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# Bench Mining Method as Future of Artisanal Mining and Community Development in Southern Africa: South Africa and DR Congo

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## ABSTRACT

South Africa and DR Congo are both considered as members of Southern African Development Community. And Zama Zama is a Zulu expression of artisanal miners in South Africa which means "those who keep on trying" and Mchimbaji is a Swahili expression of artisanal miners in DR Congo which means "diggers". Artisanal mining is a cultural heritage and significant contributor in mineral production in both countries of tantalum, gold, cassiterite, chrome, diamonds and other precious minerals. The artisanal miners are organised in Cooperatives or sometimes operate illegally with manually intensive work or indigenous practices by using hammers, shovels, pick-axes, sack, chisels, head-torch, welding-gloves for prospectus and excavation and processing minerals with a magnet to remove impurities in case of DR Congo and towers, buckets, heat and mercury in case of gold-process in South Africa. The practice is often due to abandoned mines shaft associated with environment's degradation, retrenchment from large-scale mining companies, alternative livelihoods & economic empowerment, smuggling, effort to regain land with its resources, but unfortunately causing insecurity and death associated with roof falling, gangs activities in South Africa and rebellions in DR Congo. Hence, the application of Bench Mining or Open pit machine such as Dozer and tractor-trailer with mining PPE for mining layers as applied in Rwanda and Burundi is becoming crucial in the sector to reduce death associated with roof falling, structure the operation, purchase abandoned mines, facilitate registration for mining permit, boost the production, increase safety measures, rehabilitate sites and attract more sponsors.

**Keywords**: Artisanal Mining, Bench Mining Method, Cooperative Registration



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## 1. Introduction: Background Mineral in South Africa and DR Congo

South Africa in one hand, its total reserves remain some of the world's most valuable, with an estimated worth of R20.3-trillion ($2.5-trillion). Overall, the country is estimated to have the world's fifth-largest mining sector in terms of GDP value. It has the world's largest reserves of manganese and platinum group metals (PGMs), according to the US Geological Survey, among the largest reserves of gold, diamonds, chromite ore and vanadium. With South Africa's economy built on gold and diamond mining, the sector is an important foreign exchange earner, with gold accounting for more than one-third of exports. In 2009, the country's diamond industry was the fourth largest in the world. South Africa is also a major producer of coal, manganese and chrome [1]. And the Democratic Republic of Congo on the other hands; is a significant factor in the world's production of cobalt, copper, diamond, tantalum, tin, and gold. DR Congo's largest source of export income and in 2009, the country had an estimated $24 trillion in untapped mineral deposits, including the world's largest reserves of coltan (tantalum) and significant quantities of the world's cobalt.[2,3]. The United States Geological Survey estimates that the DRC has 1 million tons of lithium resources [4].

Both countries have similar opportunities and problems such as investment from large cooperates for large-scale mining, closure of mining activities associated with currency's fluctuation, mines are getting deeper with higher costs associated, political instability, country's corruption and abandoned mines shafts associated environmental degradation & pollution due to non-rehabilitated sites in post-operations, company retrenchment (ref. Figures 1 & 2 below), under-developed mining communities, degradation of infrastructures and higher rates of unemployment and retrenchment associated with closure or companies financial difficulties of large scale mining companies, poverty, smuggling, effort to regain land with its resources by the local community, death associated with roof falling during artisanal mining excavation, gangs activities in South Africa and rebellions in DR Congo. Sometimes the population are questioning themselves if having a lot of mineral resources is a good thing or not because it is causing more problems than solution?

The Minerals Council of South Africa has presented a report in 2018 about "Facts & Figures" [5] which are presenting an alarming situation in Platinum and Gold Sector from 2008-2018. The figure 1 below is presenting the trend in Gold sector in South Africa. The figure 1 has presented a high peak in Gold production in 2008 and the lowest peak in 2015 close to 120 tons but a slight increase in 2016 and slight decrease until 2018. The production of 122.2 tons in 2018 gives an average decrease in production of "-14%" from 2008-2018. In terms of Mineworkers, the retrenchment has been significant with a steady decrease from 2008-2018 of about 110 000 workers losing their job.

The figure 2 has presented a high peak in Platinum production in 2011 and the lowest peak in 2014 but with significant increase in 2015 and slight decrease until 2018. The production of 259 tons in 2018 gives an average decrease in production of "-1.2%" from 2008-2018. However, in terms of the Mineworkers, the retrenchment has been significant with an average of 120 000 workers losing their job from 2008-2018 regardless of the tendency to reduce the figure in 2012. The major strike actions in South Africa began in the year 2012 when the workers at the Lonmin-owned Marikana platinum mine in South Africa walked off the job (Anderson, 2012). The industrial upheaval spread quickly through the mining industry and even leaked into transport, textiles, and the public service. Les Holmes attributes the recent upheavals to be due to frustration of the populous on the non–delivery of housing and jobs (Anderson, 2012).

