspectives to respondents.

Overview of artisan and small-scale gold mining in Ecuador

Legal context

The *Ecuadorian Mining Law,* in 1991, legalized all de facto ASM settlements, an essential component of the formalization process. The 1991 mining legislation and its subsequent reforms in 2000, consisted of regulations that stipulate the mining and processing of gold must be done in an environmentally responsible manner. Concession holders are required to prepare and have accepted an Environmental Impact Assessment (EIA) that details their management plans to mitigate environmental impacts and which also provides plans for mine closure. In addition miners are required to submit yearly environmental audits to determine their adherence to management plans (Tarras-Wahlberg 2002). Artisanal miners are relieved of some of these stipulations and are allowed to mine in a concession without applying for the title, provided the concession is not being actively mined. Artisanal miners are responsible for recuperating Hg used in amalgamation and adequately storing tailings under Ecuadorian law. In many cases the artisanal miners have made agreements with the individual concession holders and must adhere to their guidelines as well. The Ecuadorian government is also required by law to provide "a program of information, education and capacity building aimed especially at artisanal miners" (Tarras-Wahlberg 2002, 169).

The Ministry of Energy and Mines (MEM) (Ministry of Energy and Mines 2005) is responsible for monitoring and control of mining activities, work which is carried out through the Mining Environmental Unit (MEU) (or Unidad Ambiental Minera UAM), a department based in the capital, Quito. In1997 the 'Law of environmental management

and decentralization' placed some of the responsibility for environmental control and management on municipalities and gave any member of the public the right to participate in the decision making process for developments that may have adverse environmental impacts (Tarras-Wahlberg 2002). In 2001, a few regional government offices were opened in an effort to improve control in mining regions. The Ministry is currently undergoing a process of reorganization that will hopefully help improve the fulfillment of their roles in the sector (MEM 2005).

.

Study regions

The two main gold mining areas selected for study in Southern Ecuador were Ponce Enriquez and Portovelo-Zaruma (Figure 1). These gold mining regions are the largest in operation today according to the latest reported production numbers and are important due to their locations (MEM 2005). Particularly, the mining region of Ponce Enriquez could potentially risk contaminating Ecuadorian shrimp farms and banana plantations located downstream of mining operations, thus they have been of particular interest to studies and programs (CENDA and PRODEMINCA) to improve extraction and processing practices and reduce negative environmental and health impacts (Appleton et al 1996; SGAB 2000). Because Portovelo and Zaruma are near densely populated cities they have presented a good opportunity to combat these problems by working with the local populations (Hruschka 1993). In addition, recent studies have found severe pollution of water resources and environmental degradation in these communities.

Figure 1. Map of Ecuador demonstrating location of mining regions in the provinces of Azuay and El Oro

Portovelo-Zaruma

Gold mining has over a 500 year history in the region. However, the invasion of the old SADCO mine by local miners in 1984 marked the beginning of the artisanal and small-scale mining operations today. In 2000, there were close to 400 small mines in the area (Tarras-Wahlberg et al 2004). Today, there are 63 mining concessions in the

Portovelo-Zaruma region organized in groups of 10 to 20 miners. There are 800 mining partners (socios) and a Chamber of small miners in each of the towns. There are approximately 110 plants and mills operating in Portovelo and almost all process materials from their own mines. Many of the processing plants are located along the Calera River in an area known as "El Pache" (Figure 2). It has been estimated that 50% of the population in Portovelo is economically dedicated to mining, and approximately 80% of the population relies on mining or indirectly benefits from mining operations. Of the 4000 people of working age, approximately 2070 work in mining as either owners or workers (24). The Bira Mining and Processing Operation located in Zaruma, which began in the mid-1990's, is considered to be the most modern operation in Ecuador (Tarras-Wahlberg et al 2005). Bira processes approximately 100-150 tons of ore daily (109) in a state-of-the-art cyanide processing plant. In 1999, Bira accounted for approximately one third of gold production in the region (28,000 oz), while artisanal and small-scale operators produced approximately 50,000 ounces (Tarras-Wahlberg et al 2004). In 2005, there were an additional three larger mining companies operating in the region which maintain agreements with the artisanal miners: Yellow River (American), Nevada (American-Canadian), and Empec Merendon (Canadian-German) (24).

Figure 2: Processing plants located along the Calera River in the sector "El Pache"

Bella Rica-Ponce Enriquez

Gold deposits were first discovered in 1983 in Bella Rica. The Bella Rica mining concession is located within the canton of Ponce Enriquez and is the largest concession at 1430 hectares (**6**). The canton developed around the mining activities in the region and the local economy remains heavily dependent on these activities. The population of Ponce Enriquez is 9,648 (Cárdenas 2005) and the population living within the concession, including the community (mining camp) of Bella Rica (Figure 3) is estimated at 2000, approximately 50% of which are miners (12). The cooperative consists of 140 partners or members, of which around 100 are in the mining industry. Those involved in mining operations are organized into 50 societies. The cooperative

establishes the rules that all mining societies must follow and is the entity responsible to the State with regard to environmental, production, and social issues (6). It is this cooperative form of organization and efforts to improve on the social and environmental aspects of their livelihood that has led Bella Rica to be one of the most widely recognized examples of the formalization process in Ecuadorian mining (Cárdenas 2005).

Figure 3: Processing plant and town center of Bella Rica mining concession

Organization

In Ecuador, miners can be currently separated into three distinct groups: artisanal, small-scale semi-mechanized, and small-scale industrialized (Tarras-Wahlberg et al 2004). (Figure 4) Most artisanal miners are still considered to be informal, though they do have agreements with concession owners to mine in the area. They usually work in small groups of 2-4 people and rarely more than 10 people. They have few tools and mine on a subsistence level with no capital. There is very little to no investment needed for this type of mining, because it is extremely labor intensive with poor recovery of gold from the ore (Tarras-Wahlberg et al 2004).

Small-scale semi-mechanized operations generally include processing and some mining; they generally purchase ore from artisanal miners because they don't have their own mines. These miners are often organized into small groups, cooperatives, or societies and together own the mills and processing plants, thus they do have some capital. They may also have a couple vehicles for transportation of the ore. These groups of miners in Ecuador have some capital and limited investment (Tarras-Wahlberg et al 2004).The small-scale and more industrial operations generally have full ownership of their mining, milling, and processing equipment, with more substantial capital and investments. There are few gold mining operations in Ecuador that have achieved this industrial scale; however, increased foreign investment in some areas is helping with this transition.

In addition, it is important to note that not all of the miners who work in extraction and processing have some level of ownership. There are examples where societies and cooperatives have hired employees to work in the tunnels or mills and these employees are wage earners. There are examples of this in Bella Rica as well as in Portovelo and Zaruma. Because some of the employees are wage earners the cooperative form of organization doesn't apply in all cases. When environmental improvements must be made by these societies and cooperatives it is the members who are responsible for the costs not necessarily the employees of these operations.

Figure 4. Scales of mining operations: top - artisanal, middle - small-scale semi-mechanized, bottom - small-scale industrialized

Progress and Challenges – Stakeholder Perspectives

Mercury and cyanide use in processing

Following the legalization and formalization of the mining sector, a combination of improved education and awareness due to campaigns in the 1990s by programs such as PRODEMINCA and CENDA, and the necessity for more efficient mineral recovery, has led to the decrease in processing by mercury (Hg) amalgamation. When mercury is used to recover coarse gold, most often retorts (Figure 5) or other recovery systems are utilized. Miners are aware of dangers of Hg use; however, it is still cheap and legal to use in Ecuador. The most common replacement for Hg amalgamation is processing with cyanide (Sandoval 2001; Cárdenas 2005). Interviews and observations confirm these changes, although there is debate about the degree of these improvements over time.

The overwhelming majority of miners interviewed stated that the use of Hg for amalgamation has been reduced and most often replaced by cyanidation. One miner who was recently elected to local government felt that, "[the] most successful projects /programs were to not use Hg. [Miners] are trying to eliminate Hg (24)." One miner who uses cyanidation with agitation believes that, "few [miners] use Hg, the majority work technically [w/cyanide] (106)."

However, when processing is still done with Hg, the majority of miners are using retorts to recover the Hg and keep it from being released into the air during the burning stage. "There's been some change because the law makes us comply. In the cyanide process, there was more discharge in the river, but now it goes to the tailings cemetery. And the mercury is recovered in the retort. Around 80% of miners use the retort; I'd be

lying if I said 100% (7)." Another miner was in agreement, "for example, today less mercury is used, we are using activated carbon, we have the retorts so that the mercury isn't volatilized and doesn't destroy the environment and all, true. So already less mercury is used. There is less use of toxic chemicals than before (8)." "The chanchas [where they mill with mercury] have implemented extractors for the gases. When mercury is used now they use retorts and recover gases (29)." In Bella Rica, "With the cylinders we have eliminated the direct contact with Hg. We have even done metallurgic tests to [try to] eliminate the amalgamation process. We've tested for a direct smelting of the mineral. After the secondary crush, it would go to a smelting plant. That would eliminate the use of Hg. [Today] 95 to 98% have eliminated manual manipulation of amalgam, and use the cylinders (2)."

The integrity of retorts used for Hg recovery is critical. One consultant, who was also a miner, reported that "what we need is the maintenance of the retorts. They are not very functional…(18)." Another miner reported that process at his mill consists of: crushing with Chilean mills, then gravimetric sorting in canals, washing in plates, and then adding Hg to form the amalgam. This process is followed by burning with a retort; however, the retort at his mill had been broken for some time. There were miners who were currently working there but were not using retorts because they only had a little material. Supposedly if the miners (who rented out the mill) had more material they would bring the amalgam to another mill to use a retort.

In discussing the use of retorts at his mill in Zaruma, one miner stated, "[it] is a closed system but the miners don't like it. The miners don't have confidence in these systems because you can't see the gold. Most use retorts but there are a few, 'the old

ones' (los mas viejitos) that don't use them because don't believe it so bring it [the amalgam] to their homes. But this is only a very few (102)." To combat this mistrust one of the largest gold mining operations in Zaruma (and Ecuador) discussed how they were one of the first to use the retorts for amalgamation in order to "try to set a good example for the small miners (109)," but have since switched to cyanidation to eliminate Hg.

Figure 5: Examples of different retorts used in Southern Ecuador gold mining

Only 1 out of 20 miners interviewed, a mine owner, responded that there wasn't as much change with regard to Hg use over the years since legalization, "[Hg use] has improved a little bit over time with respect to Hg in open air; [however] 50%, of the smallest who have amalgam of 5-10grams, still don't use retorts, [they burn] in the kitchen. [Overall], ten percent of production Hg is still burned in open air. Perhaps in

Bella Rica, 20% still burn Hg without retorts. [The miners] need more technology to use retort and [processing] is faster without it. Depends on how much amalgam they have, if have more [amalgam, they will] use retorts (27)." Nevertheless, the approximate percentages he provides are an indication of improvement overall.

Gravimetric concentration and Hg amalgamation are still used to recover coarser gold while finer gold is recovered by further cyanidation. When it is possible for them to do so, the miners are working to switch to cyanidation because: "people now understand the importance of protecting the environment (5);" "there's been some change because the law makes us comply (7);" "it [Hg amalgamation] is not cost effective. Now [we] are only processing coarse gold and waiting to process the fine gold (111);" "it was more work – this [cyanidation] is an easier process, not quicker but recover more because our material is fine gold not coarse gold (25);" and "now [we] are thinking about activated carbon because it's faster (103)."

Most government officials also agreed that the use of Hg for amalgamation has decreased. "[Miners] practically don't use Hg anymore. [They] have drastically reduced the use of Hg because they are now using cyanidation and flotation (9)." Other officials stated that "fifteen years ago it was completely anti-technical artisan mining, and we've improved a lot because they [the miners] are all legal (13)," and "cyanide plants are replacing mercury (11)."

Not all government employees were in agreement that the amount of Hg used in processing has been greatly reduced. However the disposal of tailings has improved according to one government employee, "no changes [to the amalgamation process], [miners] continue doing the same. There is one change – mills. Before [miners] directly

put Hg tailings in the river, now they are brought to plants (12)." Another government official felt that mines are great for the economy and that there are more problems with the large companies, though he conceded that there are still problems here with people sometimes burning amalgam without retorts in the city.

The consultants and NGO workers were the least convinced of the changes in Hg use and improvement in environmental management since legalization. Most did feel that some improvements have been made, but not to the same degree as the miners. One person felt that some changes had been made by larger cooperatives to switch to cyanidation; yet small miners were still amalgamating, stating "the environmental impacts of activities are more or less the same. There haven't been any important improvements in environmental and social management. There are some groups that are more responsible but generally these environmental and social facts are ignored (14)."

