A Ranking Methodology to Prioritise Artisanal and Small-Scale Mining Projects

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A number of interested parties active in the minerals industry do not fully understand the requirements to explore and develop projects. These parties are important to the industry, as they will often provide financial support to mineral projects with the intent of securing the off-take of the metal concentrate; however, these same individuals are unable to support the technical aspects of mining to support artisanal and small-scale miners. This paper provides a methodology to assist potential investors in the area of exploration and project development. By investigating several inputs into project development, a ranking methodology is proposed to prioritise artisanal and small-scale mining projects. The following areas are discussed as a means to rank projects: historical mining method; strike and depth of mineralisation; thickness and continuity of mineralisation; infrastructure. Based on the above criteria, potential investors should be better informed as to which of their projects offers the best opportunity towards development of a mining operation.

INTRODUCTION

For many investors, the prospect to take an artisanal mining operation and develop the deposit to a small-scale mining operation is a difficult task. Upsizing an artisanal operation is inherently risky as small-scale operations incur additional costs, such as in-country office and adherence to local regulations, including safety and environmental compliance. To generate a profitable small-scale mine, some means of mechanisation will be introduced in the mining stage, as well as the introduction of industrialised beneficiation. To justify this capital expenditure, the prospective owner seeks to identify a deposit(s) large enough and with a grade high enough to provide a sufficient return on investment to warrant the risk of the investment. The conundrum with small-scale operations is that there are usually limited funds to conduct exploration activities; therefore, it is imperative that suitable exploration sites are identified so that the limited available capital is appropriately spent. Common mistakes are to invest in areas that may not have sufficient grade or continuity, as often the explorer is more interested in finding the mineralisation than actually understanding the potential of the mineralisation. Hence, continuity of the mineralisation and finding grades above the economic cut-off grade is important. The proximity to infrastructure and the ability to have sufficient available land is also important because many projects may be hampered by inadequate space for infrastructure, such as plant, waste dumps and tailings storage facilities. Proximity to roads, power and water are also important inputs to be considered.

POTENTIAL OF PROSPECTS

Table I illustrates some of the critical considerations for evaluating the potential of a deposit at early stages of exploration.

Table I. Considerations for evaluating the potential of a deposit.

Historical mining	Strike & depth of mineralisation	Thickness & continuity of mineralisation	Tonnage & grade of mineralisation	Infrastructure

HISTORICAL MINING AND CUT-OFF GRADE

The presence of historical (Figure 1) and/or current artisanal mining is one of the best ways to determine the viability of a deposit. Historical artisanal mining is often limited by the hardness of the rock, as near-surface mineralised material can be free dug but, as mining progresses deeper, the impact of weathering is decreased and it becomes very difficult to break the rock without the use of a rock drill and explosives. Rock drills are expensive and require a means to power the drill; in the case of explosives, it becomes expensive to purchase, requires specialised skills to use and regulatory permission. In other cases where the mineralised material can be exploited further underground, the limitations of natural ventilation inhibit mining to progress beyond 20 or so metres. In these cases, artisanal mining is forced to stop due to a lack of funding, technical expertise or equipment. Small-scale mining operators, based on their financial strength, technical capabilities, and equipment can then exploit the deposit. Small-scale miners can introduce mechanised machinery, suitable mine access, explosives, transportation systems, ventilation and improved beneficiation techniques to extend the life of the operation. Thus small-scale miners are often exploring and evaluating areas previously mined by artisanal miners.

However, historical artisanal operations on their own are not enough, as artisanal miners are often operating on a subsistence level and may exploit a deposit just to provide sufficient funds to feed their family. In these cases, the deposit may be too low grade to substantiate a small-scale mining operation. Small-scale miners will determine the cut-off grade required for them to economically mine a deposit, i.e., the grade at which a profit is realised through mining after taking into account all mining, processing and other costs associated with supporting mining activities. An example of applying a cut-off grade is provided in Eqatioin [1]:

$$\text{Cut-off Grade} = \frac{\text{Total On-Mine Production Costs}}{\text{(Metal Market Price – Off-Mine Costs) x Recovery (\%)}} \quad [1]$$

In the case of tantalite (Ta_2O_5), the following information would be used to determine the cut-off grade for a small-scale mining operation:

- realised price of Ta_2O_5: USD 121.00/kg concentrate;
- recovery: 80%;
- estimated mining cost: USD 8.00/t;
- estimated processing cost: USD 6.00/t;
- estimated general and administrative (G&A) cost: USD 3.50/t.