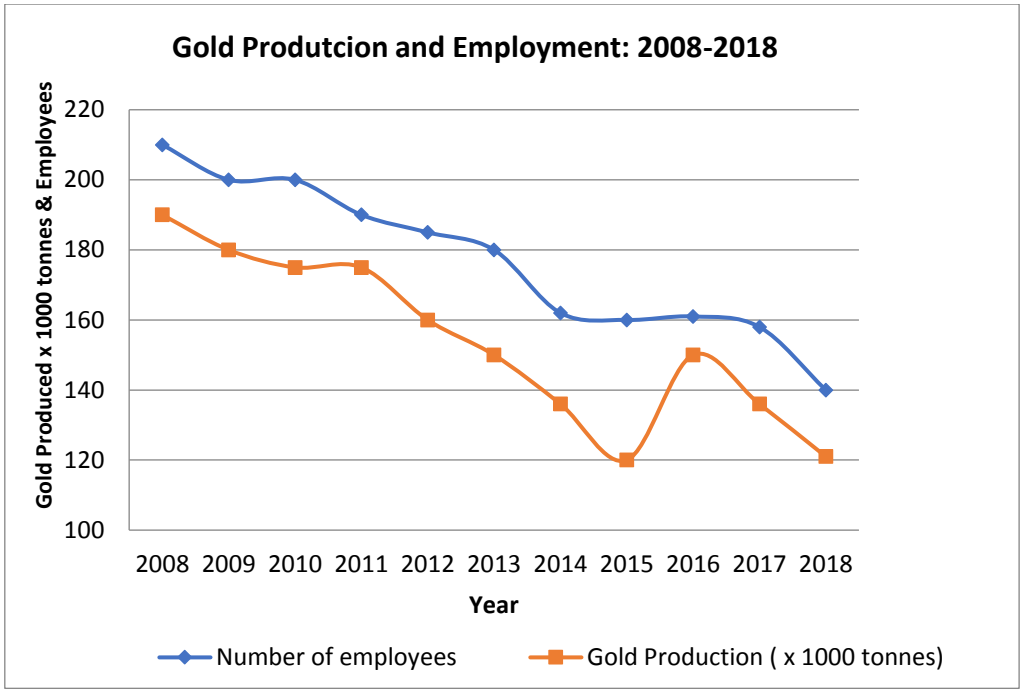


**Figure 1:** Gold production and loss of employment in South Africa: 2008-2018 (Minerals Council of South Africa, 2018)

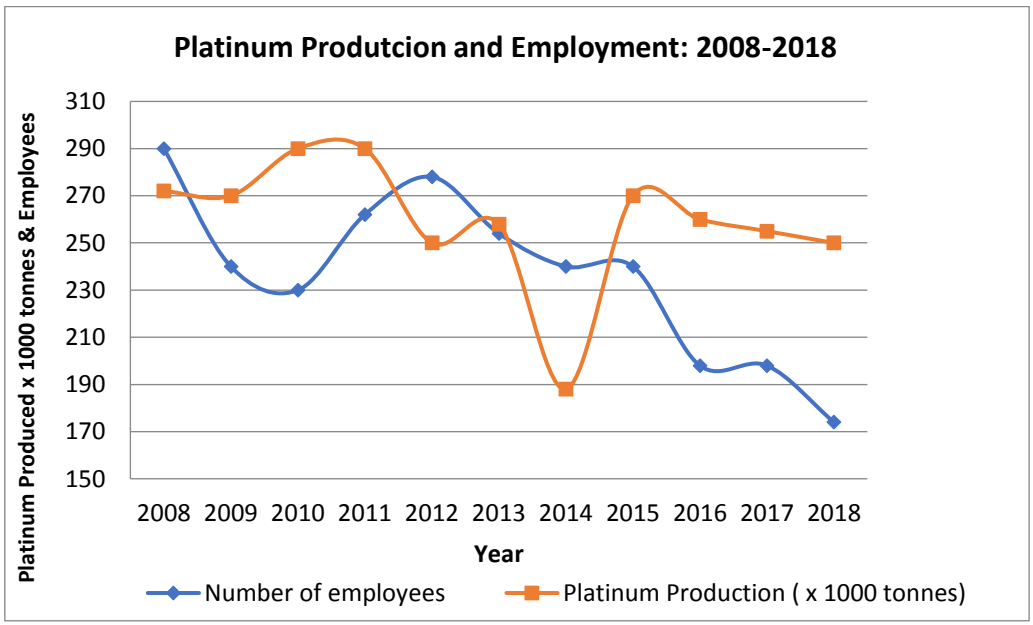


**Figure 2:** Platinum production and loss of employment in South Africa: 2008-2018 (Minerals Council of South Africa, 2018)

