Invited comment: accommodation of small-scale mining: a postscript on possible directions

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1. Introduction

Small-scale mining is an endemic feature of many poor countries that have geological deposits conducive to such activity. These are at or near the surface, easy to mine with simple tools, and are characterized by the relative simplicity of marketing arrangements. The gold doré and raw diamonds produced by small-scale miners are easily sold, and the same can be said for more nondescript commodities such as building materials, industrial minerals, and coal. Transport is a related issue: gold and diamonds are extremely compact and simple to transport over long distances. Industrial minerals, on the other hand, are wholly dependent on having nearby uses.

The papers in this special issue deal with both targets of small-scale mining, although a majority of the papers emphasize gold. Regardless of their chosen commodity, it is important to note that market forces drive small-scale miners. Understanding how these forces work is the key to any policy intervention.

All of the papers in this issue mention poverty as a significant driving force behind small-scale mining operations. There is also fairly broad consensus about the range of environmental impacts caused by this type of mining. The use and misuse of mercury heads the list, followed by hydrological modification (impact on rivers and streams due to physical disruption of banks and vegetation), general destruction of vegetation, and the issue of what happens to a region and its people once local deposits have been exhausted.

What concerns us in this commentary is the various solutions put forward as means with which to solve the environmental problems arising from the activities of artisanal small-scale miners. Although closely inter-related, solutions can be classified as either: (1) promotion of cleaner technology; or (2) efforts to engender cleaner behavior. The following sections deal with each in turn. They then offer some further reflections on the scope of reform required to bring about cleaner technologies and practices and thus make artisanal and small-scale mining less environmentally disrupting.

2. Cleaner production technologies

In their extensive review of technical issues in artisanal and small-scale gold mining, Hinton et al. [1] list many different items, including, on the technical side:

- Reserve determination (aimed at mine planning);
- Comminution (crushing to liberate gold);
- Gravity concentration (to reduce the need for mercury);
- Other forms of concentration (froth flotation, again to avoid mercury);
- Safe practices in using mercury or cyanide (if the other methods are not taken up for some reason).

While this list covers only the core technical issues (perhaps opportunities is a better word), many of the items on it recur in all of the other papers dealing with artisanal and small-scale gold mining. Indeed, the most depressing set of facts conveyed by the papers in this issue is the great difficulty in accomplishing any kind of departure from tried and trusted practices in the industry. These obstacles bode ill for the technically, more complicated solutions described by Hinton et al. [1], their technical attractions notwithstanding.

Two conclusions can be drawn from the technical side of the papers in this issue. One is that a number of fairly simple technical advances in mining practices are possible. Some are very well esteemed, in the sense that the original advances were made long ago, as a much earlier
3. Institutional constraints

The two papers on artisanal gold mining in Ghana indicate that some governments are working with the institutional side of the problem. However, despite extensive campaigns and effort by Ghana’s Minerals Commission, success has been only partial. Drawing on "extensive campaigns and effort by Ghana Minerals Commission", the following areas of institutional uncertainty can be identified (using the mining sequence from Fig. 1 in Babut et al. [2]):

- Exploration and exploitation of ore;
- Ore processing;
- Amalgamation/distillation with mercury;
- Marketing and sales; and
- Accounting and taxation.

3.1. Exploration and exploitation of ore

Because many operations aimed at gold and diamonds are currently illegal under the laws of their host country, everything about them is necessarily unregulated. These operations are, for the same reason, highly temporary, and any investment in (less mobile) physical equipment would defy the objective of recovering as much mineral as possible before detection.

The investment needed to improve both efficiency and, by extension, environmental performance can be financed either from cash flow or by obtaining credit. Regardless of who makes the investment decision, individuals want to know what the financial return will be. If the gold reserves run out next week, and the investment in a gravity gold-separation device will only be returned after two months, a miner will be reluctant to initiate such a project. Thus, the rationale for establishing reserves is clear. Unfortunately, the unofficial character of most artisanal mining operations means that there is no security of tenure and thus any success in determining reserves may be subject to seizure by others (more powerful miners) or the government. The risk of loss that follows from poor security of tenure is particularly acute in the case of investment in exploration and reserve determination. In contrast to most equipment, information about in-situ reserves is inextricably linked to the physical location of those reserves, making investment in collecting this type of information a pure sunk cost.

Considering other minerals than gold and diamonds will not change this problem but may instead exacerbate it. The reason is that lower-value minerals are likely to be associated with thinner margins as a result of their absence from the unconsolidated deposits — such as river sand and gravel — that make gold and diamonds such attractive targets.

The magnitude of these exploration costs plays a role. First, and foremost, reserve estimates in this discussion do not refer to the type of detailed reserve calculations demanded by reputable stock exchanges and formulated by national mining organizations such as the Australian Institute of Mining and Metallurgy. Given that they are to be used as an implicit collateral for borrowing, the level of precision demanded lies with the lender. It is also likely to depend strongly on the type of deposit being mined and the precise security of tenure the borrower possesses.