Based on the above parameters, a small-scale miner would require at least a run-of-mine grade of 200 ppm (g/t) Ta_2O_5 to make a profit; however, for an artisanal miner this "cut-off" will be lower as mining and processing costs will be lower and no G&A cost will be associated with artisanal mining. For the artisanal miner, the cut-off grade will be in the region of 100 ppm.

During a recent site visit in Burundi, one of the poorest countries in the world with over 60% of the population living in extreme poverty (Nations Encyclopaedia, ND), artisanal miners were exploiting tin deposits running at a grades below ±0.3% Sn. Based on cut-off estimates for small-scale mining, these low grades cannot support a small-scale mining operation, yet may support subsistence artisanal mining (Figure 2).

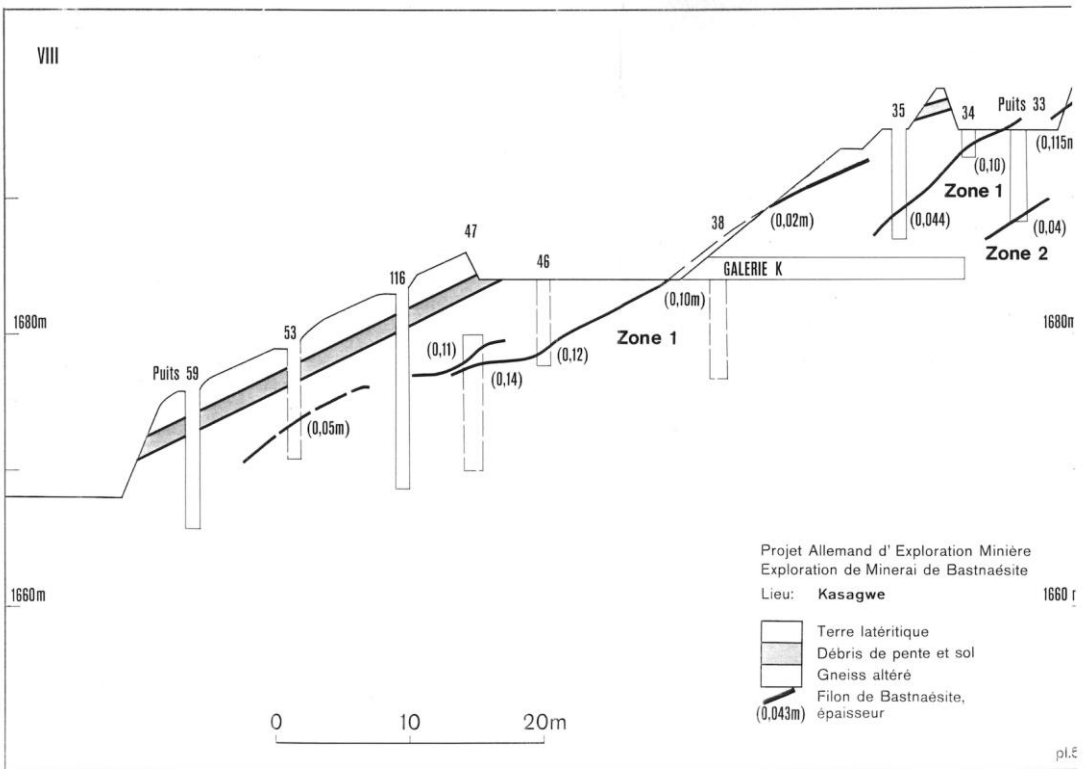

Figure 1: Example of historical information (Brinkmann and Lehmann, 1983).

Figure 2: Subsistence artisanal mining.