The sum of job loss from Gold and Platinum in figures 1 and 2 above is 230 000 job loss from 2008-2018. The Minerals Council of South Africa has listed few reasons that may cause the problem in Platinum and Gold industries such as the decrease in investment, illegal mining, electricity (Eskom) and unrest. In the DR Congo, in 2003, with the support of the World Bank, the Congolese state-owned enterprise Gécamines (State-Own Enterprise) implemented a voluntary departure programme for 10,000 employees with more than 25 years of service. These employees were asked to regard their severance pay

as a capital to be invested in new activities [6]. In June 7 in LUBUMBASHI (Reuters) – DR Congo's mining sector has lost at least 3,000 direct and 10,000 subcontractor jobs since commodity prices began to tumble last year, the chamber of mines said on Tuesday. Congo, Africa's largest copper producer, is heavily dependent on the mining sector, which together with its smaller oil industry accounts for 98 percent of export earnings. Benchmark copper on the London Metal Exchange lost a quarter of its value in 2015 and is down slightly this year [7]. DR Congo has 50% of world reserve in Tantalum and the increase in demand of 3TGs (Tin, Tantalum, Tungsten and Gold) in 1990 could have been at the base of instability in the Great Lake and wars in the East of the DR Congo which caused approximately 5 millions of death. The minerals are dubbed 3TG, for tin, tantalum (sometimes known as coltan or blue gold), tungsten, and gold. The three "Ts" are mostly mined in the Democratic Republic of the Congo (DRC), and are all used extensively in electronics. The minerals are also mined in other places, like Australia and South America — generally by large industrial conglomerates. Mining operations in Africa produce a huge percentage of the global supply of 3TGs at cheap cost (Android authority, conflict minerals). The minerals have many usages in electronics and are found throughout smartphones [8].

The reasons of the mentioned above problems are linked with mining operations from the increasing cost of mining at depth (the deepest operating mine), declining mineral grades, rising operating and labour costs, large-scale mines reducing their workforces isolating some mine dependent communities and damaging their economic capability. Unprofitable shafts and underground workings being decommissioned, and in some cases, abandoned outright Shafts, waste dumps and non-rehabilitated tailings dumps (McCarthy, 2011; Kim Hein & Kgothatso Nhlengetwa, 2014) [9] and the 3TGs demands in the case of DRC associated with retrenchment of large-scale mining activities may have been the cause of illegal or artisanal mining activities to sustain livelihoods or regain the ownership of land's resources.

## 2. Artisanal and Small-Scale Mining

Zama Zama is a Zulu expression of artisanal miners in South Africa which means "those who keep on trying" and Mchimbaji is a Swahili expression of artisanal miners in DR Congo which means "diggers". Artisanal mining is a cultural heritage and significant contributor in mineral production in both countries of tantalum, gold, cassiterite, chrome, diamonds and other precious minerals. The artisanal miners are organised in Cooperatives or sometimes operate illegally with manually intensive work or indigenous practices by using hammers, shovels, pick-axes, sack, chisels, head-torch, welding-gloves for prospectus and excavation and processing minerals with a magnet to remove impurities in case of DR Congo and towers, buckets, heat and mercury in case of gold-process in South Africa as illustrated in the figure 3.

Most artisanal and small-scale mining (ASM) activity is labour-intensive, populated by persons or groups who use traditional techniques which relies on manual methods of extraction using simple equipment such as shovels, pans, chisels, pick-axes, hammers and others. This manual aspect of ASM has remained unchanged for hundreds, if not thousands, of years in sub-Saharan Africa and around the world (Anon., 1999; Hein, 2007), (Kim A.A. Hein *, Todani A. Funyufunyu, 2014) [10]. The current problem of artisanal mining practice is death associated into roof falling, registration, and formalisation, structuring the operation, boost the production and funding acquisition. This problem are not helping the sector to become viable by creating more job opportunities for the mining communities and neither for the government to issue permit unless they are organised in cooperatives with sufficient information required, mine planning, safe practice (Ref. Figure 4,5,6,7: Some of Artisanal mining unsafe practices in South Africa and DR Congo with their consequences) and proof of funding, this why Bench Mining method has been proposed to assist in this regard.

