CASE STUDY #3

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USING A MARKET-DRIVEN APPROACH TO IMPROVE ECONOMIC RETURNS AND MINE SAFETY

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INTRODUCTION

There is a financial bottom-line to everything in artisanal and small-scale mining (ASM). The main concern for most people running and laboring in ASM operations is to make enough money to put food on the table, send their children to school, and if possible, invest in their futures. So, what if it was possible to increase economic returns while also improving mine safety through a package of low-cost and easy-to-implement measures? This is the approach that the Sustainable Development of Mining in Rwanda (SDMR) program[1] took in one of its interventions; the lessons from which can help achieve part of SDG target 8.8 to "promote safe and secure working environments for all workers."

Why is a market-driven approach needed?

Artisanal and small-scale miners can be faced with meeting stringent criteria as part of their licensing conditions, sometimes at levels similar to expectations for large-scale mining companies. Yet ASM communities lack the capital, additional technical knowledge, and incentive to meet these regulations. While the remote and informal nature of many ASM operations also makes it challenging for government to monitor and enforce them. The limited information available to miners is usually focused on what not to do and addresses one issue at a time. The cost of training and ongoing technical support to ASM from government agencies and development partners is high and can be unsustainable long-term. Taking a market-driven approach in ASM addresses these systemic failures (McQuilken 2018) by providing tailored and practical guidance to improve mining practices that also have clear and direct economic benefits. It is this combination that makes the approach useful.

Drawing on experience over a 30-year career, SDMR Consultant and Director of Green Horizons Environmental Consultants Limited Paul Mitchell[2] has developed a written guide in the form of a Technical Environmental Management Plan (TEMP) specifically for ASM. The TEMP provides practical solutions an ASM company can implement to increase efficiency and productivity while simultaneously addressing the damaging social and environmental impacts. Tailored each time for a specific ASM site, the TEMP has two components: 1) The "general guidance and operational principles" provide an overview on topics including occupational and community health and safety, upskilling, and water, sediment, and waste management; 2) The "site-specific mitigation measures" provide clear actionable recommendations for ASM operators to follow.

Working with its partner, Coopérative Minière of Kababaru-Gikingo (COMIKAGI) a small-scale mining cooperative, SDMR along with Paul Mitchell and Daniel Limpitlaw, a mining engineer, has over the course of the program developed and piloted a TEMP for its three mine sites. Based on this experience, this case study provides details on the practical market-driven approach taken to address mine safety and operational efficiency at the same time.

Why is better mine planning needed?

Mining in Rwanda is now the second greatest foreign exchange earner after tourism (New Times, 2019). The country's green rolling terrain, earning it the pseudonym "The Land of a Thousand Hills," and temperate tropical highland climate with frequent year-round rains presents unique challenges to mining. Employing a total 60,000 workers in all mining and quarrying activities in 2019 (NSIR 2019), of which at least half are estimated to be artisanal and small-scale miners (Barreto et al. 2018),[3] ASM activities currently dominate the sector accounting for 70 percent of production. Focused mainly on the extraction of tin, tungsten, and tantalum (3Ts) ores, total mineral exports from Rwanda were worth US$377 million in 2017-2018 (Lesser and Habyarimana 2019). Through an ambitious development program, the government intends to treble the sector's economic contribution and to transform many of the country's small-scale mines.