CONTINUANCE, TONNAGE AND GRADE OF MINERALISATION

The continuity of the deposit will indicate the potential size of the deposit, noting that the continuance of the deposit does not necessarily equate to viably mining of the entire length of the mineralisation. Many deposits are quite variable in grade and thickness and thus understanding the continuity of the mineralisation is essential when ranking a deposit. For example, in Rwanda in artisanal mines, it is common to see a series of shafts positioned every 10 m to outline the strike of a tin or coltan deposit (Figure 3). In other cases, shafts may be limited or abandoned due to the pinching and swelling of the mineralisation, as well as low-grade intersections. Developing a project will invariably always rely on the continuance of the mineralisation concerning payable grades and containing sufficient tonnage.

Tonnage and grade will always be critical when evaluating a small-scale deposit. Often artisanal miners will follow high-grade veins; however, the sustainability or continuity of the high-grade area is always put in question. Gaining a basic understanding of the continuity and grade of the deposit is important, as both the mineable tonnage and grade are critical information to an investor. Often small-scale miners lose sight that both continuity (tonnage) and grade of the mineralisation both contribute to the viability of a mining project. Continuity alone is not enough to justify mining operations, as the mineralisation may not contain sufficient recoverable metal to provide a sufficient return on investment. In contrast, one may intersect samples of high grade, but not enough high-grade material to support mining. Therefore, the continuance, tonnage and grade must be considered when ranking potential deposits.

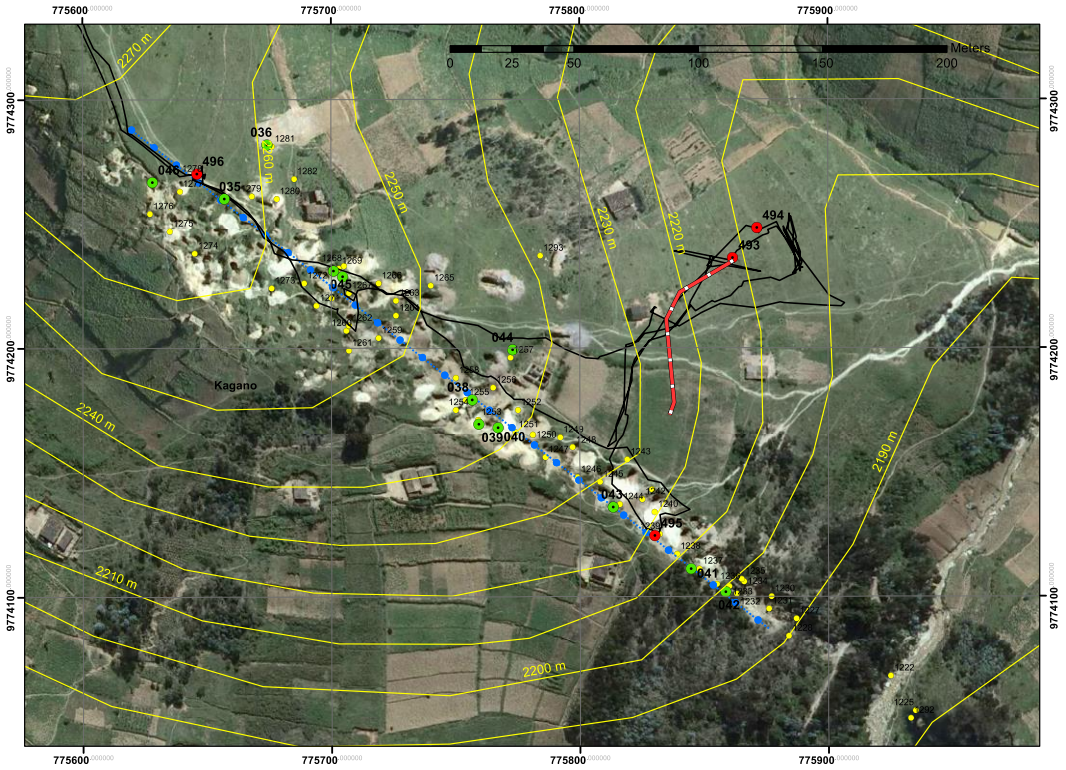

Figure 3: Plan view of coltan workings, demonstrating how artisanal workings demonstrate the strike of the deposit, as shown by the blue line (Rupprecht, 2015).