One consultant felt that the switch to cyanidation itself was a big improvement, "we are using cyanide now, that is better than mercury, no (17)?" There wasn't complete agreement about the changes due to increased awareness of the impacts from Hg use. One consultant believed education efforts have been successful, "as for mercury, people are more conscientious and know that it is dangerous. At least they don't burn in their houses anymore. Before they'd burn the amalgam balls in their houses, but not now... there was a strong campaign from the CENDA foundation, they did a very good job. And they [miners] don't burn [Hg] in their house anymore, use the retort (18)." Another foundation leader felt that miners ignored the risks from Hg use, "… And they burn the gold to get rid of the mercury… they know how bad to their health it is, it could kill them. But they don't use protection. I told them use gloves when grabbing the mercury,

or to wear a mask when burning it… They know, but still, they don't protect themselves (10)."

One technical consultant stated the continued use of Hg amalgamation was due to a number of factors including a lack of confidence in new methods, "[miners] are still using amalgamation today because it's simple and fast. The problems with cyanidation: takes more than five weeks to recover, only fine gold is recovered so prefer gravimetric and amalgamation. Nelson Concentrator is alternative but is very technical so need to know how to use it. [The] problem is with confidence - if owner can't do it won't use the process. Need confidence in the team. Need to educate the people to have confidence in the technicians who demonstrate the technologies/methods that they can use. The security of the methods –everyone wants the gold in hand – 'todos quieren oro en mano' (26)." Another foundation leader discussed changes in processing methods, "They are using some retorts and other processes to recover Hg. [They] catch 40% with funnel and 60% goes to the pools after gravimetric sorting. So [they] need to recover more of the gold – use cyanidation." However he voiced concerns over the use of cyanide and poor environmental management, "[the] community doesn't know about dangers of cyanide. Enterprises don't use Hg, only Cn. I think that the main problem – throwing tailings and effluents to the river and use of mercury is present, just a little change since the legalization (21)."

Overall, the majority of those interviewed believed that the use of Hg has been reduced; however, it is still being used today. If Hg is being used, most miners are using retorts to recover the Hg. There remain two cases where Hg is still being used without retorts: when the artisanal miners have a small amount of Hg-Au amalgam and by "old-

timers" who still don't trust the system when they are unable to observe what is occurring. Many interviewees said that much of the improvement with regard to exploitation and processing is due to the geology of the gold deposits and need for improvements in efficiency of mineral recovery.

This is confirmed by processing methods used in larger scale operations and their justification for use of cyanidation. Gold typically occurs at very low concentrations in ores - less than 10 g/ton and in the mining regions in Ecuador these concentrations are decreasing.

> At these [low] concentrations the use of aqueous chemical (hydrometallurgical) extraction processes is the only economically viable method of extracting the gold from the ore. Typical hydrometallurgical gold recovery involves a leaching step during which the gold is dissolved in an aqueous medium, followed by the separation of the gold bearing solution from the residues, or adsorption of the gold onto activated carbon. After elution from the activated carbon the gold is further concentrated by precipitation or electrodeposition. Gold is one of the noble metals and as such it is not soluble in water. A complexant, such as cyanide, which stabilizes the gold species in solution, and an oxidant such as oxygen are required to dissolve gold (Institute 2006).

In other words, the changes have been necessary for continuing to mine in these areas, not always due improvements in education and resource access because of legalization and formalization. While these changes have begun to decrease the negative environmental impacts from small-scale gold mining, there are many management challenges which remain.

Current environmental impacts

As mercury use decreases, the management focus turns to other environmental impacts and the barriers to achieving cleaner production. The artisanal and small-scale gold mining sector in Ecuador has seen improvements with regard to cleaner production over the past 15 years. Legalization of mining and mining titles have given miners ownership over the land and thus a greater likelihood of investing in their mining operations, and hopefully implementing cleaner production methods. However, despite legislation which requires EIAs, management plans, and environmental audits, many environmental impacts persist. This was discussed by one consultant to the sector:

> When you go to Bella Rica you will have a strong impact, because it's a situation… let's say 'it's not pretty.' There is a lot of contamination, a lot of production problems. That current situation is way better than before formalization (legalization) happened. But that doesn't mean it is at an ideal level. We are far away from that. But without formalization I think it would be worse, because someone who has no security in their property does not invest a penny in cleaner or more careful production or anything beyond the basics to extract. But now if that person has concessions, you'll see plants and some improvement in water and waste management, which is not ideal, but it's not as bad as that of someone who has to run away from the authorities. When I learned about all this 15 yrs ago it was much worse (13).

With the shift from an artisanal sector to a small-scale sector new environmental challenges are emerging.

In P/Z the principal environmental problems in the region were found by the PRODEMINCA-SGAB (2000) study to be: "discharge of heavy metals, mercury, cyanide, and suspended solids into the rivers due to bad management of tailings; absence of information about mineral reserves and inefficient exploitation of mineral reserves; poor planning of the use of the ground/soil; deforestation and loss of vegetative cover, causing soil erosion; loss of water and chemicals in gold processing methods; indiscriminate

discharge of used waters with high content of organics, nutrients, and bacterias; and inadequate disposal of domestic and municipal solid wastes." These results come from project studies undertaken in the 1994 and completed in 2000. Tailings have a high concentration of heavy metals since the process recovers only Au, Ag, and some Cu, and the geology of the mined regions also contains heavy metals such as Zn and Pb. Many of these same problems were discussed by miners, government, and third party stakeholders. It was also easily observable that in Portovelo, cyanidation plants along the river still emit liquid tailings directly into the river due to lack of space for permanent tailings ponds (personal observation January 2005).

One interviewee summed up the general sentiment about the challenges in mitigating environmental impacts since legalization, "I have seen improvements, but not what is hoped… (4)." The government first worked on legalization and the presentation of EIAs in 2000 and some feel there has been good progress in the past 5 years as 70% of EIAs have been submitted. Plants and mines that didn't previously have EIAs now have them (9). Despite the completion of EIAs, the management of tailings is one of the greatest challenges that is complicated by the history of mining in the regions. "Normally, with much lament, in the principal districts of the country, in Zaruma, Portovelo, and Ponce Enriquez/Bella Rica, the tailings/sands have historically been dumped in the river… This problem isn't new, but the same SADCO, an American company, that opened the mine, they also dumped mine wastes in the river. So, in this sector these problems are 50 years old and in the other sector they are 25 years old (3)." However, the same interviewee states that, "now small mining is more technified… The problem was much graver 10-20 years ago. So in this aspect has lessened enough. But I

want to emphasize that for the environmental part, still resist a clean production of gold (3)."

These difficulties were echoed by another interviewee, "the problem is the area of El Pache was placed by the river, because at that time they were allowed to build by the river and throw their wastes right there, but they didn't know the big problem they were getting into by polluting the river; there are no fish left. [Today] the formal miners don't handle wastes properly. They have small pools, but in the end the sands (waste) and wastewater end up in the brooks and rivers. You can't see results yet…mining problems won't be solved overnight, they are long-term (10)."

According to one state employee, since PRODEMINCA's base studies in 1998, they've evaluated all aspects and determined the most urgent impacts to be: "waters used for processing in the beneficiation plants and solid metallurgic residues. That's where we want to focus in the short term (20)." Another government official also discusses these same challenges, "…but processing waters are very contaminated with heavy metals, cyanide, etc. So it's how the Cn is used and how the Hg is used which determines the level of environmental impact and how the contaminated water and tailings are disposed of. This is the current fight. [It] needs to be reinforced in the culture, the government, technical people with titles, and the owners of the plants (9)."

One miner discussed his struggle to obtain better environmental management at his processing plant in Portovelo. This miner had constructed a tailings pond but "the river washed it away (25)." He expressed frustration because he did not want to be responsible for this contamination today, even though 10-12 years ago it was okay to put the tailings in the river because it was declared an industrial zone. Once authorities

discovered the level of contamination as far downstream as Peru this practice of tailings disposal was prohibited. The government decided the miners needed to have ponds; however, now the miners need help to construct them. This miner felt that the only acceptable ponds are those of Bira and Coronel, which are both larger operations (25). Another in Portovelo echoed this miner's frustrations, "miners publicly commit themselves to all environmental regulation [by signing legal documents], and it is specifically expressed they will not dump tailings in the river. But there is nowhere else to put them (18)!"

Despite the numerous challenges some progress has believed to have been made. One miner stated that where, "before raw mill waste was dumped; now it is taken to the mineral treatment plant (12)." Another example given was, "one issue that has had some successes is water management, but there is a long way to go. Because we should achieve a closed water loop that wastes little water, but that's far [off] (13)."

The mining concession run by the Bella Rica cooperative serves as an example for some of the improvements discussed. Every society (organized group of miners working in the concession) now has primary pools for sedimentation of mill wastes. The coop conducts environmental audits to mandate compliance with management plans and provides recommendations for changes. One important management challenge is the necessity for a good impermeable tailings pond. There haven't been any spills of the entire pools but there have been some small leakages. To combat this, the coop has been working to build new pools by eliminating all of the pools that had walls made of sand sacks. Now the ponds are excavated and impermeable, in some cases lined with a geomembrane, though this is more expensive. They have also worked to build high

capacity decantation dams, one completed under a partnership during PRODEMINCA, while the other is currently under construction. The improvements they have made in management have allowed fish to return to a local river, the Guanache, where six years prior no life had been found. They are working on implementing the same environmental works in hopes to remediate the Siete River (2).

Some of the potential solutions to these problems were discussed by various interviewees. In Portovelo, a miner spoke of the improvements they hoped to make which included by 2005/6 they wanted Nelson Concentrators which will help lower the use of Cn, and are working to create an industrial park to recover wastes and recycle water (24). Others are researching the possibility of using flotation which will decrease the Pb, Cu, and Zn in the tailings, because currently miners are only recovering Au and Ag with cyanidation. Flotation would be better for the company and the environment (Tablon 3).

Many of the same environmental problems diagnosed by PRODEMINCA are still the biggest challenges to cleaner production today. Because it was once legal to dump tailings into the river, they remain contaminated today despite any improvements in environmental management. Some of the impacts cannot be blamed on miners of today; however, in order to mitigate the short and long term impacts from gold mining activities changes need to be made quickly. There were some better alternatives to current processing methods and improved technologies and plans for environmental management proposed by all stakeholder groups, but great hurdles for their implementation remain. One member of the private sector and former government employee feels strongly that much effort has been made by technicians, miners, and other forces over the years to improve production methods and decrease impacts; however, they haven't had a big

impact because they have only begun to scratch the surface of dealing with the severe damage done. Miners and community members are aware of the contamination in the rivers, yet the reaction to remediation has taken quite long. Why is it that "for the time and effort put in the results are very poor (3)?"

Barriers to cleaner production

Traditionally, the first barrier to cleaner production is illegality and informality. The acceptance that legalization is essential for the investment in cleaner mining operations was reiterated by one miner. "It would be too risky to do large investments being illegal because they [the government] could have vacated the premises and removed the illegal miners. So to risk our capital we had to be legal first. As illegals there would not have been large investments. We could have gotten into trouble (2)." This barrier has almost completely been overcome as the majority of miners have legal mining titles or agreements with concession holders to mine within them.

During the field study and interviews it became apparent that there are essentially two remaining types of barriers that the gold mining sector must overcome to become cleaner: the first are the barriers faced by the miners directly such as lack of access to credit, educational, technical, etc. (Hinton et al. 2003), while the second set in Ecuador are caused by the historical organizational/ structural nature of gold mining, such as the continued presence of processing plants along rivers in Portovelo and subsequent lack of space for tailings ponds and inadequate planning for the future. Discussion about barriers

to cleaner production inherently relates to the control and regulation of the sector and the barriers that the government faces in adequately enforcing legislation.

The following barriers were identified by study participants as the major obstacles to the cleaner production of small-scale gold mining (Figure 6): miners' lack of educational (E), technical (T), and financial (F) resources; a lack of understanding or environmental awareness (U); the historical structure and lack of planning (P); miner organization (MO); government capacity (GC); government organization (GO); and corruption (C). (In Figure 6 it is important to note the number of respondents in each category: n miners = 12, n government = 7, n third party = 12.) It was also found that these barriers are not mutually exclusive; there is often overlap among the barriers and one barrier may exacerbate the difficulty in overcoming another. The three barriers which were mentioned most often were the lack of access to financial resources, lack of access to technology, and limits of government capacity to implement control and provide support to the small-scale gold mining sector. Similar results were found in Bella Rica in the study undertaken by CEDA. The report repeatedly mentions financial barriers and the lack of government capacity for control and enforcement (Cárdenas 2005). The first barriers to cleaner production which will be discussed are those faced by the miners. Following this there will be discussion of the government's capacity to effectively monitor and control artisanal and small-scale gold mining activities.