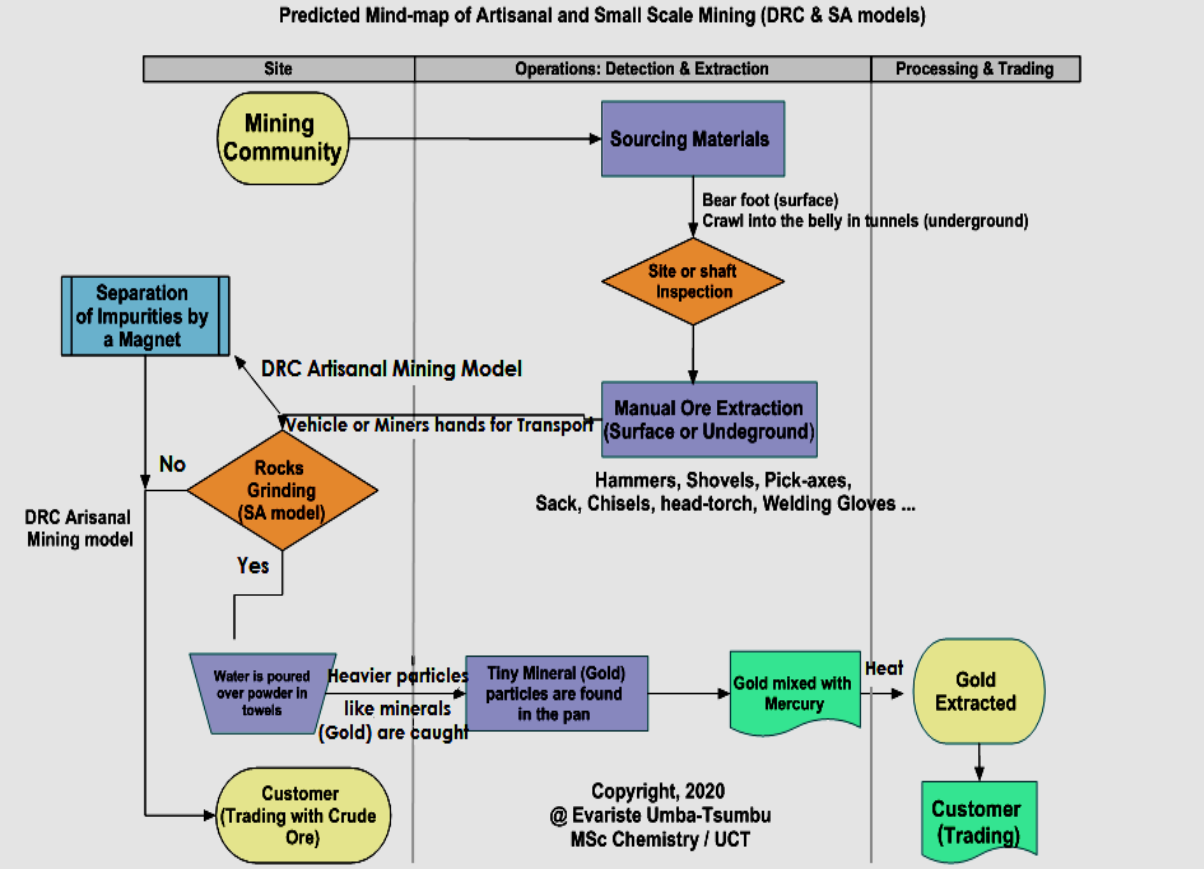


**Figure 3:** Predicted Mind-map of Artisanal and Small Scale Mining Operations & Process in South Africa and DR Congo

**Figure 4:** Luwowo Coltan mine in the east of the DRC (via MONUSCO/Sylvain Liechti)
Roof falling problems associated with death in Artisanal Mining in Goma/DRC [8]

**Figure 5**: Soil collapse in Goma – picture taken by Cooperative Miniere BUUMA-COMIBU agent in 2019

**Figure 6**: Artisanal Miner emerging from Mining Shaft in the West Rand / South Africa

*1. Women start by grinding the rocks into a powder*

*2. Water is then poured over the powder over towels, where heavier particles (including gold) are caught*

*3. Tiny gold particles can be found in the pan*

*4. The gold is mixed with mercury, which forms a ball which will later be heated to extract the gold*