ESTIMATED DEPTH OF MINERALISATION

The depth of the mineralisation plays an important role in small-scale mining. Ideally, one would like to develop the project in a "pay as you go" manner; in other words, let the development of the deposit

pay for itself with the opening of mining blocks establishing cash flow for the project. When evaluating small-scale deposits, it is always advantageous to exploit mineralisation near surface. Typically, mineralisation below 20 to 30 m below the surface are considered deep for artisanal mining. Artisanal workers commonly exploit working depths from 10 to 20 m; however, beyond these depths, a more formal approach to mining is required. Beyond 20 m, mechanised hoisting should be considered, with the necessary rock handling arrangements included in the shaft design. As mineralisation continues with depth, additional infrastructure development is usually required, i.e., additional shafts. Upon initial investigations, viewing artisanal workings can provide good information regarding continuity (Figure 3).

THICKNESS OF MINERALISATION

Depending upon the commodity of interest, the thickness of the mineralisation may play an important role in determining the mining method. The thickness or mining width of the mineralised zone is important in determining the mining rate (run-of-mine tonnage) and estimating the life of mine. Unlike artisanal mining, small-scale mining requires capital for mining equipment, metallurgical plant, and associated infrastructure. Thus, the life-of-mine plan must have sufficient tonnage to support the capital expenditure and provide a sufficient rate of return on investment. When discussing thickness, it is important to consider minimum mining thickness as well as maximum mining cut. Often in artisanal mining, the workers attempt to mine only the mineralised vein because the removal of waste is seen as extra effort without any financial reward; however, when applying small-scale mechanised mining (pneumatic rock drills, explosives, rail bound transport), it is necessary to include a portion of waste to mine at the necessary minimum mining width. Small-scale mining is also limited to a maximum mining height, usually limited by the operating parameters of the mining equipment. For example, pneumatic rock drills will limit mining to a maximum mining cut of the order of 2.4 to 3.0 m. Underground operations will usually require some form of support and generally in the way of a pillar. Thus, the pillar requirements should be considered if one is considering underground mining methods (Figure 4).

INFRASTRUCTURE AND SERVICES

Access to sufficient unpopulated areas is crucial as very few small-scale operations can accommodate the relocating of people and property. The proximity to local housing is an issue in a number of ways. Firstly, mining operations must have sufficient open areas for the placement of mine-related infrastructure, such as mine pits or mine access, waste rock dump, water storage, beneficiation plant, tailings storage facilities, mine offices and change-house facilities.

The proximity to services, such as roads, power and water, plays a significant role in ranking a project as development of roads can be very costly and the delay and costs associated with the construction of roads will have a negative impact on the project's profitability. The use of generated power can have a significant cost impact on operating costs. Access to water is also crucial and in some cases may impact on the sustainability of mining activities.

SUMMARY AND CONCLUSION

Potential investors may be interested in projects that are at an early stage of exploration with only limited data available for analysis purposes. At a very early stage, it is possible to rank projects based on many factors. Six areas of a project are considered; historical mining, strike and dip extension, continuity of the deposit, infrastructure, and an estimate of the tonnage and grade of the deposit. The use of a ranking method to evaluate small-scale mining projects enables the investor to prioritise the deposits to conduct exploration activities.