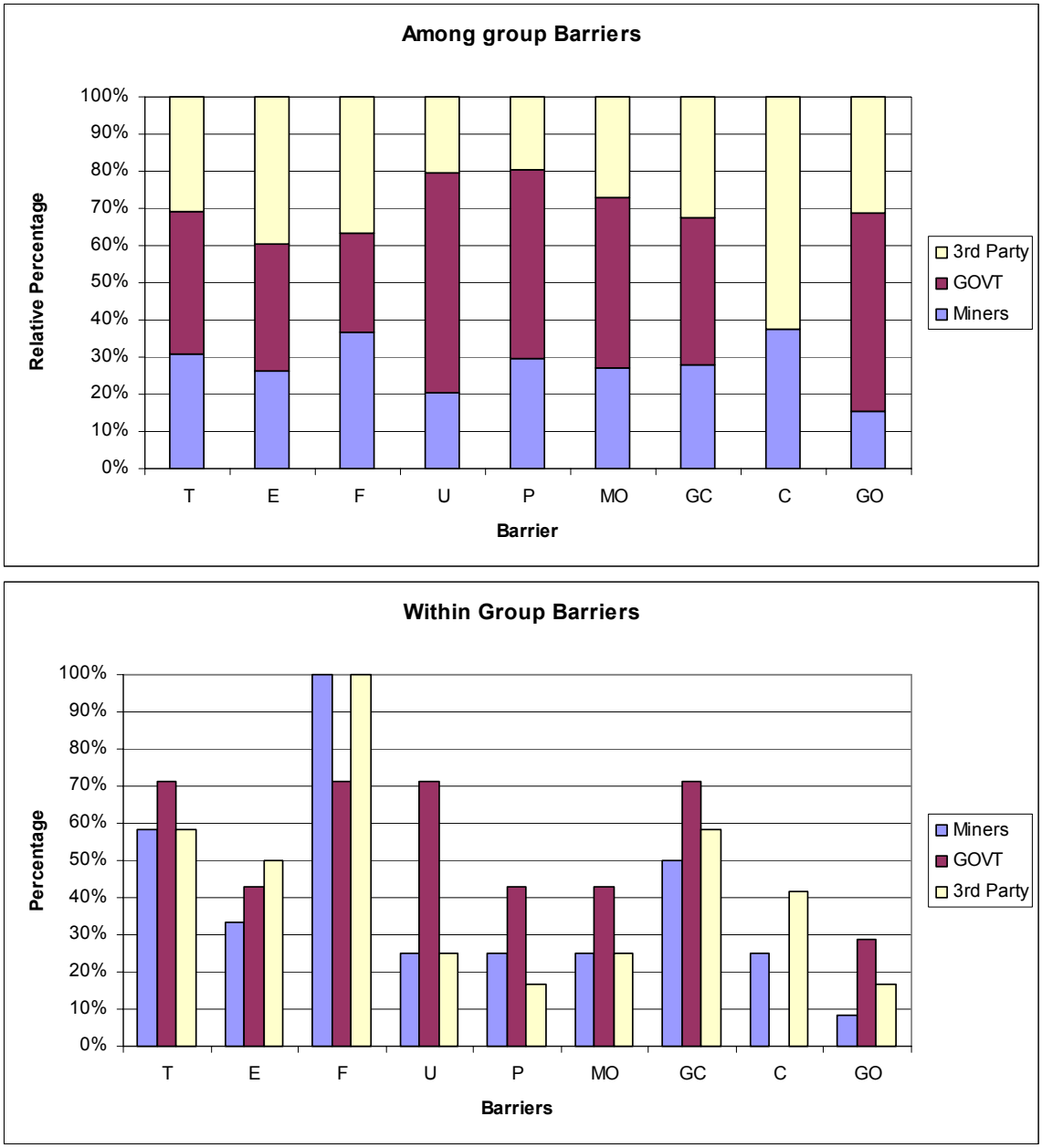


Figure 6: Barriers to cleaner production: a. Among group barriers, b. Within group barriers. (Only stakeholders who were coded for the barrier category were included in these figures)

I. Miners

Financing:

Although government and 3rd party projects such as PRODEMINCA and CENDA were successful in educating miners about the dangers of mercury use, environmental contamination from mining operations, and diagnosed many of the environmental and social problems with ASM, they have not had the sustained results that many miners and others had hoped for. With an improved awareness, the miners remain unable to implement cleaner production methods due to the lack of financial resources to invest in these often more expensive technologies.

According to the majority of those interviewed, the financial barrier or access to credit remains the greatest obstacle to improving mining operations. Often mainstream financial institutions are unwilling to provide miners with credit due to the high risk of these operations as an investment. This reluctance relates to the lack of sufficient exploration of mining concessions, an inherent aspect of financial and technological barriers. Thus there is a vicious cycle at work here.

Access to credit facilities is a major issue that must be addressed as small-scale miners most often do not have the acceptable forms of collateral that traditional banks demand. Additionally, because miners are often working in scattered, rural areas they do not have direct access to banking facilities (Amankwah 2004). The formation of cooperatives, companies and small enterprises has been suggested as a means to better access the resources through micro-lending programs. Microfinance programs serve persons who are in subsistence lifestyles or are low income and unable to accumulate the amount of capital necessary to acquire loans (Cooper 2004).

The lack of access to a system of financing has been extensively discussed, and it has been highlighted as a major barrier to cleaner production in Ecuador. During his work as a consultant to the PRODEMINCA project, Alcides Sanchez found that in Ecuador there doesn't exist any direct financing system for mining in general and financing opportunities are worse for small and artisanal mining (1997). Despite this acknowledgement it appears that little has been done to improve access to credit for small miners as the financial barrier was cited by 100% of miners and third party interests and 70% of government officials interviewed as a major challenge to cleaner production (Figure 6b).

Improvements depend on the investment capacity of the society, and more specifically on the capital available for technical improvements because machinery is expensive. There is initiative in Bella Rica to change the processing methods to remove Hg, but it depends on the cost as the operations are small-scale or artisanal and capital is critical. The government has not provided capital in the mining industry because mining doesn't contribute much to the gross domestic product (GDP); "in Ecuador everything is oil (2)." A member of the mining private sector and former government employee echoes this opinion, "here there definitely isn't a culture for financing mining. There aren't financing fountains for the miners in general and worse for the small miners… You have to have the resources, the financial resources to improve the sector (3)." These sentiments are reiterated over and over by many miners: "the primary obstacle is an economic obstacle and lack of technical knowledge (4);" "they [private banks] don't give credit sometimes because the [mining] project is too risky...and there are no plans, no research (5);" "the lack of financial resources limits us (6);" "the cost of a good

(exploration) study is $5-7000, and for a small society this is a lot. [There are] economic limitations, equipment is very expensive…and there isn't a line of credit specifically for them. [Ecuador] lacks a mining bank (8);" "it's all an economic problem! (29);" "[miners] lack capital; the small miner can't do it and the state hasn't done anything. With private inversion and with the number of small miners could have a cleaner and more sustainable mining sector (24);" "all of the environmental works have costs…and if [miners] don't have the money [they] can't do it (27)."

Every third party stakeholder interviewed mentioned the lack of available financing as one of the major barriers to cleaner and more sustainable production. They often discussed the connection between the financial and technical barriers to more efficiently and cleanly produce gold (1). The lack of sufficient exploration of mineral reserves due to these technical and financial barriers makes it more difficult to receive financing and then conduct sound environmental management practices. One consultant explains this situation clearly,

> Even though they have approved credit or micro credit many times, when it's time for the bank to give the money, there is no trust or experience to start giving value to the mining industry. I mean, if you are a small retailer (comerciante) or small farmer I think you can get loans easier than if you're a miner. Because they don't see that there is value, profit in extracting minerals. The banks don't trust the mining properties can guarantee payback. And this makes improvements difficult. The other problem is that since small miners don't do the exploration step before exploiting the deposit, it is hard to specify the exact investment sum if the miner doesn't know how much he/she will extract. So that influences the quality of the plants and in turn their environmental performance (13).

Another foundation worker states, "classic problems: no capital, technology, technicians, which leads to confrontation with local communities and pollution of rivers and water, [and] problems with soils… the private financial sector has no lines of credit for small-

scale mining (14).” With improved environmental awareness he believes the miners are caught in a classic catch 22 situation, “they [miners] are at least worried about impact, but in a catch 22, how to deal with that? They know they are polluting water but what can they do? Where is the money to build tailings dams? Everything is on paper (14)!” An environmental consultant to the mining sector discusses the difficulty in obtaining financing to improve technology, “it is also a money problem. It is a little hard with no financing. But people [now] understand that if they have lower operational costs, they'll have more revenue. That extra revenue can be assigned to comply with environmental regulations. That has been a big battle of FUNGEOMINE and the mining chamber, to try to get financing for small miners. But during these times it's been difficult, because it [financing] has to come from the miners themselves… (18).”

The lack of an economic policy and economic incentives to comply with laws and weak enforcement capacity are the major problems according to one lawyer. “Economic environmental policy does not exist even though law says the state will do this; it has not been done yet. Right now is only “command and control” no other incentives. You need money to apply cleaner production, [and] 80% population is under poverty (16).” A non-miner in the community believes that the miners are conscious and aware of the impacts from their livelihood but don’t have the money to remediate. Miners often need to hire an expert to complete the required environmental management plans, a collaboration that is difficult to obtain on the subsistence wages garnered by small-scale miners (19).

Although the majority of government workers also agreed there was a financial barrier, they often discussed possible ways for miners to lower costs or obtain these resources on their own. One government employee recognized that “it’s very

difficult/costly to do EIAs and implement environmental works alone so the miners need to organize together and do them together to lower costs as the law allows (9)." She felt that a way to overcome the financial barrier was that "[we] need to raise awareness and understanding that they [the miners] should do this and it's their responsibility because it's their way of life (9)." Another government employee similarly addressed the financial barrier, "people [miners] want a cemetery [for mining wastes] and that's expensive. They have to find resources to build it. They don't have the capital to organize so don't have planning (10)."

When it is the poor members of society who must bear the cost of environmental improvements which will also benefit the larger community, the process for implementation is often slow unless these technologies generate improved economic returns as well. Even when these technologies may increase profits the initial implementation costs may be prohibitive, thus miners may still need help with the initial investment. Technologies which generate profits with improved mineral recovery will help to create a win-win situation where environmental improvements also provide economic benefits to the miners.

Technology:

The next major barrier that was mentioned by over 50% of each of the three stakeholder groups was technology. It is a problem that miners have been using the same process for the past 20 years, that there is no advancement in the processing of minerals (18). The argument was made that improvements in technology would lead to more efficient production, thus increasing revenues which could be put toward better

environmental management and implementation of necessary environmental works. Improvements in technology with regard to processing methods could allow for the recovery of other minerals such as copper, zinc, and lead, increasing profits and keeping the heavy metals out of the waste stream. Because Hg amalgamation is simple and fast it is still widely used for recovery. A Nelson Concentrator is an alternative method but it is very technical so the miners need to know how to use it (26).

The miners also need help with the designs for environmental works such as tailings dams, ponds, etc (9). One processing plant owner said that he has a good relationship with the community despite the lack of good environmental practices due to economics. He still needs more money and technology to solve the problem of the detoxification of the liquid effluent from his plant (27). The implementation of cleaner practices has been slow because of the lack of advanced technology in the sector. Many miners simply don't have the technology to implement the environmental procedures (21). One suggestion given by a government official to artisan and small-scale miners is to look for the advancement of technicians to direct them, although this is difficult to afford. The natural resource should be used 100%, in other words all minerals should be recovered not only Au and Ag, but due to the lack of technology some are wasted (20).

Many interviewees felt that improvements in technology were a necessity to ensure, not only the achievement of cleaner production, but also a future in small-scale mining. Without more efficient technology that is able to recover minerals from greater depths and generate profits from decreasing gold concentrations, there will be no more small-scale mining sector. One miner and local mayor believes that "mining has to be more "technical" (tecnificada), use mills with more capacity. Because now with the

Chilean mill very little gets milled, while ball mills (molinos de bola) can mill 100-200 tons/day… It's the only way we can take mining forward (7)." Miners must become more technical is they are to subsist, and if not they risk disappearing because they will not be competitive (18). The miners need this technology but it is costly and again they lack these financial resources (102).

In addition to miners' lack of technical and financial resources, the next barrier which was discussed the most often was the lack of government capacity not only to adequately monitor and control the sector but to support the miners and provide them with the opportunities and incentives to comply with environmental obligations. This topic will be discussed separately.

Education and Awareness/Understanding:

While most miners and third party stakeholders felt that there have been great strides made in improving miners' education and awareness about the negative impacts from their work and have helped them to realize the importance of sound environmental practices, some government employees and others feel that there is still a long way to go before a true environmental consciousness has been achieved in the sector. One Bella Rica Coop technical assistant discusses the work that he has been doing to instill an environmental culture in the miners, but it is a slow process that has taken 5-6 years of training, seminars, and workshops to achieve. They wanted miners to realize that the environment works should be implemented not out of fear their operations will be closed down, but because these works are not a wasteful expense without benefits (2). This improved awareness has helped achieve a reduction in Hg use and recovery of Hg by

retorts; however, for further evolution of the sector the miners need more educational programs (106). One government official noted that even when miners are environmentally aware, they may not have the knowledge to operate in a technically sound manner (20).

Another government employee feels that it is not only miners who lack the environmental consciousness, but also the professionals, consultants, and members of government as well. It is especially difficult because there isn't the environmental culture necessary in Ecuador. There is a lack of comprehension of miners, professionals and consultants who don't understand the necessity of good environmental management, and "[miners] have the excuse that they are very poor, don't have the resources, so [they] can't achieve the environmental regulations (9)." One lawyer believes that it must be an education theme because otherwise it can't be explained why miners put the environment and their own health in danger (1).