To reach this target, however, significant improvements in planning and organizing underground artisanal workings is needed (O'Neill and Telmer 2017). Prior development of a mine plan is key to ensuring safe and efficient development, operation, and closure. Optimal resource use and timing of production activities can significantly affect profitability by lowering cut-off grade,[4] extending deposit lifespan, improving work conditions and productivity, increasing incomes, and stimulating the economy through job security. But in ASM, inappropriate mining methods, poor layouts, and limited division of labor and coordination are often evident (Priester, Hentschl, and Benthin 1993). These issues can result not only in inefficiencies but also dangerous working conditions. For example, ground failures can often be attributed to a lack of planning, limited knowledge of rock characteristics, and inappropriate mining methods (Bansah et al. 2016). Well planned ground support is essential because the rock conditions may change greatly over the length of a tunnel; the first few meters

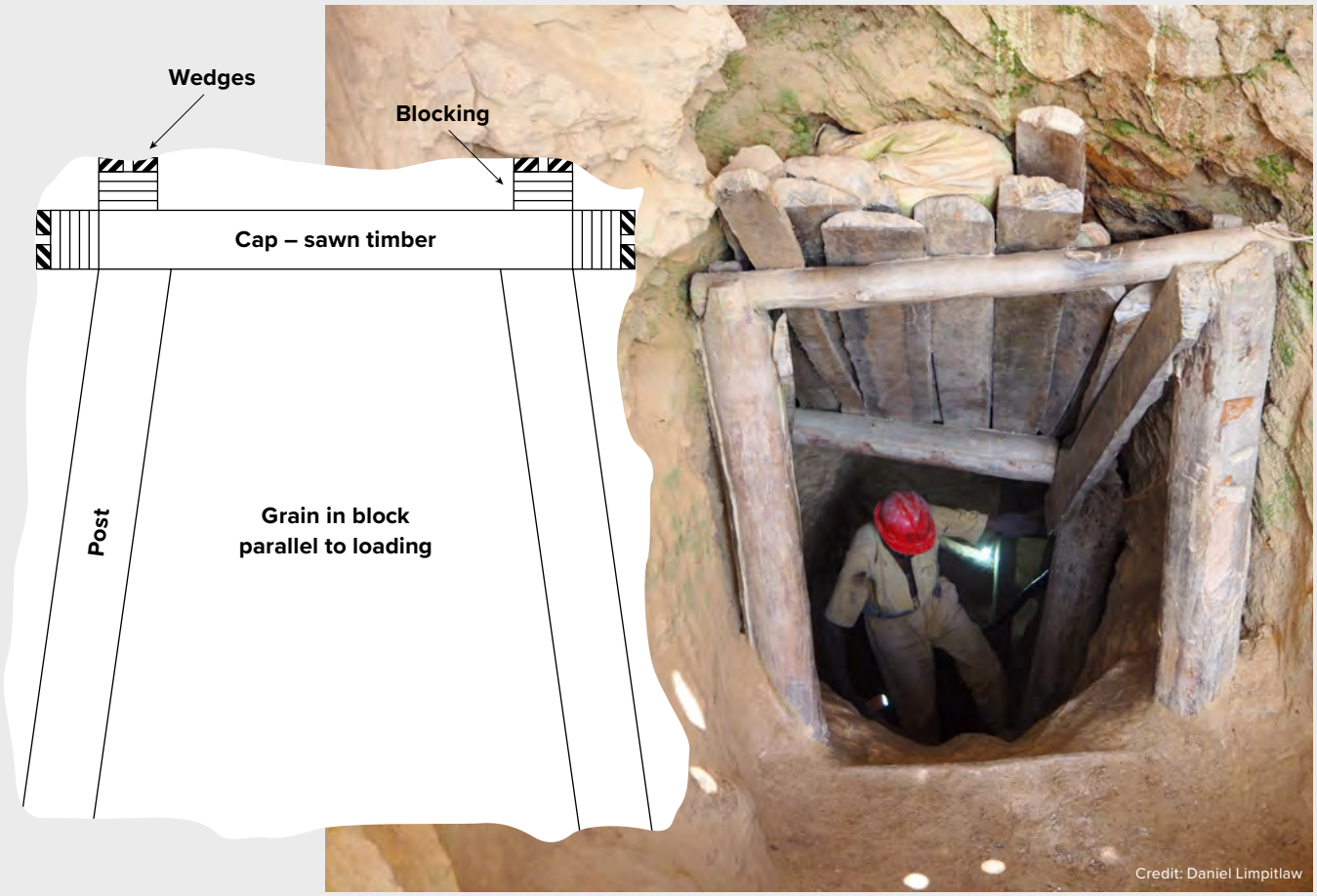
through unconsolidated material near the surface being particularly dangerous.