**Figure 7:** The four majors process of artisanal mining in Krugersdorp/ South Africa [11]

## 2.1 Bench Mining Methods

Bench Mining utilises manual labour and mechanized equipment. The method represents almost a buffer between small scale and large scale Mining methods as it is semi-mechanised with intense labour. Bench mining offers a simple and safe method to exploit a deposit, but requires a systematic approach, with manual work combined with mechanical loading and hauling, the removal of waste and ore in a sequence (S.M. Rupprecht, 2017) [12]. Based on observations made by the author in Rwanda and Burundi, one man can load 1 $m^3$ to 10 $m^3$ (*in situ*) of rock in eight hours, depending mainly on the geology, the size and density of the rock pieces, and the height to be lifted. The bench configuration is based on empirical design, relying on in-field measurements from a number of defunct Belgian operations that were mined during the 1950s. The following figures are describing the process of bench mining methods by the Open pit done by a Dozer or Multi-loader (Ref. Figure 8):

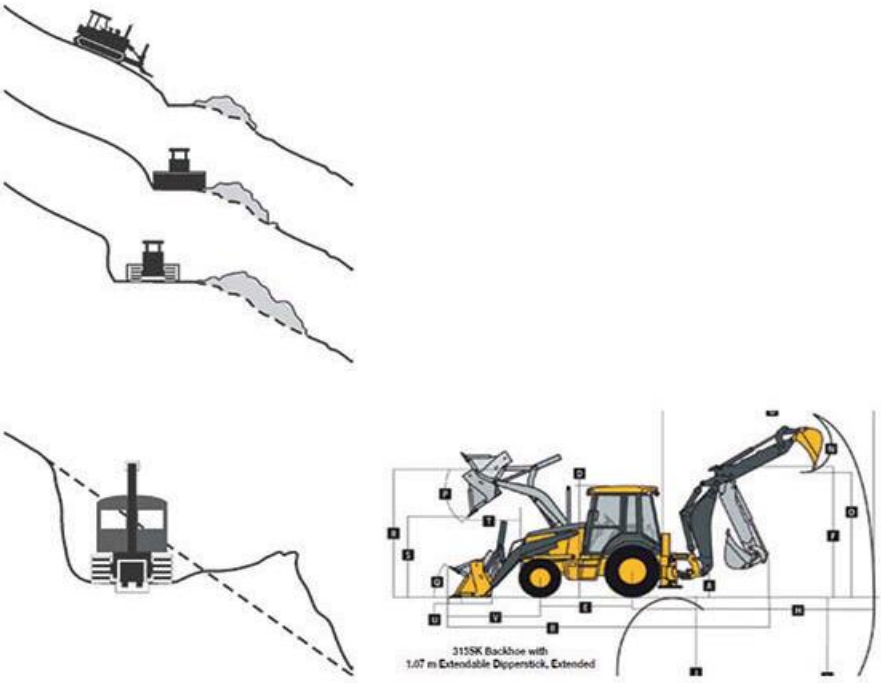


**Figure 8:** Dozer and TBL (tractor loader-bucket) establishing bench mining (Nichols, 1956; Bell, 2014)

The Figure 8 above indicates the start or the first cut of bench mining from the side of a hill or mountain. The height and widths between roads can be appreciated by the miners. The excavation and transport of materials (Rocks) off the pit can be done by using TBL or manually by using picks with workers forming a line and transporting the material with shovels down-dip to the slusher in the centre of the mining area. The benches and slopes may remain in stable condition from 60 years and up in case of Rwanda and Burundi. The figure 9 below is presenting a possible excavation & transport done with machineries; it illustrates some basics of sections of an Open Pit Mine [13].

Figure 9 shows an illustration of an Open Pit Surface Mine. The main objective in any commercial mining operation is the exploitation of the mineral deposit at the lowest possible cost with a view of maximizing profits. The selection of physical design parameters and the scheduling of the ore and waste extraction program are complex engineering decisions of enormous economic significance.