One consultant believes that the miners, beyond their lack of training, don't have an environmental conscience. Without government control and lacking a strong environmental conscience, miners won't abide by the laws (18). Another mining consultant believes that even with improvement in education miners need to see tangible results before they are willing to change their methods, "I think small miners only believe in successful experiences, in tangible things. So if they read a book on cyanide amalgam, it's not enough. They need someone to do a live proof of cyaniding in their land with their gold (13)."

Miner Organization and Mistrust:

One barrier that is steadily being overcome, through the legalization process, is miner organization. Legislation was written to allow miners to organize in groups and undertake EIAs together, which helped immensely in reducing costs. It also helped them with the construction of tailings ponds, because collectively they can obtain the fiscal investment necessary (112). Despite incentives to organize and work collectively, there still remain numerous miners who prefer to exploit in small groups and many small processing plants unable to implement necessary environmental works. The possible explanations for this become more apparent in the discussion of the government and third party perspectives.

An obstacle which contributes to the lack of miner organization is the mistrust among miners. Some believe it is the hope of "striking it rich" that keeps miners working in small groups, while others highlight the belief of one mining group that the vein they are working holds a higher gold concentration than another group of miners (13). An additional reason given is the lack of trust in plant operators who don't all use the same methods and have the same gold recovery percentage. If plant owners were clearer about their operations so that miners were able to trust them, some small mills could be eliminated. In addition, if it were possible to convince people to have just one central plant that processes 200-300 tons/day, pollution could be greatly reduced (5). One consultant feels that the proposals to do collective plants or commercialize collectively has been one of the biggest failures of formalization efforts. In Portovelo, if successful, collective mining could have an enormous impact on reducing the amount of pollution

output. It is a problem of trust and of the lack of recognizing that there is a way of organizing (13).

One mine owner discusses the improvements that would occur if small companies would join together and exploit the deposits; however, he believes that it is a cultural problem which will prohibit this from occurring. "[People in Ecuador] don't have the same idea about business; here [there] is one owner (27)." An artisanal miner in P/Z agreed with this assertion, "[it] would be good to unite and work together but people don't want to (102)." A potential solution is to collectively manage waste collection rather than extraction and processing. Trust is not a necessary prerequisite form communal storing centers for mining wastes because the wastes have little value, thus could be accomplished by working toward joint environmental management plans with well-defined individual responsibilities within the plan (13).

It has also been discussed that there has been a correlation between the level of planning or organization before mining and the success of the operation. One consultant discusses the advantage of the Bella Rica Coop over some of the mining in Portovelo-Zaruma and other Amazon regions, due to the introduction of the cooperative concept by a Catholic priest in the area before mining operations began. Thus the organization of the Coop and the Azuay province in general has helped them generate a longer term vision. He contrasts that with Zaruma where miners and officials have had more of a short term vision focused more on the individual (13), yet a poor individual miner can't make the necessary big investments (21). Again it was proposed that if the miners organized in coops they would have better access to cheap external credits, but when mining

concessions are under different concessionaires and there is no internal organization it is more difficult to access credit (15).

History and Planning:

The final barrier to cleaner production that miners face is due to the legacy of past pollution in the mining sector and a lack of government planning mechanisms to apply lessons from these mistakes. One former government employee discussed how the poor standard for environmental management in Zaruma was set by the SADCO Company for whom it was a custom to dump tailings directly into the river (3). A plant owner in Portovelo discussed how only 10-12 years ago it was okay to dispose of tailings in the river. Now that the extensiveness of the contamination has been realized, miners must construct ponds in an area with no prior planning (25). A government employee also discussed this difficult situation, "the problem is that the mining area of El Pache was placed by the river, because at that time they were allowed to build by the river and throw their wastes right there, but they didn't know the big problem they were getting into by polluting the river (10)." In addition the lack of technical people with mining knowledge when artisanal mining began in the Bella Rica region contributed to the lack of adequate planning. One regional government employee strongly stated, "…Bella Rica is chaos because it is a cancer that was growing before they [current miners] got there. They want to do something now, but there is not much to do because it is damaged already. But they started a process of environmental organizing 'ordenamiento ambiental' (20)."

There are often no strategies for mining: someone simply finds gold and mines the area, without proper exploration. One consultant clearly states the challenges due to lack of planning,

> I think the problem is that even though they have brought the environment into their rhetoric, they haven't brought it into practice… At least they have expressed concern for the environment, and that's important. The problem is that they start from concessions with very little planning. So doing environmental improvements in an ill-planned operation ends up being harder and more expensive. People have noticed environmental improvements in processes that also bring financial improvements (13).

The lack of planning allowed small plants to be cited one next to another along rivers in Portovelo, limiting the space available for the construction of permanent environmental works. An obvious dilemma that emerges is what should be done with the plants which are in violation of environmental regulations. Are these regulations enforced?

II. Government monitoring and control

Another issue in artisan and small-scale mining is the weakness of the Ecuadorian government to enforce the law. When discussing this perceived failure of the government to monitor and control ASM in Ecuador, it is first important to recognize how government works in general and the challenges to the fulfillment of their goals and responsibilities. According to Appleby (1945, 123) the government is a system which cannot be understood "except in terms of the public employees themselves, their conceptions of their positions, and the attitudes of the public about what is required in and from our civil servants. These elements together are what make government a system, for in combination they comprise what we call a bureaucracy." The government

must be able to organize personnel, material or informational resources so that objectives become accomplished. Appleby (1945, 124) believes that the government "exists precisely for the reason that there is a need to have special persons in society charged with the function of promoting and protecting the public interest." Ecuadorian citizens in general and those involved in mining in particular should hold the government accountable for accomplishing the objectives of their position. The government is different from private institutions because it is subject to more public scrutiny and public outcry and because it is politics (Appleby 1945).

Although, government exists to promote and protect the public interest, Sharkansky (1992) found that there are several varieties of politics that may reduce the quality of public policies such as populism, partisanship, patronage, ideology, professional and technical predispositions, bureaucratic politics, and self-interest. Decisions are reached according to persuasion and preferences and answers are not are derived objectively as is often the assumption. There is always something else going on such as budget reviews or new meetings that may alter the implementation of existing policies and change decisions which were already made (Sharkansky 1992). The National Performance Review (NPR) (1993) of the US Government provides some ideas for solutions to the problems associated with top-down centralized bureaucracies. Many federal organizations are monopolies with few incentives to improve or innovate, and the politics of government only aggravates this problem because the greatest risk to the government is not a record of poor performance but the risk of scandal (NPR 1993).

Much of the decision making processes come with so much red tape that even the smallest actions take longer and cost more than they should. With the emphasis placed

on process, resources are taken away from the government's real job which is to serve the people. The steps taken by government organizations in the U.S. which improved performance provide potential solutions that the Ecuadorian government could use to improve their monitoring and control. These organizations achieved success by both measuring their performance and encouraging competition. Through the cutting of the red tape employees were not only accountable for rule following but for achieving real results (NPR 1993). They empowered their employees to get results sometimes through the decentralization of authority, allowing those who worked on the front lines to make more of their own decisions and solve more of their own problems. The goal of the NPR (1993) is not only to have a more efficient but also a more effective government.

Most stakeholders feel that the government through the Ministry of Energy and Mines (MEM) has been unsuccessful at monitoring mines and sanctioning those which have not complied with their environmental management plans. It was conceded by some that the government has begun to improve in the past few years due to more regional control and presence; however, control is far from sufficient. Some of the many reasons given are: lack of capacity to monitor including lack of personnel, centralized mining personnel, disorganization and redundancies within the MEM and Environmental Ministry, corruption, and MEM resources allocated toward the more important petroleum sector. This lack of control allows many miners to continue their operations without implementing and following through with their EIAs, environmental audits, and management plans. If they face no repercussions, there isn't a reason to spend more money on these improvements which do not generate economic benefits. Thus the miners are not forced to seek out ways or help to overcome the barriers they face directly.

One lawyer stated bluntly, "[there is] no enforcement and monitoring. Nothing has gotten better on the government side to control, monitor, and apply sanctions. [There] are paper laws only. [The] MEM is the weakest of all the ministries. [They] have made efforts but not enough (16)." Even when the government does shut down operations, they often continue working because there isn't the presence necessary to enforce the sanctions (26). One consultant discussed the impact the lack of control has on miners, "those with a mining concession realize the state is not monitoring them, so there's no incentive to find solutions. There are no periodical visits to the mining centers, they are sporadic and based on complaints. So without strengthening the state and its institutions, no progress will be made (15)." When discussing government capacity, miners often focused not only on the lack of control but also on the lack of support for mining. They feel that the government has not fulfilled their roles and obligations that are defined in the legislation (7, 8). There needs to be a better relationship between the mining chambers, small miners, and government; however, this is challenging when the Sub-Secretary of mining changes 3 times in 1.5 years (17).

It is not only miners and third party stakeholders who discussed the lack of control, central and regional government personnel also acknowledge that enforcement has not been that successful. They express frustration at their lack of capacity to fulfill this responsibility and extensively discuss the resources they need to achieve capacity.

One former government employee said the government, both central and regional, doesn't have the means to realize control at the appropriate level: they lack the resources and personnel. "They [state government] don't increase the salary of government workers but ask each to do the work of 20 people. No one can do this. The result of this was:

mediocrity...A person has to analyze 100 cases daily; it's impossible. As we are now, we can't control nor help (3)." Another regional government employee agrees, especially focusing on the lack of personnel. "In the technical aspect, there are no major difficulties. It is mostly in the administrative aspect, where we need more human resources to make decisions if a plant needs to be closed... In this region it is impossible to monitor each one because we have 400 concessions, and we do hydrocarbons (fossil fuels). That totals 800. For one person to be chauffer, technical inspector, secretary -because we issue the documents, and social liaison, it is too much. So we choose critical points to do some advances. So control is not effective (20)."

Not only are more people needed to make control effective but, a collaborative effort among those personnel is required as well. Even government employees need to be educated so that they are able to complete their function well. One ministry employee feels that "the problem is when there are 2, 3, 4 different messages which generates chaos. So as a state, we need a process of awareness and capacity building at this level. And [we] need to reinforce institutionally because we are very few [people] (9)." In addition to the focus on capacity building, the employee highlights the need for technical resources such as GPS, digital cameras, recorders, water quality testing equipment, etc. Without these resources they do the best job they can with "the little or nothing that they have (9)." A third party stakeholder agrees with this assessment, "the unit (MEM) is weak in terms of budget and technically [there are] not enough people and instruments and restrictions to go to areas [mining regions] (14)."

In addition to the lack of resources required to effectively control mining operations, there was also discussion about the contribution that government organization

makes to this failure. Again a regional government employee believes that the employees of other regional units, despite their careers in various environmental fields, do not know enough about the mining process. Regionally he does what he can but is dependent on the mining and hydrocarbon division for coordination; thus they need to be allied to move ahead (20). A regional DINAMI employee also discussed frustration with the lack of enforcement due to government organization. He feels that many times when recommendations are given to sanction or close a plant the paperwork ends up stalled in Quito in the MEM since they are responsible for direction and control and the miners continue working and contaminating. However, the EIAs submitted by miners are approved by the Sub-secretary of Environmental Protection (SPA), thus if SPA had the authority to close mines this could lead to better enforcement (11). A consultant also discussed the confusion present in the government because of different organizations conducting the same work. There has been some "change with the Sub-secretary of Environmental Protection but this person is a dependent of the MEM, but acts like the Ministry of the Environment (26)." He also reconfirms that there simply aren't enough people to help monitor and control.

Another potential barrier to better enforcement was given by a government official in charge of regional environmental control, "the mining industry is not as important an activity for the state as petroleum. The state policy is of giving preference to the fossil fuel (petroleum) industry because they generate more revenue. So the higher ups in the government should promote mining development while paying attention to the social and environmental aspects (20)." Another former government official agrees with the lack of emphasis placed on mining within the ministry, "mining is like 'el patito feo'

(the ugly duckling) because oil is what people care about in Ecuador (3)." It is acknowledged by one technician that government control has improved a little more in the past few years; however, "since mining doesn't contribute much to the GDP they [government] don't pay much attention (2)."

One miner and local mayor remains frustrated that the municipalities do not have the authority to control the mining operations, because the municipalities are the ones that are living with these realities and impacts from mining. The central government is in charge of enforcement yet they "only control when it favors them; otherwise there is no control (12)." He believes that decentralization of authority could help but only under transparent conditions; if the towns and municipalities are corrupt there would be no change in control.

Corruption:

One miner feels that the laws and control are manipulated because it is possible to pay [officials] to continue operating the same way (29). Another miner was more explicit in making this accusation, "there is corruption – DINAMI (National Mining Direction) calls and says they will arrive tomorrow and then the miners have everything all ready (102)." One former government employee said, "in addition are political compromises in more remote regions where the enforcer is the [equivalent of a] first cousin or brother-in-law (3)."