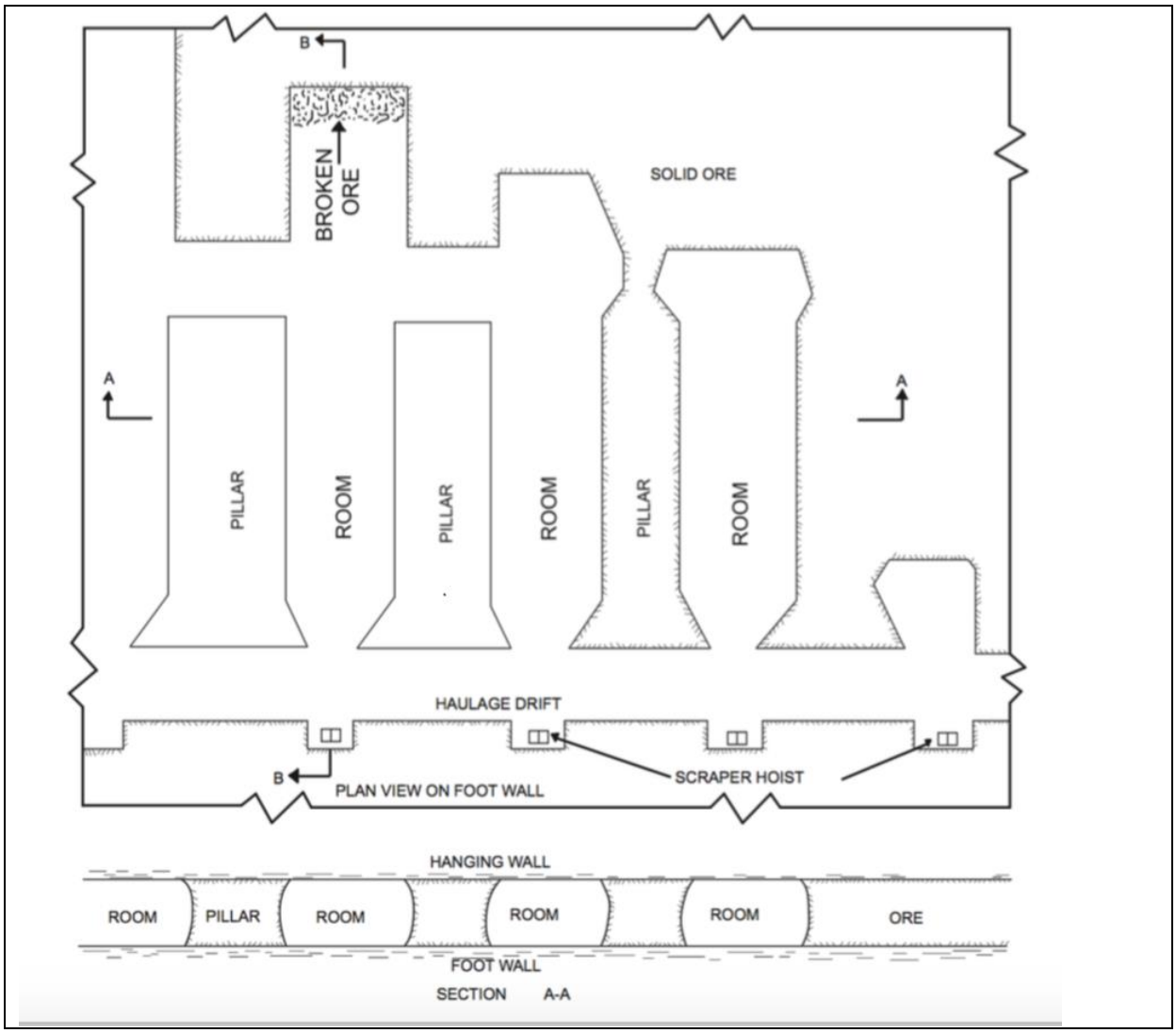

Figure 4: Vertical room-and-pillar mining (Rupprecht 2016).

REFERENCES

Brinkmann, J., Lehmann, B. (1983). Mining Exploration Project Exploration Report on Rare Earths – Gakara Region. Project No. 81.2026.3.

Nations Encyclopedia of the Nations, Burundi – Poverty and wealth. http://www.nationsencyclopedia.com/economies/Africa/Burundi-POVERTY-AND-WEALTH.html. Accessed 13 March 2018.

Rupprecht, S.M. (2015). Kagano concession – Kaziz adit review. Consultancy report to Gruvan Mining, Kigali, Rwanda.

Rupprecht, S.M. (2016). Rwinkwavu – Gahengeri Conceptual Study (Mine Plan and Schedule). Consultancy report to Gruvan Mining, Kigali, Rwanda.