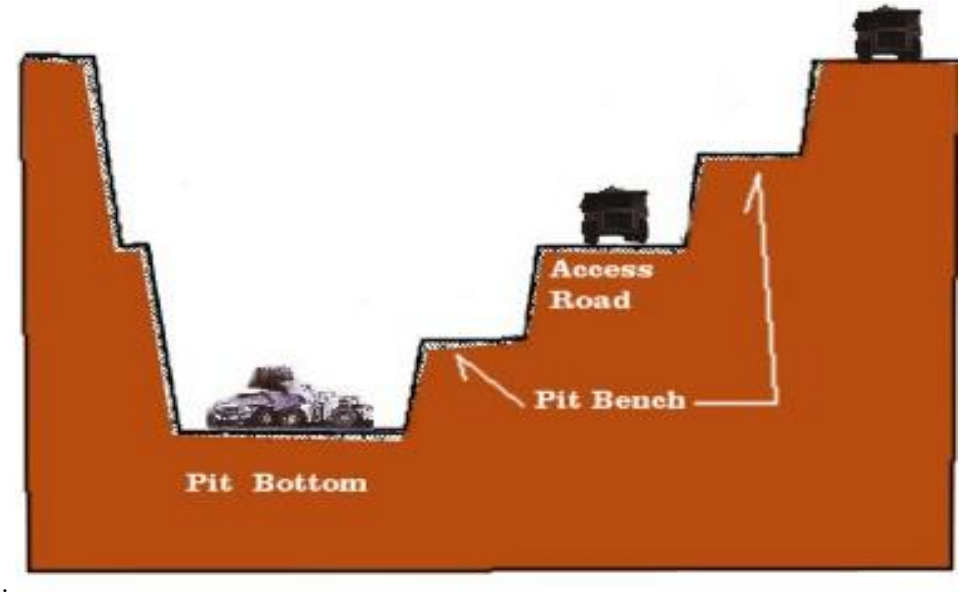


**Figure 9:** Basics Sections of an Open Pit Mine

The planning of an open pit mine is, therefore, basically an exercise in economics, constrained by certain geologic and mining engineering aspects. The Planning must account for both environmental protection, beginning as early as the initial exploration, and for reclamation. It is critical that planning alleviate or mitigate potential impacts of mining for two key reasons: (1) the cost of environmental protection is minimized by incorporating it into the initial design, rather than performing remedial measures to compensate for design deficiencies, by ensuring that the core holes are sealed and site reclaimed during mine closure, through a plan impact include aesthetics, noise, air quality (dust and pollutants), vibration, water discharge and runoff, subsidence, and process wastes; sources include the underground and surface mine infrastructure, mineral processing plant, access or haul roads, remote facilities, etc and (2) negative publicity or poor public relations may have severe economic consequences. From the start of the planning process, adequate consideration must be given to regulatory affairs.

## 2.2 Bench Mining Machineries

Mechanized loading can be done with a multi-terrain loader (Figure 10) or a TLB, which can be used to excavate and load the bench material. This a typical 3 t machine with 1.75 m wide and 3.5 m long, with a reach of 3.8 m and a tipping height of 2.2 m, its capable of a maximum speed of 11.3 km/h with the ability to navigate gradients up to 40 degrees.

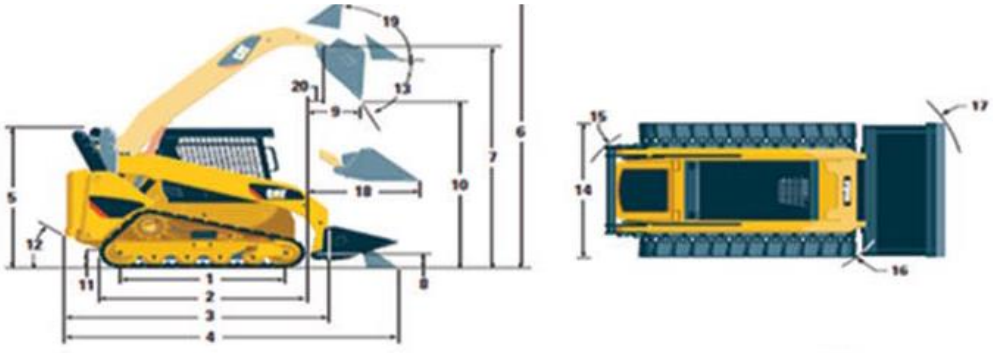

**Figure 10:** Multi-terrain Loader (Cartepillar, 2012)

There are many multi-terrain loaders available in the market, with purchase prices in the order of US$65 000 to US$95 000. A TLB would cost in the range of US$87 000 (Bell, 2016). Loading of mineralized and waste material is often conducted by a combination of manual shovelling and mechanized loading. The broken material is often transported to the beneficiation plant by a tractor-trailer arrangement, as shown in Figure 11 below, waste material is handled in a similar manner, and transported to the waste dump.


**Figure 11:** Tractor-Trailer arrangement (Bell, 2012)

## 2.3 Bench Mining – Mineral processing

Mineral process is typically conducted by means of sluicing or panning (Figure 12). Mineral processing in artisanal mining is generally inefficient, with recoveries in the order of 30%. Recovery improvements between 10% and 30% can be achieved using modern processing techniques. However, due to the size of the deposits and the entry costs of modern processing techniques, up-to-date processing equipment is usually beyond the reach of artisanal miners.