Others don't place blame on any particular sector of government, but believe that in the entire country there is a climate of corruption. Because of this corruption those in the public sector don't complete their responsibilities (23). Another citizen takes this

further placing blame on all citizens for their lack of interest in politics. This "political immaturity" allows for bad leadership to take office and often these leaders do not have the interests of the small miners in mind but are focused on larger companies (22).

In Ecuador, efficient and effective governance has been difficult not only due to corruption but also due to the lack of stability of the central government. In 2004 a National Mining Plan was developed which the President had approved; however, with the removal of President Gutierrez from office in April 2005 it remains to be seen how the plan is implemented. Gutierrez was the third Ecuadorian president to be forced from power in eight years (BBC News 2006). This government instability at the national level may make it more difficult to achieve sound monitoring and control at the centralized level. This lends discussion to the role of local control or community driven mining activities.

In her study of community-based forest management in Honduras, Nygren (2004, 639) discussed that "in theory decentralization can increase democratization of natural resource management by allowing local populations to make decisions on the control of and use of local resources." There are both pros and cons to decentralization of authority. Decentralized management of natural resources may give local people a greater sense of ownership over the rules for resource use and allow them to be more engaged in their implementation, monitoring and enforcement. In addition, decentralized management is considered to make it easier for marginalized groups to influence environmental policies. However, Nygren (2004, 639) finds that "local governments may be more subject to bribery and political pressure from local resource users, or they may be captured by political elites who promote hierarchical relations instead of democratic participation and

political accountability." This concern was raised in Ecuador, that local authorities may negotiate trade-offs with higher-level authorities after being elected to their positions. Nygren (2004) states that there need to be explicit rules and enforcement mechanism in place both vertically and horizontally which allow local authorities to confront those in violation with rules, while also ensuring these local authorities can receive the support of higher-level authorities if necessary.

Decentralization alone does not eliminate corruption. In Honduras it was found that top-down supervision of local forestry authorities may have actually increased the possibilities of corruption by creating additional groups of officials who could be bribed. Nygren (2004) therefore proposes that the establishment of a local resource user committee with representatives selected by local residents could provide complimentary oversight that increases accountability. NGOs and other civic society members could work to increase local people's awareness and confidence in strategies for building political transparency and social commitment through education. Finally, Nygren (2004, 651) proposes that "lobbying, political pressure and social resistance can also be effective mechanisms in making municipal authorities more responsive to local populations." It is important to note that decentralization does not allow the central government to be alleviated of its responsibilities toward mining policy. The involvement of all levels of government is necessary to achieve sound environmental management of mining operations.

Summary

Together these barriers faced by miners and government and the challenges of enforcing regulation present great difficulties in achieving cleaner production of small-scale gold mining in the short term. It is often complicated to recognize these barriers as tangible issues due to their inherent correlation. There are a number of barriers which remain and they are not necessarily mutually exclusive upon examination.

When discussing the barriers to cleaner production, interviewees often began speaking about one barrier in particular but ended up discussing a number of them together:

> First, the lack of green conscience in miners [is one barrier]. And also the lack of modernization; they keep at those old processes. Without modern technology in mining, we continue to waste minerals, because here we only exploit gold and silver. What about copper, lead, zinc…? It all goes to the river. If we look at it, to have cleaner production we have to spend money and that money must come from the mine. No one is going to invest money from elsewhere into the environment. And the only way is to be more efficient and to be more efficient, we need to be modern and [have] more technology, all in conjunction with a conscience for the environment (18).

Reaching the goal of a clean mining sector is more complex than simply solving the problem for one barrier, for example education, and assuming this will take care of the rest. While it is a good and necessary first step, more must be done. It will take a comprehensive effort to achieve cleaner and more sustainable production of gold mining. Therefore it is extremely important to determine the roles and responsibilities of each stakeholder.

Achieving cleaner production

Whose Responsibility?

The lack of control and lack of access raise a very important and critical question about whose responsibility is it to clean up the ASM sector and ensure a more sustainable livelihood. Is it the miners themselves who should be providing all investment and following environmental and mining legislation and regulations or shutting down operations? Or is it the government's responsibility to provide miners with access to financial resources and incentives to legalize and improve their operations?

If it is the government's responsibility to be enforcer of laws and regulations should it also be their role to promote mining activities by helping with access to resources? One consultant believes that the fact that the authority (the MEM) that has to promote the sector also has to regulate it is inherently a conflict of interest which also affects the oil sector (14). Should there be some separation of these roles within the government? Who should control? Who should help with resources? When the roles of each stakeholder group are well-defined, the overlap of their cumulative responsibilities fulfilled will theoretically lead to cleaner production (Figure 7).

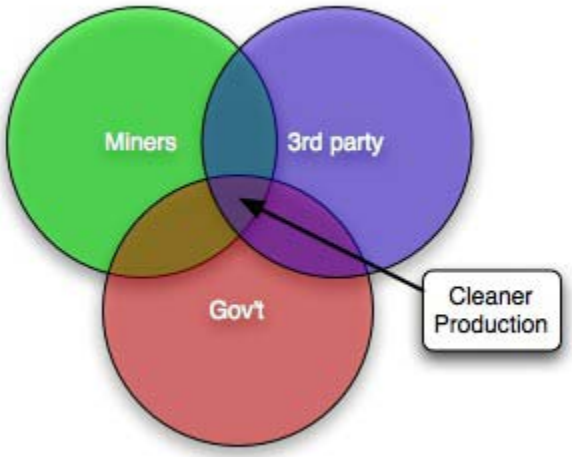


Figure 7: Stakeholder cooperation needed to achieve cleaner production

According to miners and many 3rd party interviewed, the miners have received almost no benefits in becoming part of the formal sector other than the mining title, nor have they received much in the form of education, technical help, or improved access to credit. This is despite a mining law which requires miner training (7). Miners feel there have been no incentives from the government (8), and that after legalization the mining industry has been left unattended (12). The government simply collects the taxes from mining but gives nothing back to the sector; miners have only their own resources (7). A leader of the small miners believes, "there is no real commitment from the mining authorities. These people don't understand the social problems of small mining. So the state has only given titles, but have not provided technical advise, training, or credit, like small miners [have received from the government] in Peru, Chile, and Bolivia…They [government] haven't understood that although it [small mining] doesn't generate revenue, it's created 10,000 new jobs in the South of Ecuador. Indirectly it involves

250,000 people. Organizing has been successful, but without support from the government. The mining ministry has never organized...; it's all been our initiative (5)."

It has been debated whether the government and NGOs have been successful with education; however, most miners today are aware of the impacts from mining and at the very least espouse the importance of improving environmental management. But they are left on their own to find the resources to bring about these changes. The improvements that have been made thus far have been due to the work of miners, not government. It has been under their own leadership and with their own meager resources that they have become better organized and are developing plans to improve environmental management (2, 5, 6, 8, 12 102, 105, 107,).

Statistics provided by all stakeholders estimate that no less than 80% and up to 95% of miners have achieved legal status. Even those working in an artisan manner have agreements with concession holders and must adhere to the laws and regulations. Now that the miners have achieved legal status they believe the government should work to create a bank for mining (8). Miners do acknowledge that they must do their part internally, but believe that there should also be external help from both government and non-governmental organizations (12). One consultant, however, believes that neither the government nor miners accept full responsibility for introducing cleaner procedures. The miners think the MEM is responsible, while the government thinks it is the miners' responsibility, thus it has in many cases been merely a few groups from society (civil society organizations) that have introduced these procedures (21).

Perhaps the only intervention by the state in small-scale mining was the Mining Sector Development Project, Proyecto Desarollo Minero y Su Control Ambiental

(PRODEMINCA). This project, initiated in 1994 and completed in 2000, was executed by the Ecuadorian Government with the support of the World Bank, and Swedish and UK governments. The main goal of the project was "to stimulate the development of a modern and environmentally sustainable mining sector (Tarras-Walhberg et al 2004)." All stakeholders believe that the project was successful in conducting socio-economic and environmental investigations which detailed the many problems with the small-scale gold mining sector. These were very important as such comprehensive environmental studies had not been done before. One project worker believed that PRODEMINCA was also successful in establishing a relationship between the government and the miners and promoting the use of cyanide (13).

Many stakeholders while recognizing PRODEMINCA's effectiveness at diagnosing problems felt that despite the monetary budget spent, little lasting solutions had been found. They criticized the project for only providing recommendations, such as implementation of the Tailings Management Plan (TMP) for Portovelo-Zaruma, that were not within the reach of the resources available to the miners (20). Thus the project spent enormous sums of money without achieving results. A number of stakeholders felt that the project wasted their resources on the high salaries of employees and international experts, and that once the project was over the money vanished and no monitoring or follow-up has occurred (15). One consultant agreed that overall projects have been short-term, lasting only 3-4 years, yet the mining industry requires longer-term investments (13). Some stakeholders were especially critical stating, "they did a bunch of studies but didn't do anything, a mountain of reports and ideas – all on paper but no results (27);" and " the results of the PRODEMINCA project were absolutely poor (3)." One miner felt,

"PRODEMINCA did almost nothing compared to the money they had…but they did help with retorts and miner organization. Before 1996 there wasn't any organization (102)." However, in terms of solving the problem of environmental contamination the project did very little as plants in Zaruma, Portovelo, Bella Rica, and San Gerardo continue depositing contaminants directly into the river (9). Projects shouldn't just diagnose and think in terms of environmental regulations, because the solution to environmental problems isn't the construction of only one environmental work and it isn't an environmental impact study (9).

One regional government employee felt that it seems the government policy "has changed its course, and there is no strategic project to help them [miners] directly. We have changed control methods, assuming they are capable of solving their problems. So the government went from playing the role of promoting the economic development of mining, to being the controller of mining activities," but that in the last 5 years there has not been a state policy to direct this (20). It is believed that the authorities need a more effective presence in the mining regions (101). Authorities have been talking about decentralization of many sectors, specifically by putting the municipalities in charge. However, as previously discussed, this process has been weak in reality as local authorities have no control (14). Decentralization is a potential solution to the lack of control, while deconcentration of control is another option (Nygren 2004). Through deconcentration of power, the environmental ministry could open local offices with the authority to sanction mining operations, allowing control to remain centralized (8).

One consultant believes that "one last thing I'd have changed is a having a group of technicians specialized in small mining, because the environmental consultants was a

disaster, because there is no creative application of the technology… they simply do an environmental study for the heck of it. They don't make it to be used in the industry. They only do it to fulfill requirements, when the study should be a work tool (13)." Another environmental foundation leader is in agreement with this critique of the private sector that is in charge of environmental management and EIAs, "they have a perverse mechanism of copy and paste (14)." There are individual firms specializing in EIAs which copy them from one sector, one region, and one concession to the other, sometimes even forgetting to change the names. He feels the EIAs have become a way to fulfill legal procedure, the equivalent of a "rubber stamp;" in addition, the national environmental authority doesn't follow up about the fulfillment of the management plans (14).

Achieving the goal of cleaner production will also take each miner accepting responsibility for their livelihood and not only practicing sound management themselves but encouraging their fellow miners to do the same. This is especially important in Portovelo where the many small plants are along the river, because without everyone making these efforts real changes won't occur. Mining leaders in the Portovelo region are currently working on a solution to the tailings management problem, by promoting the creation of an industrial mining park. All miners in the El Pache area (Figure 2*)* would relocate to the park which would have enough space for many small plants to operate with a communal, centralized tailings impoundment. Water and energy supply would be available communally. In addition, the central government proposed the idea of creating a tax free zone to attract inversion to the area. The local municipality is lending machinery, while the national geology unit helped determine the best location for

the project. Plans have been presented to the municipality and the MEM and the land owner has approved a 50 hectare site. They are hoping that within 5 years the majority of processing plants would be in this new location; however, they need financing for the transportation costs of moving the plants (18). Successful completion of this project could greatly reduce environmental impacts from tailings in the Portovelo region, a result that is to this day a failure of formalization efforts in the sector.

It was found that in Bella Rica, the effects of formalization have been both important and significant, as numerous improvements have been made to address both environmental and social concerns. The principal improvements identified by Cardenas et al (2005) involve the change and modernization of production technologies, which has lowered production costs and allowed for investment in environmental protection. The same modernizing technology generally has helped to decrease environmental impacts. In Bella Rica, the largest change has been the shift from using mercury in processing to the use of cyanide. Formalization of the sector also contributed to greater security in investments and brought intervention from NGOs and development projects. In the social arena, significant work has been done to eliminate child labor through a joint project with the International Labor Organization (ILO) and Ecuadorian non-profit Desarollo y Autogestion (DYA). While great strides have been made in Bella Rica, there remain many challenges to reach the goal of clean production. The barriers faced by miners in Bella Rica are the same as those faced by the miners in the Portovelo and Zaruma region.

In order to achieve cleaner production of all gold mining operations the roles and responsibilities of each major player need to be defined. Many interviewees provided suggestions for improvements that each stakeholder can make to more effectively

contribute to this goal. In addition, Cardenas et al (2005) provide a series of recommendations for stakeholders from their study of the Bella Rica Mining Cooperative. Together these suggestions are presented in Table 6.