3.2. Ore processing

For the present discussion, ore processing involves all steps in ore treatment prior to final recovery of gold through either amalgamation with mercury or cyanidation. Common processing steps employed by artisanal miners include (primitive) gravity separation and in
some cases prior crushing of hard ores. The issue of ore processing, and especially crushing and grinding, gains importance as artisanal miners move from the processing of unconsolidated gravel to harder rocks. Such moves may be driven by commodity prices (when high, entry into an existing area of artisanal miners will be more difficult than otherwise) or by exhaustion of unconsolidated gravels.

The ore processing is not in itself a matter of more or less clean technology. Arriving at the particle size that liberates gold is of key importance to achieving high levels of recovery. To the extent that this processing step does not conclude by using mercury, or reduces the consumption of mercury relative to output, they represent cleaner technologies. These processing steps share some of the characteristics of investment in reserve information. Even if the equipment is not sunk cost to the same finite degree as reserve information, it is still very specialized and thus, to some degree, a sunk cost. The main obstacle, however, is another item of investment that is arguably also a sunk cost — human capital — which must be acquired through education, training, or learning by doing. On the one hand, pilot schemes promoting alternatives to mercury amalgamation can be successful, as indicated in several papers in this issue. On the other hand, several papers mention that artisanal mining is often not the main occupation of those who practice it. For this group, mining is a means of survival and members are unlikely to view mining as the preferred option for investing in improving their own stock of human capital. Behind the difficulty of improving human capital lies the limited prospects associated with an activity that receives only limited official recognition. Yet again, these limited prospects have one fundamental explanation: lack of security of tenure to mineralized ground.1

3.3. Amalgamation/distillation with mercury

Once some form of concentrate has been produced, most probably with the crude sluice box, mercury is applied. The amount varies significantly as miners add extra mercury to ensure that no gold is left behind [2]. Once the amalgamation process is judged to be complete, the amalgam is heated to vaporize the mercury, resulting in a gold doré. This product is directly saleable; alternatively, the doré may be further processed before marketing. The problem with this process is the very severe pollution caused by releases of mercury. Despite the impacts on health and environment caused by mercury, it remains a preferred method with many artisanal miners. Commonly cited reasons include: process simplicity, high recoveries, low cost, and mobility. Further, amalgamation is probably a strongly institutionalized practice, a “taken-for-granted” approach handed down from one generation of miners to the next. Several approaches have been tried to reduce the magnitude of the problem. Substitution of other technical solutions has met with little success, as noted earlier. A far less ambitious but potentially more effective alternative is to encourage artisanal miners to use their mercury more effectively. Many of the papers in this volume describe various versions of very simple and cheap retorts that can precipitate and collect mercury vapor. Only a small additional step is needed to make the recycled mercury usable again [1].

Another effective means of reducing mercury emissions is to construct centers that specialize (among other things) in the distillation of amalgams. The case of the Shamva Mining Centre in Zimbabwe is particularly interesting as it is based on facility access rather than on custom processing. When miners operate the equipment themselves, the risk that such equipment is perceived as a black box in which “their gold” may be lost is somewhat reduced. This so-called “black box” problem exists even with very simple enclosed retorts (Babut et al. [2] describe a glass retort that addresses this problem) and processing centers are likely to require an extensive proving period during which they can build up a reputation that matches the transparency possible in the small glass retorts.

3.4. Marketing and sales

The institutional problem with artisanal mineral products is that their unofficial status means that miners are likely to receive much less that the actual value of the minerals produced. Because artisanal miners are so often illegal, they are more vulnerable to rent-seeking activities of downstream handlers of their product. Other things being equal, this may translate into an inability to generate sufficient profit, and is likely to deter investment in both efficiency and environmental protection. An example of a policy to address this problem, the government of Ghana, through its Precious Mineral Marketing Corporation, worked to eliminate the deductions charged by private middlemen [3].

3.5. Accounting and taxation

Minerals, and especially gold and diamonds, have since the dawn of time been a favorite object of taxation

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1 The basic element of mineral tenure is a legally enforceable right to extract any mineral or energy resource found within a specified geographical area. The area is determined by geological exploration that focuses on ever smaller areas. At some point the belief that a valuable prospect has been located becomes sufficiently strong to justify the cost of obtaining title. For most hard-rock minerals, including gold, application for title is an open-access process — i.e., the first applicant wins title. For energy minerals and petroleum in particular, a variety of bidding mechanisms is commonly used.
by sovereigns, other rulers, and government. The problem facing small miners and the government that regulates them is closely tied to the organization of mineral tax regulations and to the difficulties of having two sets of regulations for what is essentially the same activity.