In Rwandan tin-tantalum deposits, mineralized vein width generally varies between 0.3 and 2.0m, and most development is on-ore, meaning that the miners follow thin veins and do not excavate the waste rock surrounding the orebody. The advantage of this is that all rock broken underground has value, but the disadvantage is that the excavation tunnels are restricted by the shape of orebody. These narrow openings present challenges to materials handling and safety as while used to remove rock ore, they are also essential escape ways needed to leave the mine quickly and should be at least 1.8 m high (Rupprecht 2015). It is essential therefore that underground workings are well supported, free of obstructions (like ore sacks), and included in the mine plan from the outset.

What practical safety solutions can miners implement?

After reviewing the extensive body of Rwandan mining literature, the SDMR program team assessed the underground workings of COMIKAGI to identify ways to improve production efficiencies and practical safety measures. Excavation measurements were made using a 30m tape measure, a compass, and an inclinometer. A low-cost GPS was used to record portal locations. Rendering this spatial information in 3-D with Plotly, a free, on-line drawing package[5], several recommendations for increasing extraction, optimizing support spacing, and locating materials handling infrastructure were developed and implemented as part of the TEMP. By visualizing the workings in 3-D, better planning is possible, although still limited by the absence of exploratory drilling and, consequently, information

FIGURE 6. **Underground Timber Supports at COMIKAGI and Proposed Method of Installation**



Source: Photo D.Limpitlaw; Diagram reproduced after Stanley 1962.

about the ore grade ahead of the mine face. For example, in one of the workings, recommendations for a room and pillar extraction method were made. This would effectively increase the extraction ratio (the ratio of the volume of ore extracted to the volume left in-situ) from 9.5 percent to 28 percent—still low by large-scale industry standards, but a substantial improvement for ASM.

The first key improvement was to streamline the timbering—a simple and low-cost ground support method in incompetent rock (Priester, Hentschl, and Benthin 1993). Ideally timber mine poles should yield slightly under the weight of the hanging which can be achieved using headboards (Staley, 1962). Headboards provide softer support and show signs of damage before the poles fail therefore acting as a warning sign that can be replaced before failure of the main support.

At COMIKAGI, miners already make extensive use of timber supports (Figure 6). Using simple techniques developed in the USA in the middle of the last century (see Staley 1962), the SDMR team hosted a workshop where technicians from COMIKAGI and surrounding mines were shown how to properly calculate the number of wooden supports per length of tunnel needed for safe extraction. The calculations at COMIKAGI showed that, given the excavation dimensions, rock competence, and depth of the workings, support spacings could be increased to 1.2m from an average of 0.5m—reducing the amount of timber needed by over half. In addition to improved mine safety, the lower intensity of pole usage decreases operating costs and the labor needed to install timbering can be re-directed elsewhere, such as for more profitable extraction and processing activities. It also reduces environmental pressure on Rwanda's limited timber resources helping reduce deforestation and forest degradation.

A second improvement in both mine safety and efficiency was to address materials handling. Inefficient methods are employed at many ASM sites: loose material is re-handled multiple times through reloading, re-dumping, and relocating it. Properly locating these heaps through advance mine planning can reduce and eliminate the need to move mineral ore and waste multiple times when opening new tunnels and processing areas. As is common in many ASM operations, at COMIKAGI's sites small sacks, each around 25 kg, are transported to surface from the rock face. Sacks are often stored temporarily in the travelling ways—a safety hazard to miners moving between working places and restricting ventilation. For workings less than 30m in depth, sacks can be loaded into buckets and hoisted up small shafts using a windlass (Rupprecht 2015).