Table 6. Roles and responsibilities of stakeholder groups in the small-scale gold mining sector

Stakeholder	*Suggestions: Roles and Responsibilities*
Government	- effective monitoring and control - a rule/method which recognizes s-s mining and contemplates how to obtain incentives for miners to formalize, financing, association, and builds capacity - develop a bank for miners
Miners	- closure and conservation plans - study of reserves - decrease costs/improve recovery - look for alliances with ngos, projects, funds, external capital and better technology - improve organization to manage wastes
NGOs	- work together with miners to develop solutions - contribute suggestions and pressure for political and structural changes - external actors should not judge other's experiences without obtaining a profound understanding - projects should have long-term vision and presence – not just diagnose problems and leave
Consultants	- prepare and conduct sound EIAs and environmental audits

(Adapted from suggestions by Cardenas et al 2005)

Discussion

Future of gold mining in Ecuador

The future of gold mining in Ecuador is uncertain. As gold deposits become increasingly more difficult and expensive to mine, artisanal and small-scale miners in Ecuador face another challenge: how to find investment to make the mining operations more efficient and profitable and to purchase the machinery and technology to exploit deeper deposits. Many believe that the sector must move in the direction of larger, more mechanized operations in order to reach deeper and less concentrated deposits. Without access to credit, the miners must decide whether to join together, look for foreign investment, or to sell their concessions. Will these larger operations be an improvement with regard to environmental impacts, worse, or will there be a different set of impacts?

The case of Bira exemplifies that small-scale gold mining in Ecuador can be conducted in both an environmentally sound and an economically profitable manner. However, though Bira may be considered small-scale in an international context, it is both larger and more modern than other Ecuadorian operations. In a few cases in Z-P international investment has increased the processing capabilities of mining operations, yet these operations overall do not compare to Bira with regard to the mitigation of environmental and social impacts. Bira has done much to reforest mined land and grows 80,000 trees from seed in their greenhouses every year (114). Although Bira provides better working conditions for their employees, many of which come from the region though were not necessarily artisanal miners previously, they do not employ as many people because of more efficient extraction and processing techniques. In addition, the

engineering and technical staffs are often from outside the region, and many of the profits from mining operations are invested in the larger cities in Ecuador. Some artisanal miners believe that companies like Bira will take away their source of livelihood.

The relationship between small miners and the larger companies has been improving according to one miner (102). Previously, the larger companies felt that since the small miners didn't have the necessary technology to exploit deeper deposits the government should allow the companies to do so. One conflict was due to the belief that one company was trying to bribe the government to get the small miners land, thus the miners united, rented buses to go to the capital city of Quito, and were successful in their fight to the right to their concessions (102). Since 2001, the mining titles provide mineral rights from the surface to the center of the earth and the small miners have paid for these titles. Despite this one mine leader in Portovelo believes that if miners continue as they are they will not have a future in mining, thus the new generation of miners have begun looking for capital from foreign investors, specifically Germany and the US. He feels that as long as the companies and investors respect the rights of the artisanal miners who are there, and work cooperatively, there will be a future for everyone (24).

In Zaruma, mining used to be the number one economic activity in the region, but it has slipped to third because many miners lack the technology to extract metals, which only larger operations are able to afford (10). Some in the industry believe there will be a transition from small to medium scale operations with regard to production output. The vision of the National Chamber of Small Miners (CAPEMINE) involves the consolidation of current projects and to have at least 25 projects on proven mining reserves, in other words "to make micro-projects mid size (5)." By uniting all miners with less than 5

hectares and creating a company with more capacity there would be a reduction in investment costs and improvement in achieving less contamination. Cooperation among countries in Latin America and the creation of a Chamber of Small Miners of Latin America and the Caribbean is one of CAPEMINE'S goals in hope to improve access to foreign financing institutions to obtain credit to develop these projects. In 10 years, the hope is to have about 15 projects generating jobs, respecting all environmental laws and well integrated with the community (5).

However, as these operations become larger and more efficient, the number of jobs generated decreases leaving uncertainty for the livelihood of the artisanal and small-scale miner. The official unemployment rate for 2005 was 11.2%; however, more importantly the underemployment rate is estimated at 47% and approximately 65% of the population was living below the poverty line in 2003 (CIA World Fact Book 2006). While not a financial concern at the national level, gold production is an important source of income on the local level (Figure 8, Appendix C).

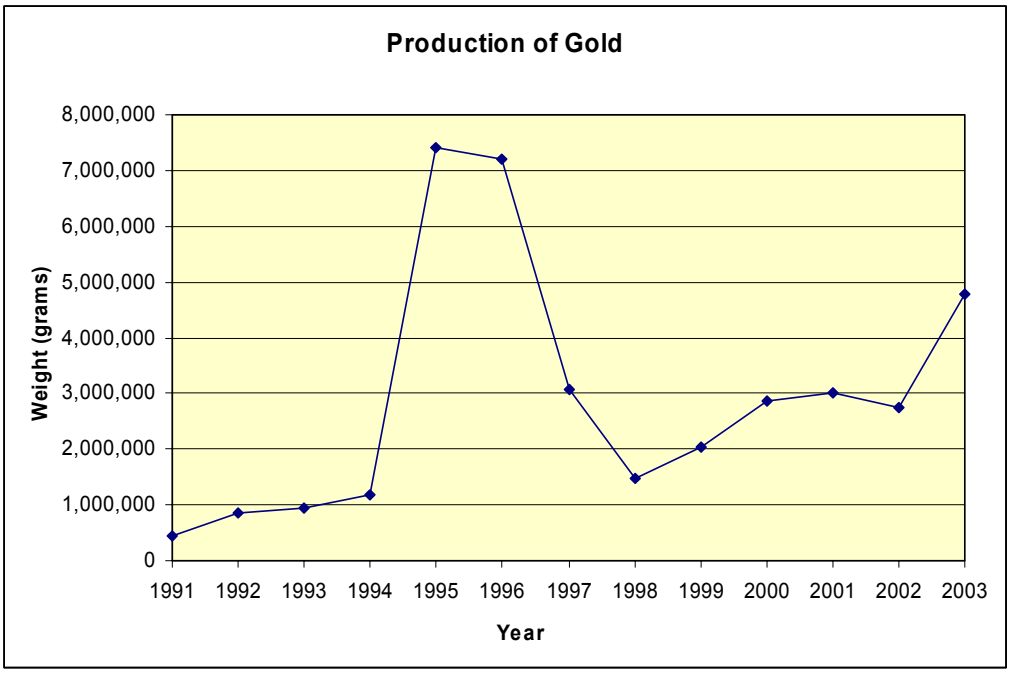


Figure 8: National production of gold reported for the years 1991-2003
(Source: National Direction of Mining, Ministry of Energy and Mines 2005)

Alternatives to Mining

There is validity in the conclusion reached by Tarras-Wahlberg et al (2004, 713) that "small-scale and artisanal mining may provide a source of livelihood but there is usually little beauty associated with it. Therefore, it should not be promoted as a business under normal circumstances but only in situations of socio-economic alert, when no other reasonable alternatives are to be found." Globally, artisan and small-scale miners were often subsistence farmers who moved into mining as a survival strategy. Quiroga (2002) found that in Bolivia this is often due to failed development policies such as unfulfilled land reform and settlement schemes, natural disasters, and crop failures. Ecuadorian miners also moved into mining due to failing agriculture and El Niño events, which leads to the question: are there reasonable alternatives in these regions which exist?

In the Portovelo-Zaruma region, the towns rely heavily on mining for employment and there are already a great number of men (and women) who have gone overseas to Spain and the United States in search of a job to feed their families. Overall the 2005 estimate for the net migration rate in Ecuador was -6.07 migrant(s)/1,000 population (CIA World Fact Book 2006). Overseas migration, causing the separation of family units, is not a good solution for these communities. Many believe that they can use the regions extremely long history with mining and natural beauty to promote tourism. One of the oldest mine tunnels has been improved and turned into a historical and educational tourism attraction by the owners of Bira (114). In addition, some of the infrastructure from the SADCO mine was left in place and could provide the basis for a mining history museum (24). These are some of the ideas being discussed in these communities. Mining tourism could be a source of employment for some; however, it is unclear whether the communities can rely only on this.

Bella Rica and the Ponce Enriquez region also face an uncertain future without mining. Many mine workers are also employed seasonally in agriculture. But it was some of these same agricultural workers who started the mining in Bella Rica when they could not support themselves in agriculture. The Chamber of Small Miners has proposed the consolidation of agro-mining tourism projects in the region, which would bring tourism and agriculture to the mining towns. "There are two alternatives: 1. SanGerardo-El Carmen de Pijili, and 2. Bella Maria-Valle Hermoso in Santa Rosa, a project to have agriculture, cattle ranching, clean mining, and eco-tourism all together (5)." Currently, the Bella Rica Cooperative remains focused on mining activities and generating more

investment in the sector, while also encouraging other employment opportunities through mining such as jewelry making (7).

The promotion and development of alternative livelihoods today will help lessen the shock to the economy when mineral reserves in the regions are exhausted. Andrews-Speed et al (2005) found that in south-west China, coal mining areas with greater wealth and more diversified economies were better able to absorb the shock of mine closure than poorer areas and those with less diversified economies. Alternative economic opportunities that were promoted were commercial agriculture and animal husbandry. These alternatives were encouraged with the provision of low interest loans, grants, and the construction of the necessary infrastructure for their development such as roads and water supplies. Currently mine closure in the small-scale mining sector has received little attention as the priority has been to regularize or formalize mining itself rather than to plan for mine closure. In Ecuador miners are required to submit plans for closure and rehabilitation, yet the provision for the monetary resources necessary to complete these plans is not legislated. However, it is undoubtedly important to begin planning for a future without mining in order to prevent future unemployment and migration.

Conclusion

It is obvious that the challenges associated with the artisanal and small-scale mining sector are complex. Because the sector began illegally and informally, it was allowed to develop without the necessary environmental and social considerations to prevent negative impacts. This is the problem with largely poverty driven livelihoods in developing countries that do not have the capacity to control operations. Legalization has helped give miners the ability to more securely invest in their operations; however, the needed changes are not seen in the short-term. A government official today speaks to the challenges in lesser developed countries and the complexity of the situation,

> Well, the deal is that it'd be good to improve technology more, and to share technological advances between neighbor countries... This is very important to improve in all stages: exploration, production, transport, and eliminating the main polluter: chemicals. Those chemicals can be replaced. I believe the use of Hg is restricted in the whole world, but it is still sold here. I don't know if cyanide has been found to be dangerous, but it is sold freely here. All these situations should be regulated, and responsibilities should be assigned so that mining is within the technical and environmental laws, and reaching to the socio-economic realm. Because if you speak to NGOs and ecologists, they say 'the miners are predators, and the authorities sitting at their desks are their accomplice for not stopping them.' But it is not that easy because we need to change policy to effect change and implement recommendations (20).

The major findings of this study are that formalization of ASM is likely to improve mining operations; however, given the existing conditions in the mining regions and in the government it has not achieved the desired results. In the 15 years since legalization of the ASM sector in Ecuador, some improvements have been made with regard to environmental and social impacts from gold mining. Yet in the 4-5 years since the completion of PRODEMINCA, little progress has been made with regard to tailings management in the Portovelo-Zaruma region, though use of retorts has improved,

according to those interviewed. In Bella Rica, improvements have been made with the use of retorts, yet numerous challenges to sound management of mining activities also remain. Many of the barriers recognized in previous studies in the literature largely remain in place. The three barriers that were mentioned most often were the lack of access to financial resources, lack of access to technology and limits of government capacity to implement control and provide support to the sector, confirming the results of the study of the Bella Rica Cooperative by Cárdenas (2005).

Access to the financial resources necessary for sound mining operations has been the greatest failure of formalization in Ecuador. Overwhelmingly, lack of financing was discussed by all stakeholders in the sector. Because of this failure, mining leaders have been forced to look to foreign investment to sustain mining operations and to better comply with regulations. They maintain a positive outlook that this cooperation will be successful; nonetheless, foreign investment should be cautiously regarded due to prior negative experiences with larger mining companies.

The lack of government capacity in Ecuador to effectively regulate ASM reconfirms the findings of previous studies of ASM. Quiroga (2002) found that government authorities in Bolivia were also unable to manage the conditions of ASM because they lack adequate resources to enforce existing regulations. This is often cited as a vicious cycle in lesser developed countries, because this lack of enforcement and control allows for environmentally destructive mining practices to persist.