**Figure 12:** Panning operations

## 2.4 Bench Mining – Dump, tailings disposal and Reclamation

Waste management is an integral part of the mining cycle. The use of mechanized equipment allows waste to be loaded and hauled to selected and approved sites (Figure 13). These storage facilities can be benched and contoured and used to plant crops such as cassava or coffee. Reclamation plans include many of the following concerns: drainage control, preservation of top soil, segregation of waste material, erosion and sediment control, also solid waste disposal, control of fugitive dust, and restoration of waste and mine areas. The plan must also consider the effects of mine subsidence, vibration (induced by mining, processing, transport, or subsidence), and impact on surface water and groundwater. These environmental items often dictate the economics of a planned mining operation and determine its viability.

**Figure 13:** Waste Rock Dump

## 3. Some current cases study

### 3.1. DR Congo

In the East of DR Congo "Goma", the artisanal miners organised themselves in Mining Cooperative with a Board Administration and Business plan. The Cooperative is operating with minimum funds and resources, and unfortunately death associated with soil collapse as presented previously in figure 10; Bench Mining method could seriously help Artisanal Miners and save lives. The Cooperative has implemented a very innovative Memorandum of Understanding of Shareholders Fund distribution between the Government, Traditional leaders, artisanal miners and the company which brought more peace and prosperity between parties from income generated and this model is really needed in South Africa in particular and Southern Africa in general for conflict-prevention between role players and promote prosperity between all parties, the model is represented by the Table1. Besides of Bench Mining, Artisanal Mining Community is also looking for ICP-MS to assist in Metal quantitative and qualitative analysis. Instead of depending on Chinese, Russia and Rwanda, this will be an opportunity to undergo analysis locally. The picture below is an illustration of ICP-MS Instrument [14]. The author "Mr Evariste Umba" approached a potential sponsor "RafikiGold" on behalf of COMIBU for sponsorship, the matter still under discussions.

**Table 1:** Model of Shareholders Fund Distribution

| Shares | Mineworkers | COMIBU | Community | Tax |
|---|---|---|---|---|
| 100% | 35% | 30% | 10% | 25% |

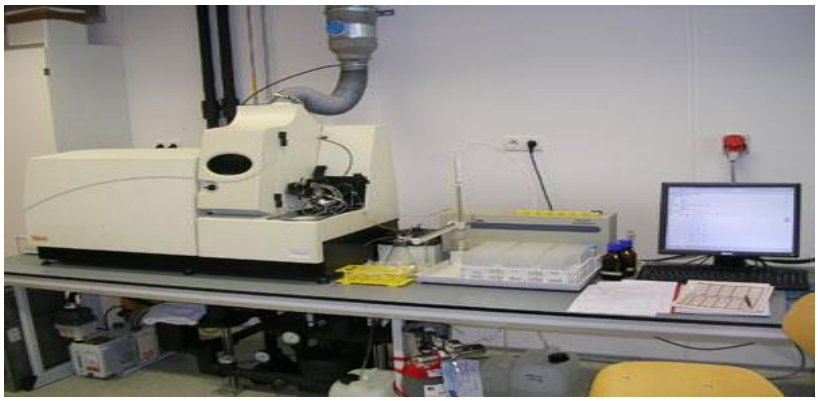

**Figure 14:** Inductively Coupled Plasma-Mass-Spectrometry (picture taken from Radboud University, Faculty of Science, General Instrumentation Department)

## 3.2. South Africa – Gauteng Province

### 3.2.1. Rustenberg area

In Gauteng Province of South Africa, artisanal mining is very active with Gold, Chrome and other minerals. The below Figure 15 is showing some artisanal mining activities in Rustenberg whereby a hired Dozer is extracting Chromite Ore (Chromium Oxide $Cr_2O_3$ of two grade 42 and 44)

**Figure 15:** Mining operation of Chrome excavation by a hired Dozer, 2020

The above Zama Zama Operation in Rustenberg is conducted by the permission of the landowners and conducted by local with foreign nationals. Miners do have buyers in the province and the Dozer was hired for R45,000 ($3,000) for 3 weeks of operations. The 4IR Yako Consulting Services been approached in October 2020 by the client to assist in preparation for compliance in Cooperative Registration by the Companies and Intellectual Property Commissions and possibly assistance in Business plan & profile drafting and compliance for Mining permit application by the Department of Mineral Resources and Energy for the purpose of boosting production and contacting some potential sponsors, the process is undergoing.

