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As A Road to Sustainability in Small Scale Mining

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Abstract: *The world is going through a new-millennium rush in precious metals, especially gold. The great increase in gold price in the last years, probably due to a shift towards safe investments in a period of crisis in the global economy, created a rapid increase in gold production. The faster response to this shift in production came from Artisanal (ASM) and Small-scale (SSM) mining units in remote locations of the world, and Brazil is one of the main countries that has ASM and SSM on its territory. The present paper draws some definitions of Small-Scale Mining and Artisanal Mining, based on its productivity and its actual social and environmental implications, and of their sustainability. The analysis of production data of Small Scale and Large Scale Mining on global scale and on Brazilian scale shows the high potential of SSM in dealing with lower mineral grades and market fluctuations, due to its high flexibility. A general growth of the role of SSM in precious metals production in the next decades is foreseen. An elaboration on world ASM data led to a clear correlation between efficiency in production and an index of human development; this result is shown and discussed. Based on the potential of SSM to attend to the mineral market needs, efficiency in productivity is finally proposed as the main path to turn an ASM unit into a sustainable and profitable Small-Scale industrial extractive unit.*

Keywords: Small Scale Mining, Efficiency, Sustainability

Introduction

Approaching a discussion about a sustainable management of small scale mining unavoidably leads to deal with the abstractness of the concept of "sustainability" and the vagueness of the definition of "small scale" in mining. Hence, the necessity to begin with a few definitions. Small-scale and Artisanal mining Often one refers to "Artisanal and Small-scale Mining" (ASM) when talking about "mining by individuals, groups, families or cooperatives with minimal or no mechanization, often in the informal (illegal) sector of the market" (Hentschel et al., 2002). Nonetheless, a more precise definition is needed when dealing with the technical aspect of the problem. In 1987 the United Nations (UN) suggested the multi-attribute criteria for defining small-scale mining: mine producing less than 50,000 t/y or 200 t/d, with capital investment below U.S. $ 1 million and annual sales less than $ 1.5 million, manpower and up to 40 workers limited to 5 (five) years. In Brazil, mean values are applied by the National Mineral Research Department (DNPM): productivity between 10,000 t/y and 100,000 t/y is used a criteria to define a mining installation as a "small-scale" one. (CPRM, 2002) Other characterizing aspects of ASM, as noted by Hilson (2002), are: mining in alluvial deposits near the surface; intense labor activity; remote and isolated location; rudimentary techniques and low technological knowledge; low degree of mechanization and low levels of environmental, health and safety awareness. Limiting the definition to the Brazilian reality, Small-Scale Mining (SSM) can be defined as a mining activity producing between 10,000 t/y and 100,000 t/y ROM. Artisanal Small-scale Mining (ASM) can be considered as a subset of SSM, falling in the same productivity range, but possessing moreover the characteristics of rudimentary mechanization, inefficient reclamation, unhealthy and unsafe work conditions and exploitation of labor.

Sustainability is a very abstract matter. It is a concept with many definitions, according to many authors, and mainly depending on the reality being considered and the scale factor of this reality. The mainstream thinking of sustainability scholars visualizes the idea of three dimensions: environmental, social and economic sustainability. Depending on the visualization, these dimensions can be drawn, as shown in Figure 1, as "pillars"(a), concentric (b) or overlapping circles (c). Figure 1 –Visualization of the main concepts of Sustainability (modified after Adams, 2006) Anyway, in order to have a more precise definition of what sustainability is and by what criteria it is evaluated in our specific field, in this paper sustainability will be limited to the definition of "sustainable mining". According to Vale (2002) the sustainability of mining depends on the spatial scale on which it is considered: International, National and Local, where on an international scale sustainability must be considered on long-term, while at a local scale the short-term conversion of the stock of mineral resources in perpetual flow of net benefits is the critical key issue. The importance of the short-term conversion of mineral resources in net benefit is shared by Montero Peña (2002), who, in its study on the sustainability indicators for the extractive industry, highlights that "the exploitation of a reserve would be sustainable if it produces net gains related to fixed assets used in its exploitation". Almeida & Torrens (2002) define some criteria for a mining activity to be defined sustainable: 1. Improvement of mining; 2. Improving safety conditions in the mine; 3. Mitigation of environmental impact; 4. Using the right equipment for the conditions of each site; 5. Rational and comprehensive use of mineral resources and mineral community benefits; 6. Reduction of geo-environmental and geodynamics threats and hazards. Concluding from the above-mentioned definitions, and the discussion of paragraph 1.2, it is possible to come to a general definition: "Small-

Scale Mining can be defined sustainable when it comes out of the artisanal dimension and can only be defined by the limits of its productivity". Data World Data in Literature Hoadley & Limpitlaw (2004), in a study on the sustainability in the livelihoods related to smallscale mining installations, highlight that ASM provides a form of livelihood for the miners, but there is usually no net generation of wealth. "The benefits provided by this activity are outweighed by the costs", such as poor safety and health conditions in the workings, or environmental degradation in a wider area around the site and social disruption. Based on a Human Development Index (whose calculation is explained in UNPD, 1990) and on the ratio of people employed in ASM over the total population of the country, Hoadley & Limpitlaw found a general trend of inverse proportionality between ASM employ and wealth conditions.