To address the environmental impacts of artisanal and small-scale gold mining in order for the sector to better contribute to development in these regions, all stakeholders must become involved and fulfill their respective roles:

- **Government:** Legislation alone is not going to solve the environmental problems associated with small-scale gold mining. The government needs to continue to improve their presence in the mining regions and develop incentives such as tax holidays and other benefits for the introduction of safer technologies in order for small-scale mining to evolve into more sustainable operations. It is imperative that access to credit for legal miners improves, and it is recommended that some type of credit facility specifically for miners should be established. The state can also help facilitate the obtainment of outside funding sources to help encourage cleaner production. Transfer of technologies among small miners in developing countries should be promoted by the government as well. This could be encouraged through tax incentives and sharing opportunities between countries. This level of government involvement is repeatedly highlighted by ASM studies worldwide as a prerequisite for successful formalization. According to Shen and Gunson (2006) in China the central government also needs to make more effort to regulate, guide and encourage the development of ASM and to create a sound environment for its operations.
- **Miners:** The next generation of miners must work collectively to implement the proposed solutions to tailings management. They must continue to the process to become better organized. The mistrust among miners and hope of "striking it rich" need to be eliminated because without cooperation many of the smallest miners will be unable to support themselves in the near future. They must also work together with the local community and government to achieve a long term sustainable vision for their regions, including alternatives to mining itself. Since formalization these relationships have improved, but must continue to be built upon for the benefit of all.
- **Third Party (NGOs):** NGOs should remain active in the region as they have been relatively successful overall with their education campaigns to reduce Hg use and eliminate child labor. The involvement of miners and community members is essential in determining the immediate needs of these regions.

One these needs are determined NGOs can help these regions obtain outside funding sources and put pressure on the government to subsidize clean mining operations and adequately enforce those in non-compliance with regulations.

- **Others:** Foreign investment should be viewed cautiously by all parties and only encouraged with collaboration among current small miners, communities, and local government. In Ecuador one of the current contentions with larger scale companies is that they have been given very large concessions that they never exploit. Because of the size of their portfolio they are able to spend millions of dollars and years in the exploration phase without ever exploiting the reserves. Many small mining leaders are frustrated with the government who favors larger companies with greater investment, thus prohibiting the small miners from new opportunities when their current reserves have been exhausted with their extraction capabilities.

I believe that the artisanal and small-scale gold mining sector in Southern Ecuador is an important sector for development donors to remain engaged in. The sector is extremely important socio-economically on the local and regional scale. I strongly recommend that development donors work with the existing mining communities to determine their needs to become better mining operators with long-term goals. With the input from these communities better development projects which can be sustained by the miners once the donors leave can be achieved. One of the major criticisms of past development projects by the miners was the lack of continuity. They felt that the donors simply came to Ecuador, diagnosed problems, and then left. They are looking for projects and donors which have a long term vision and presence, and the desire to work with their communities. Another key criticism of development projects was that the despite the exorbitant sums of money spent there were very little results to show for it.

Rather than spending a ton of money on foreign technical experts' salaries and travel expenses for in-country project workers, spend the money to achieve real solutions.

One of the major obstacles that artisanal and small-scale gold miners face in Ecuador is lack of access to the credit they need to invest in improvements and upgrades in technology. The miners do not have the capital they need to receive loans from conventional banks, thus the establishment of micro-lending programs would be extremely beneficial to the miners. Such a program has the possibility of helping miners make great strides in improving their operations and reducing environmental, social, and health impacts.

Development donors should also help to develop other activities which tie into the mining sector which will add-value to mining such as jewelry making. There has already been some success with this in the Bella Rica Mining Cooperative where teenagers and women are learning how to make jewelry. They have a workshop in the local community, thus providing additional economic opportunities for those who chose not to or are unable to work in other aspects of the mining sector. In addition, viable alternative livelihoods should be developed in these areas because eventually all gold reserves will be exhausted and a transition to other sectors is inevitable.

Lastly, development donors shouldn't follow the rule that bigger is always better; they should work to finance sustainable small to medium-scale projects which are more labor intensive and may not alter the landscape as significantly. The current mining policy in Ecuador is now more attractive to investment from international mining companies (Tarras-Wahlberg et al 2004). Rather than supporting these large operations which do not provide as many employment opportunities and have numerous

environmental impacts of their own, smaller sustainable operations run by local miners should be given priority. Instead of focusing on profit driven projects donors should work to develop sustainable projects which contribute to local development not just growth in GDP.

Gold mining, no matter the scale, is a contentious issue all over the world, but especially in the developing world where multinational corporations profit inequitably from the natural resources of lesser developed producer nations. The *No Dirty Gold* campaign run by Oxfam America and Earthworks (2004), is working to educate consumers about the social and environmental toll inflicted by gold mining operations worldwide. Because over 80% of mined gold is used to make jewelry the consumer is an important target (Ali 2006). With improved consumer awareness and pressure, the industry is taking notice. One of the world's leading jewelry companies, Tiffany & Co, as well as the Jewelers of America, a national association of 10,000 jewelry retailers, have endorsed the objectives of the *No Dirty Gold* campaign (Oxfam and Earthworks 2006). With pressure coming from consumers and retailers as well as local communities affected by mining activities, mining companies will be forced to take action and hopefully socially and environmentally responsible extraction and processing of gold will become the norm rather than the exception.

Literature Cited

(SGAB), P. a. S. G. A. (2000). Plan Maestro Ambiental: Ambientales Emergentes y el Establecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango. Quito, Swedish Geological AB: 83.

Africa, E. C. f. (2002). Compendium on Best Practices in Small-Scale Mining in Africa. Addis Abba, Ethiopia, Economic Commission for Africa: 101.

Amankwah, R. K. a. C. A.-S. (2004). "Strategies for sustainable development of the small-scale gold and diamond mining industry of Ghana." Resources Policy: 1-8.

Appleton, J. D., Carrasco, M., Maldonado, R., and H Orbea (1996). Assessment of mercury contamination in the Ponce Enríquez artisanal gold mining area, Ecuador. Nottingham, British Geological Survey: 49.

Cárdenas, C. y. E., S. (2005). Con organización y responsibilidad construiremos nuestro futuro. Sistematización de la experiencia de explotación minera de Bella Rica y Guananche Tres de Mayo. Quito, Ecuador, CEDA, Centro Ecuatoriano de Derecho Ambiental.

Centro Ecuatoriano de Derecho Ambiental, C. (2003). Con Organización y Responsibilidad Construiremos nuestro Futuro. Quito, Ecuador, CEDA: 11.

Cooper, P. J. a. C. M. V. (2004). Implementing Sustainable Development: From Global Policy to Local Action. Lanham, Rowman & Littlefield Publishers, Inc.

Hinton, J. J., M. M. Veiga, et al. (2003). "Clean artisanal gold mining: a utopian approach?" Journal of Cleaner Production 11: 99-115.

Hruschka, F. (1993). Concepts for the design of the project: Environment-Protection in Ecuadorian Gold Mining: 2.

Institute, I. C. M. (2006). International Cyanide Management Code for the Gold Mining Industry. 2006.

Limbong, D., J. Kumampung, et al. (2003). "Emissions and Environmental Implications of Mercury from Artisanal Gold Mining in North Sulawesi, Indonesia." The Science of the Total Environment 302: 227-236.

Malm, O. (1998). "Gold Mining as a Source of Mercury Exposure in the Brazilian Amazon." Environmental Research, Section A 77: 73-78.

Maurice-Bourgin, L., I. Quiroga, et al. (1999). "Mercury Pollution in the Upper Beni River, Amazonian Basin: Bolivia." Ambio 28: 302-306.

Ministerio de Energia y Minas, E. M. P. d. D. M. y. C. A. P. (2000). Plan Maestro Ambiental: Medidas Ambientales Emergentes y el Establiecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango, PRODEMINCA, Swedish Geological AB (SGAB): 94.

News, B. (2006). Protests hit Ecuador oil exports. BBC News Online.

Patton, M. Q. (2002). Qualitative Research & Evaluation Methods. Thousand Oaks, London, New Dehli, Sage Publications.

Sánchez Delgado, A. (1997). La Pequeña Mineria del Oro en el Sur del Ecuador. Mineria Ecuatoriana: Organo de Difusionde la CODIGEM y Su Associacion de Professionales y Egresados: 72.

Tarras-Walhberg, N. H., A. Flachier, et al. (2000). "Environmental Impact of Small-scale and Artisanal Gold Mining in Southern Ecuador: Implications for the Setting of Environmental Standards and for the Management of Small-scale Mining Operations." Ambio 29(8): 484-491.

Tarras-Walhberg, N. H. B. L. A. B. a. R. H. (2004). How Beautiful is Small-Scale Mining? Evidence from Small-Scale and Artisanal Gold Mining in Ecuador. Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries. G. Hilson. Netherlands, Aa Balkema: 701-715.

UNIDO (2001). Artisanal Gold Mining Without Mercury Pollution.

Veiga, M. M. (1997). Introducing New Technologies for Abatement of Global Mercury Pollution in Latin America. Rio de Janeiro, UNIDO, UBC, CETEM.

Comprehensive Bibliography

(1996). Regularizing Informal Mining: A Summary of the Proceedings of the International Roundtable on Artisanal Mining. International Roundtable on Artisanal Mining, World Bank, Washington D.C., The World Bank, Industry and Energy Department.

(2002). Aid Case Study: Peru's Yanacocha Mine. BBC News.

(2002). First Session: Environmental, Health, and Safety Issues. Regularizing Informal Mining, World Bank.

(FOEI), F. o. t. E. I. (2003). Case Study Six: Dividing and Polluting: Yanacocha Gold Mine in Peru. Hands Off! Why International Financial Insitutions Must Stop Drilling, Piping and Mining. Amsterdam, FOEI.

(IFC), I. F. C. (2001). Minera Yanacocha (Peru) Project Brief. Washington DC, International Finance Corporation.

(ILO), I. L. O. (1999). Social and Labour Issues in Small-Scale Mines. Geneva, International Labour Organization (ILO).

(SGAB), P. a. S. G. A. (2000). Plan Maestro Ambiental: Ambientales Emergentes y el Establecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango. Quito, Swedish Geological AB**:** 83.

Africa, E. C. f. (2002). Compendium on Best Practices in Small-Scale Mining in Africa. Addis Abba, Ethiopia, Economic Commission for Africa**:** 101.

Ali, S. (2006). "Gold mining and the golden rule: A challenge for producers and consumers in developing countries." Journal of Cleaner Production **14**: 455-462.

Amankwah, R. K. a. C. A.-S. (2004). "Strategies for sustainable development of the small-scale gold and diamond mining industry of Ghana." Resources Policy: 1-8.

Appleton, J. D., Carrasco, M., Maldonado, R., and H Orbea (1996). Assessment of mercury contamination in the Ponce Enríquez artisanal gold mining area, Ecuador. Nottingham, British Geological Survey**:** 49.

Bermeo, A. (2001). Confianza y enfoque integral para mejorar la minería aurífera de pequeña escala: lecciones aprendidas en Prodeminca. Jornada Internacional sobre el impacto ambiental del mercurio utilizado en la minería aurífera artesanal, Lima, Perú**:** 17.

Bugnosen, E., J. Twigg, et al. (2000). "Small-scale mining legislation and regulatory frameworks." Industry and Environment: Mining and Sustainable Development II: Challenges and Perspectives **23**: 50-53.

Cárdenas, C. y. E., S. (2005). Con organización y responsibilidad construiremos nuestro futuro. Sistematización de la experiencia de explotación minera de Bella Rica y Guananche Tres de Mayo. Quito, Ecuador, CEDA, Centro Ecuatoriano de Derecho Ambiental.

Cooper, P. J. a. C. M. V. (2004). Implementing Sustainable Development: From Global Policy to Local Action. Lanham, Rowman & Littlefield Publishers, Inc.

Davis, G. A. a. J. E. T. (2002). Should Developing Countries Renounce Mining? A Perspective on the Debate, Colorado School of Mines**:** 61.

Earthworks, O. A. (2004). Dirty Metals: Mining, Communities and the Environment. Boston, No Dirty Gold Campaign**:** 34.

Earthworks, O. A. a. (2004). No Dirty Gold Campaign. **2004**.

Easterly, W. (2002). The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics. Cambridge, MA; London, England, The MIT Press.

Echavarria, C. (2004). Formalization of Artisan and Small Scale MIning: Harnessing opportunities for private sector development, Mining Policy Research Initiative.

Fauvet, P. (2004). Mozambique: growth with poverty. afrol News. Maputo**:** 9.

GEF, UNDP, et al. (2003). "Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies." GMP News(1).

Griffin, G. (2000). Newmont;s Peru gold mine a mixed blessing. Denver Post Business News. Denver.

Heemskerk, M. (2002). "Livelihood Decision Making and Environmental Degradation: Small-Scale Gold Mining in the Suriname Amazon." Society and Natural Resources **15**: 327-344.

Hennig, W. Strategic Considerations for Reduction of Mercury Emissions in Artisanal Gold Mining. Hannover, BGR.

Hilson, G. (2002). "Small-scale mining and its socio-economic impact in developing countries." Natural Resources Forum **26**: 3-13.

Hinton, J. J., M. M. Veiga, et al. (2003). "Clean artisanal gold mining: a utopian approach?" Journal of Cleaner Production **11**: 99-115.

Hruschka, F. (1993). Concepts for the design of the project: Environment-Protection in Ecuadorian Gold Mining**:** 2.