### 3.2.2. Krugersdorp Area

The community works in Krugersdorp been conducted since July 2019 up-to-date with the aim to build a relationship with the mining community, exchange as well with Zama Zama, mining sites visit and others. The program has been sponsored by a non-profit organisation called "Life Change Ministry (NPO-050-057) with an amount of R19,000 ($1,267) up-to-date toward transport costs, communication, community feeding, and any form assistance. The program has successfully interviewed Krugersdorp Zama Zama to understand their operations and challenges. The Figure 16 below is presenting Mr Evariste Umba with Krugersdorp mineworkers in 2019:

**Figure 16:** Evariste Umba (fieldworker) with Mineworkers in Krugersdorp, 2019

The current Artisanal & less mechanised Mining Activity is demanding the creation of a Cooperative, memorandum of understanding between miners with Land Owner and Traditional leaders above a business plan which will assist toward funding acquisition not only for South Africa but for DR Congo and can be extended to Southern Africa as well.

## 4. Conclusions and Recommendations

Many artisanal mining operations are unsafe and do not adhere to good mining practices or meet the minimum with less Administrative skillful professional. And Zama Zama and Mchimbaji will not stop their practices because it is their way for sustainable livelihoods, cultural heritage, lack of job opportunity and desire of accessing their ancestral mineral lands, hence the diggers are ready to use any means which will enable them to reach such goals. This paper is recommending that previous owners of abandoned mining shafts where diggers are operating and government to invest in development of artisanal mining with aim to mine with mechanized & safe method, organise in cooperative and acquire for mining permit, rehabilitated the site, convert dumping sites into agriculture, create job and promote peace and prosperity in mining community

## Conflict of Interest Statement

The article and research work has no conflict of interest at this stage because most of artisanal miner's practitioners are looking forward that their works be known, supported and funded by the Academics, Business, Governments, other organisations and individual's readers

## References

1. Mining and Minerals in South Africa, August 2012, [online access: https://www.brandsouthafrica.com/investments-immigration/business/economy/mining-and-minerals-in-south-africa, accessed 17th October 2020].
2. *"Congo with $24 Trillion in Mineral Wealth BUT still Poor"*. News About Congo. 2009-03-15. Archived from *the original* on 2012-02-23. *Retrieved 2009-05-17*.
3. Morgan, M. J. (2009-02-01). *"DR Congo's $24 trillion fortune"*. African Business.
4. *"LITHIUM"* . *United States Geological Survey*. *Retrieved 30 June 2018.*
5. Facts & Figures, 2018. Minerals Council of South Africa .
6. Towards a life of poverty and uncertainty? The livelihood strategies of Gécamines workers after retrenchment in the DRC, [online access: https://www.tandfonline.com/doi/abs/10.1080/03056244.2016.1273827, accessed 17th October 2020]
7. Congo mining sector sheds 3,000 direct jobs since last year – chamber, June 7, 2016, [online access: https://www.reuters.com/article/congodemocratic-mining-idUSL8N18Z2OO, accessed 17th October 2020]
8. Evariste Umba-Tsumbu *et al*, The 3TGs mineral loitering: Reason of war and poverty in the Democratic Republic of Congo, [online access: https://www.researchgate.net/publication/343628740_The_3TGs_minerals_Reason_of_War_and_World_Electronic_companies_Involvement_in_looting_in_the_Democratic_Republic_of_Congo?showFulltext=1&linkId=5f350ba5299bf13404be880f, accessed on 17th October 2020] .
9. Kgothatso Nhlengetwa, Kim AA Hein, Zama-Zama mining in the Durban Deep/Roodepoort area of Johannesburg, South Africa: An invasive or alternative livelihood? The Extractive Industries and Society 2 (2015) 1–3.
10. S.M. Rupprecht, Bench mining utilizing manual labour and mechanized equipment – a proposed mining method for artisanal small-scale mining in Central Africa, The Journal of Southern African Institute of Mining and Metallurgy, January 2017 .
11. Legal Resources Centre, Artisanal Mining Report, 2016 .
12. Kim A.A. Hein *, Todani A. Funyufunyu, Artisanal mining in Burkina Faso: A historical overview of iron ore extraction, processing and production in the Dem region, The Extractive Industries and Society 1 (2014) 260–272.
13. Basics of an open pit mine, [online access, http://www.mine-engineer.com/mining/open_pit.htm, accessed on 23rd October 2020].
14. Generation Instrumentation, Radboud University, Faculty of Science, [online access, https://www.ru.nl/science/gi/facilities-activities/elemental-analysis/icp-ms/, accessed on 26th October 2020].