The easiness of installation, the low technological level and cost of equipment and the short-term of payback of the initial investment, often helped by the lack of bureaucratic authorization, create a rapid supply solution for the variations of the market demands.

Elaboration on World Data Statistics on ASM are quite scarce in Literature, but some reliable data can be found in the MMD report (2002), and on the website of "Community and Small-Scale Mining" (CASM 2012). Results are generally shown in number of ASM workers per country, and quantity (in tons or kilograms) of gold extracted by ASM in the same country in one year. Simply dividing the yearly production of gold artisanally produced by the number of ASM workers, the production of gold achieved per capita of ASM worker can be found. This production per capita is an index of the technological level of ASM in that country: the higher the production per capita, the more efficient is the extraction. The result can be compared to the Human Development Index (HDI) of each country. The latest values of the HDI can be found in the most recent Human Development Report (UNPD 2011). The result of this comparison is shown in Figure 6, where a clear tendency is visible. The trend of the regression line shows that efficient mining and treatment (higher number of grams per capita) corresponds to a more sustainable livelihood (higher HDI). This result can be seen as a significant indicator of the validity of our thesis: higher efficiency in mining corresponds to higher sustainability.

These data, part of an official report of the Brazilian Institute of Mining, might possess a census bias, being a part of SSM informal and, hence, difficult to register. Nonetheless, not all SSM in Brazil is informal ASM, hence the proportion must not greatly differ from the one shown here. Looking at the production distribution amongst the companies, the National Department for Mineral Research of Brazil (DNPM) publishes every year a Mineral Commodity Summary, containing information about national production and supply of mineral commodities. These data contain a distinction between the production of official mining companies and the one of "Garimpos", local ASM extraction sites. It must be highlighted that, when referring to "Garimpos" production, it is made reference only to that part of ASM that paid Tax on Financial Operations (IOF) to the Brazilian Government. Gold is the typical product of "Garimpos" in Brazil. The rapid increase in ASM production between 2002 and 2004, resulting in the 2004 peak, corresponds to the negative trend of production of official mining companies between 2001 and 2003, resulting in the negative peak of 2003. Looking at total gold production in Brazil, it is clear that, after the low production of 2002, ASM production in Brazil responded in a more rapid and effective way than the large mining companies. ASM has supported the total production with a prompt production shift, till the moment in which mining companies recovered their delay.

Discussion Data discussed in the paragraph above show a clear tendency of growth in SSM, due to its flexibility to adapt to geologic features and market needs. Small-scale mining meets both the rapid customization with the necessities of the market and the technological and financial flexibility to adapt to the lower grades of the deposits to be exploited. These are all signals of a future development of small-scale mining in precious metals, especially gold, along the next decades. A progressive shift can be foreseen from Large-scale to Medium and Small-scale mining in the production of a considerable slice of the precious metals market. In this international frame of growth, the question of sustainability of SSM sector is nowadays fundamental and cannot be postponed. As confirmed by the statements of Vale, Montero Peña e Almeida & Torrens, the sustainability of Small-scale mining depends on the operational capability of transforming the reserves into a rapid benefit's flow. Being the scale of the operation reduced, and, as shown in the paragraphs above, the grade of the deposits exploited always lower and lower, the economical sustainability of a SSM installation depends highly on an efficient management of the mining assets (level of know-how of the personnel and installed equipment). Any effort in the sustainability of SSM, and in the passage from ASM to a sustainable form of SSM, must pass through the technical and economical sustainability of its operation. When a SSM operation comes out of the ASM condition, it is made sustainable and the sustainability of the surrounding livelihood and environment is strictly consequent, because an active and optimized use of mining assets needs a skilled workforce and the operation of excavation and treatment equipment with a minimum impact in the environment. Conclusions To draw some definitions: SSM, at least in Brazil, it can be defined as a mining activity producing between 10,000 t/y and 100,000 t/y ROM. ASM can be defined as a subset of SSM, falling in the same productivity range, but possessing moreover the characteristics of rudimentary mechanization, inefficient reclamation, unhealthy and unsafe work conditions and exploitation of labor. Consequently, a Sustainable SSM is the one that manages to come out of the artisanal dimension (ASM) and can only be defined by limits of its productivity. There are evident indicators of a growth

of SSM in the future. Small-scale mining meets both the rapid customization with the necessities of the market and the technological and financial flexibility to adapt to the lower grades of the deposits to be exploited. These are all signals of a future development of small-scale mining in precious metals, especially gold, in the next decades. The economical sustainability of a SSM installation depends highly on a capable optimization of the assets with which it is equipped. This conclusion, as proved in paragraph 2.2, is very important: it clears that the sustainability for SSM is strictly endogenous, and it depends on its own capability of operate in an efficient manner.

When, through operative efficiency, a SSM operation comes out of the ASM condition, it is made sustainable, then the sustainability of the surrounding livelihood and environment is strictly consequent.

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