Hygelund, B. N., R. K. R. Ambers, et al. (2001). "Tracing the Source of Mercury Contamination in the Dorena Lake Watershed, Western Oregon." Environmental Geology **40**: 853-859.

Hylander, L. and M. Meili (2003). 500 years of mercury production: global annual inventory by region until 2000 and associated emissions. Communities and Small-Scale Mining (CASM) Annual General Meeting and Learning Event in Elmina, Ghana.

Institute, I. C. M. (2006). International Cyanide Management Code for the Gold Mining Industry. **2006**.

International Institute for Environment and Development, W. B. C. f. S. D. (2002). Breaking New Ground: Mining, Minerals, and Sustainable Development. Sterling, VA, Earthscan Publications Ltd.

Kirkemo, H., Newman, William L., and Roger P. Ashley (1997). Gold, USGS. **2004**.

Limbong, D., J. Kumampung, et al. (2003). "Emissions and Environmental Implications of Mercury from Artisanal Gold Mining in North Sulawesi, Indonesia." The Science of the Total Environment **302**: 227-236.

Malm, O. (1998). "Gold Mining as a Source of Mercury Exposure in the Brazilian Amazon." Environmental Research, Section A **77**: 73-78.

Maurice-Bourgin, L., I. Quiroga, et al. (1999). "Mercury Pollution in the Upper Beni River, Amazonian Basin: Bolivia." Ambio **28**: 302-306.

Miller, J. R. and P. J. Lechler (2003). "Importance of Temporal and Spatial Scale in the Analysis of Mercury Transport and Fate: An Example from the Carson River System, Nevada." Environmental Geology **43**: 315-325.

Ministerio de Energia y Minas, E. M. P. d. D. M. y. C. A. P. (2000). Plan Maestro Ambiental: Medidas Ambientales Emergentes y el Establiecimiento de un Plan Maestro Ambiental en el Distrito Minero Portovelo-Zaruma y La Cuenca del Rio Puyango, PRODEMINCA, Swedish Geological AB (SGAB)**:** 94.

News, B. (2006). Protests hit Ecuador oil exports. BBC News Online.

Noetstaller, R. (1997). Socio-economic potential of artisanal and small-scale gold mining. Vienna**:** 17.

Plowden, P. a. G. W. (1999). A Glittering Future? Gold mining's importance to sub-Saharan Africa and Heavily Indebted Poor Countries. London, World Gold Council**:** 74.

Quiroga, E. R. (2002). "The case of artisanal mining in Bolivia: Local participatory development and mining investment opportunities." Natural Resources Forum **26**: 127-139.

Ross, M. (2001). Extractive Sectors and the Poor. Boston, Oxfam America.

Salim, E. (2003). Striking A Better Balance: The Extractive Industries Review. Jakarta, The World Bank Group**:** 92.

Sánchez Delgado, A. (1997). La Pequeña Mineria del Oro en el Sur del Ecuador. Mineria Ecuatoriana: Organo de Difusionde la CODIGEM y Su Associacion de Professionales y Egresados**:** 72.

Sánchez Delgado, A. B. N., Antonio (2001). Elementos para una Descripcion del Proceso de Desarrollo de la Mineria de Pequena Escala en la Region Sur del Ecuador desde 1983 al 2000. Quito, Ministerio de Energia y Minas**:** 9.

Sandoval, F. (2001). Small-scale mining in Ecuador, Mining, Minerals and Sustainable Development**:** 28.

Tarras-Walhberg, N. H., A. Flachier, et al. (2000). "Environmental Impact of Small-scale and Artisanal Gold Mining in Southern Ecuador: Implications for the Setting of Environmental Standards and for the Management of Small-scale Mining Operations." Ambio **29**(8): 484-491.

Tarras-Walhberg, N. H. B. L. A. B. a. R. H. (2004). How Beautiful is Small-Scale Mining? Evidence from Small-Scale and Artisanal Gold Mining in Ecuador. Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries. G. Hilson. Netherlands, Aa Balkema**:** 701-715.

UNIDO (2001). Artisanal Gold Mining Without Mercury Pollution.

USAID Small-Scale Mining: Cleaner Production Fact Sheet and Resource Guide, USAID.

USGS Mercury in the Environment Fact Sheet. **2004**.

Veiga, M. M. (1997). Introducing New Technologies for Abatement of Global Mercury Pollution in Latin America. Rio de Janeiro, UNIDO, UBC, CETEM.

Veiga, M. M. (1997). Mercury in Artisanal Gold Mining in Latin America: Facts, Fantasies and Solutions**:** 23.

Veiga, M. M. (2001). "Mining with Communities." Natural Resources Forum **25**: 191-202.

Veiga, M. M. (2004). Mercury in small-scale gold mining.

Veiga, M. M. and L. Bernaudat (2003). The Global Mercury Project. CASM Annual General Meeting, Elmina, Ghana.

Veiga, M. M. and J. J. Hinton (2002). "Abandoned Artisanal Gold Mines in the Brazilian Amazon: A Legacy of Mercury Pollution." Natural Resources Forum **26**: 15-26.

Veiga, M. M., Meech, John A., and Raphael Hypolito (1995). "Educational measures to address mercury pollution from gold-mining activities in the Amazon." Ambio **24**(4): 216-220.

Wotruba, H. (2003). Technologies for Small Scale Mining. Examples of traditional and alternative mining and processing methods. Elmina, Ghana.

Appendix A: Interview Questions for Miners

1. How long have you been involved in gold mining activities in this region? How long have you worked in the mining industry in general?

2. Have you always worked in mining? If not, what type of work did you do previously?

3. What are some of the reasons why you work as a gold miner today?

4. What type of work do you do? Have you always done this same work or were you involved in a different capacity previously?

5. How many people do you work with? How are you organized?

6. Have you always used the same extraction or processing methods or have they changed? If they have changed, what are some of the reasons for this change?

7. Has the use of mercury in processing changed? Are you and other miners using retorting devices?

8. What kinds of incentives were there for you to change your mining practices?

9. What kinds of government support or programs are available for you as a miner in the formal sector?

10. What kinds of incentives were there for you to become part of the formal sector? What are some of the benefits you have received being part of the formal sector?

11. How have laws and regulations been enforced?

12. Where do you get the financial resources to mine?

13. Has your access to educational or technical resources improved with legalization?

14. How has your relationship with other miners changed since formalization efforts began?

15. From your perspective how does the community feel about mining activities?

16. Who have been the leaders of the efforts to improve the gold mining sector?

17. Are there any other alternative livelihoods available to you other than mining?

18. Is there any other information you would like to share with me today?

Appendix B: Interview Questions for Government and Third Party

1. To begin please tell me about your work history in the gold mining sector.

2. In your opinion, what have been the greatest obstacles to overcome in order to achieve cleaner production of gold?

3. Are there certain projects or programs that have helped the sector achieve a cleaner production?

4. In which areas have these programs been most effective? Under what conditions?

5. What other means have you used to encourage/enforce cleaner production of gold?

6. Have you seen improvements in the sector with respect to the use of mercury in processing? Are the miners using retorting devices?

7. How are the miners organized?

8. Are miners conscious of the negative impacts from their activities? How has this process evolved?

9. Have mining legislation and regulations been effective with regard to the small-scale mining sector? What is your opinion about the application of the laws?

10. How have regulations been enforced?

11. Who have been the leaders of the efforts to improve the sector?

12. What type of support, education, or incentives have miners received after incorporation into the formal sector?

13. How would you define successful formalization of the gold mining sector?

14. What would it take to achieve this success? What are the conditions necessary to achieve success?

15. What are the greatest challenges to the artisanal and small-scale gold mining sector which remain today?

16. What is your long term vision for a sustainable artisanal and small-scale gold mining sector?

17. What suggestions can you give to others working to formalize and improve the artisanal and small-scale mining sector in other communities or other countries?

18. Are there any other viable alternative livelihoods for the miners? Are they being sought out?

19. Do you have any statistics pertaining to the artisanal and small-scale gold mining that you could provide me with?

20. Is there any other information you would like to share with me today?

Appendix C: Reported Gold Production for 2003 by Province

PROVINCE CODE	AREA	WEIGHT GRS.	REVENUE U.S. $	INVESTMENT U.S. $
AZUAY:				
15	BELLA RICA	217,505.00	1,631,287.50	52,000.00
6	PINGLIO 1	182,214.40	1,366,608.00	
170	GUANACHE- 3 DE MAYO	31,655.00	237,412.50	6,000.00
	SUBTOTAL	431,374.40	3,235,308.00	58,000.00
EL ORO:				
152	NVA. ESPERANZA	1,000.00	7,000.00	
338	MULUNCAY	8,050.00	111,037.74	
297	BARBASCO UNF.	8,575.40	62,001.00	
2696.1	LA ESPERANZA II	393,591.94	213,013.00	
447	BARBASCO 1A	186.15	1,227.68	
139	LOS INGLESES	17,700.17	172,328.21	2,470.00
385	SAN JOSE 2	400.00	2,800.00	4,484.00
374	SAN JUAN	4,083.00	28,581.00	
158	PALACIOS*	2,339,667.56	2,112,241.34	431,217.00
2017	LIMONCITO	60,207.00	172,020.00	
311	TOSCON BL 1 Y BL2	862,037.80	615,241.44	490,059.00
506	EL SOROCHE UNIF.	4,780.00	33,460.00	
389	MINANCA	236,551.47	2,655,552.96	538,820.00
	SUBTOTAL	3,936,830.49	6,186,504.37	1,467,050.00
ZAMORA CHINCHIPE:				
80	GUAYSIMI ALTO	234,896.48	2,702,915.98	292,556.71
81.1	SULTANA UNIFICADA	127,939.32	1,455,321.48	484,000.00
246	CAMBANA Y COCAROSA	3,600.00	37,800.00	21,500.00
315	NAMBIJA COND. NORTE	14,400.00	165,600.00	98,800.00
316	NAMBIJA COND. SUR	36,000.00	414,000.00	70,200.00
		416,835.80	4,775,637.46	967,056.71
*BAR BULLIONS				
TOTAL		**4,785,040.69**	**14,197,449.83**	**2,492,106.71**

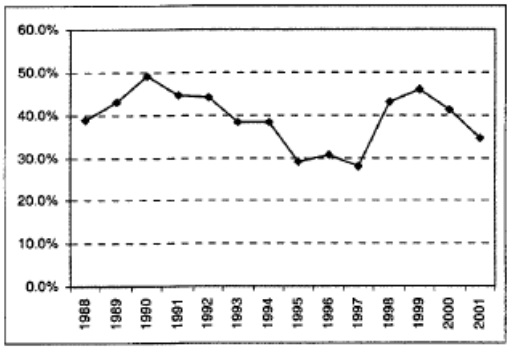
(Source: National Direction of Mining, Ministry of Energy and Mines, 2005)

Appendix D: Processing plants along the Calera River in Portovelo

Appendix E: Photos of Bira extraction and processing operations

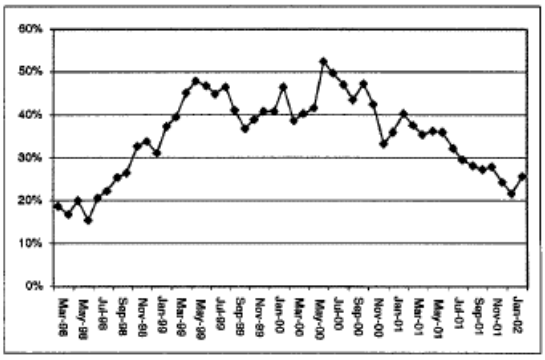
Appendix F: Ecuador Urban and Rural Poverty Statistics

Figure A.6.1. Urban Poverty Measured by Income (annual), 1988–2001



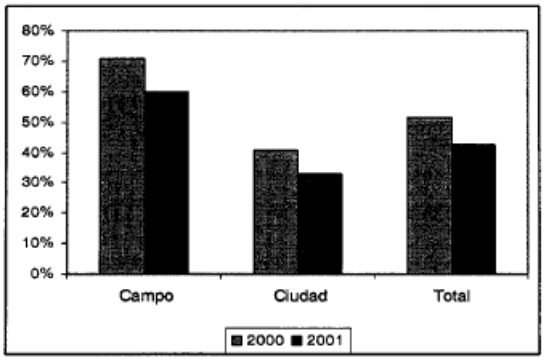
Source: Surveys on Employment, Unemployment and Underemployment.

Figure A.6.2. Urban Poverty Measured by Income in the Main Cities (monthly)



Source: Surveys by the Central Bank of Ecuador.

Figure A.6.3. Poverty Measured by Income in Urban and Rural Areas, 2000–01



Source: Urban Surveys on Employment, Unemployment and Underemployment.

(Source: International Bank for Reconstruction and Development, Program Document For a Proposed Fiscal Consolidation and Competitive Growth Adjustment Loan in the Amount of US $50 million to the Republic of Ecuador, 28 April 2003
Country Dept VI Latin America and the Caribbean Region
Report No: 25786-EC)