The past decade or two has seen extensive efforts on the part of many national governments to reform their mineral taxation systems in order to make them more attractive to international investors. This has been a reversal of previous policies that, in broad terms, emphasized state ownership and/or participation as well as emphasis on adding as much value to products before they left the country of origin. Part of the movement away from the so-called ‘resource nationalism’ has been the adoption of taxation instruments that rely on fairly detailed accounting of profit in the mining operations. These more efficient taxation methods have replaced more traditional forms such as state equity ownership, and especially royalties. The problem is that while these taxation forms are a major improvement for larger ‘formal’ mines, they are administratively cumbersome. Royalties, typically levied as a small percentage of total revenues, bypasses the need for miners to keep accounts and for tax authorities to audit them.

Artisanal miners would rather avoid paying tax at all. This reluctance, and the difficulty of enforcing any form of taxation, is an issue not explored in any of the papers in this issue, perhaps because of the magnitude of the effort needed to bring them under some form of control. However, the effective relative subsidy given to artisanal miners as a result of non-taxation is likely to end up promoting this form of mining at the expense of formal ‘operations’. Thus, the decision about ‘going artisanal’ will depend in part on the tax advantage, and in part on the probability of tax regulations being enforced.

4. Environmental regulation

A recent study of environmental impacts in developing countries by Jha and Whalley [4] emphasized that pollution is not the only source of environmental externalities. Degradation, in the sense of soil erosion, the silting of rivers, congestion and problems with management of open access resources, is a problem that is equally or more important than emission of pollutants, but much less understood, studied, or emphasized. Together, the two forms of externality cause social costs that for some countries may reach 10% of annual GDP.

Artisanal mining is one of those activities that involve both kinds of impact, particularly when unconsolidated river valley deposits are being mined. As noted in several papers, destruction of soils is a widespread consequence of artisanal mining. However, even if many developing countries have regulations on the books that approach those of developed nations in terms of stringency, monitoring and enforcement, is much less complete [4]. In any case, the extra-legal character of most artisanal mining operations means that formal environmental regulation is perhaps not the most suitable approach to address the environmental impacts associated with artisanal mining.

The notion put forward by Jha and Whalley [4] is that environmental improvement in developing countries relies on development of local-level social norms and also on environmental NGOs (which raise environmental issues locally). Additional, more diffuse pressure comes from developed countries (emphasized through threats of sanctions), from international providers of development financing, and from international NGOs. For artisanal mining, these approaches, especially those stressing local capacity development in the area of environmental management, seem more likely to be effective than does traditionally designed and enforced environmental regulation. It should be noted, however, that a policy based on informal social norms can be difficult to implement, effective only where clear benefits to those involved are apparent and susceptible to outside shocks. In a discussion of poverty and environmental quality Måler [5] suggests that shocks may disrupt or delay processes whereby environmental externality costs are internalized. Such shocks may originate with population growth, technological change, or shifts in markets. The link to artisanal mining is intriguing. On the one hand, a discovery may cause a sudden large inflow of miners (a “gold rush”) that is harmful to established social norms. Subsistence farmers may abandon their land to join the rush when a discovery or a price increase creates a mineral rush. As time passes in an area with artisanal mining, however, social norms do evolve [6] and it is arguable that this evolution might also include environmental management components.

One avenue of environmental policy not explored in any of the papers is the origin and life cycle of mercury. A policy approach worth exploring might be the creation of a mercury tax. Given that the number of mercury producers is fairly small, and that mercury is a product with few cost-sensitive uses, development of a globally accepted tax on mercury should not be an impossible task. The idea would not necessarily be a tax that puts mercury out of reach for artisanal miners, but rather one that provides just the right incentive to switch to retorting and recycling of the metal. A tax set too high is likely to cause rapid substitution of other chemical processes such as cyanidation, a strategy that requires more process control than amalgamation with mercury. Such a tax on mercury would have to be implemented in such a way that it applies to all possible sources of the metal. This means that it might have to be agreed among current producers and set at such a level that it did not encourage new mercury mines to begin operations.
5. Legalization, regulation and social norms

The solution to the many and different environmental problems surrounding artisanal miners is likely to come from a variety of sources. Even the most careful and competent regulatory effort is likely to fail if it looks at the problem from only one perspective. Among the issues raised here and in the other papers in this issue, legalization is likely to be the most important element. In many cases, especially outside placer mining for gold and diamonds, legalization and the creation of a tenure system that treats all mineral land in the same way may lead to a changing role for small-scale miners, from being little better off than in their alternative subsistence farming form of employment, to being the finders of mineral deposits that go on to become ‘real’ mines. Even where artisanal mining remains, the availability of secure mineral tenure, and the benefits that this can unlock in terms of incentives to invest for miners themselves and incentives for financial institutions to support this. While legalization through development of mineral tenure systems that cover artisanal activities is not the main objective, such a system is also the foundation for environmental regulation of the sector, even if this still requires government capacity to apply and enforce regulations.

References