Another improved materials handling measure implemented at COMIKAGI was the clearing and building of stable paths inside and between excavation tunnels, storage and processing areas at site using inexpensive crushed stone that is readily available as a waste by-product. These make transporting ore easier and quicker increasing efficiency and productivity while also having positive health and safety benefits for workers by reducing the risk of trips, slips, and falls and making carrying the heavy barrows and loads less strenuous.

Ore and waste are not the only materials that require handling—the timber and equipment for underground workings must also be moved. To improve efficiency, SDMR helped COMIKAGI plan and install a simple mono-winch and haulage system to transport ore from hillsides and steep valley bottoms up to processing sites and timber down to the mine portals. Mechanized materials transport (two people with a mono-winch and zip line) replaces large teams of miners hand-carting ore up slope to the sluices in the afternoons thereby increasing efficiencies and reducing the need for repetitive manual labor which has long-term health impacts and a higher risk of accidents when carrying heavy loads.

SDMR has also helped COMIKAGI investigate the feasibility of replacing inefficient ground sluices (used for ore washing) with a small treatment plant. Fewer miners are therefore required for ore washing which requires them to stand on slippery loose slopes bending and twisting to turn over heavy ore with spades as water travels downhill. By reducing the labor burden for materials handling, again, these miners can then be redeployed elsewhere

such as for the construction of tailings storage facilities and the maintenance of silt dams—two tasks that are currently under-resourced.

Helping policymakers and practitioners introduce a market-driven approach

Although a TEMP needs to be developed and tailored to each ASM site, the measures introduced at COMIKAGI and the novel approach of identifying improvements in health and safety that also increase productivity and profitability are key lessons from this case study. The efficiency gains made by removing large manual labor teams from transport and processing at SDMR and elsewhere are expected to more than compensate for the cost of redeployment to other service tasks. Increased production time and a healthier workforce due to reduced ore transport requirements as well as fewer lost time incidents and injuries translates into potentially increased profitability.

By unlocking market-based levers for ASM companies to introduce improved health and safety measures based on simple century-old techniques, the burden on government for monitoring and enforcement is reduced. This leaves more resources to support ASM to fulfill its development potential across all 17 SDGs. Communicating these market-based approaches to improved economic returns and mine safety simultaneously is key to achieving wider uptake. It is also needed to reach the policymakers and practitioners that could facilitate training and knowledge transfer as well as the ASM communities and workers that would benefit immediately from a safer and more secure working environment.

ACKNOWLEDGMENTS

This case study is based on the COMIKAGI Mine Planning Report (SDMR 2019) an output of the SDMR program researched and written by Daniel Limpitlaw. It also draws on an earlier policy brief regarding the TEMP approach published by the program in December 2019 (McQuilken 2019). The authors would like to extend a special acknowledgement to COMIKAGI and especially Mining Technician Jean Bosco for working closely together to improve mine safety and efficiency in the Rwandan mining sector.

END NOTES

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2 Sustainable Development of Mining in Rwanda (SDMR, 2020) was a three-year (April 2017-Sepetember 2020), GBP 4.3 million market systems development program funded by the UK Department for International Development (DFID) and implemented alongside partner Rwanda Mines Petroleum and Gas Board (RMB). It aimed to create a more professional, transparent, open, efficient and economically viable mining sector with environmental best-practice, increased private sector investment, and improved incomes of artisanal miners. It was managed and implemented by Cardno in partnership with Pact, Projekt-Consult GmbH, and Rwanda Women In/And Mining Organization (WIAMO).

3 30,000 artisanal and small-scale miners were estimated to work in Rwanda in 2015 (Barreto, 2018).

4 The cut-off grade is the lowest concentration of the target mineral in the ore that can be mined profitably. Ore with concentration below the cut-off grade must be excluded from the mine plan as it is not profitable to mine.

5 https://plotly.com/

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