

Small Scale Mining in Ghana: Improving Operations by Utilizing Professional Engineers

K. J. Bansah, A. B. Yalley, N. K. Duamkor-Dupey and G. B. Sakyi-Addo

Bansah, J. K., Yalley, A. B., Duamkor-Dupey, N. K and Sakyi-Addo, G. B. (2016), "Small Scale Mining in Ghana: Improving Operations by Utilizing Professional Engineers", *4th UMaT Biennial International Mining and Mineral Conference*, pp. CSR 24-34.

Abstract

Small scale mining continues to contribute significantly to the socio-economic needs of Ghana. The operations have transformed from artisanal to the use of sophisticated mining techniques in recent times. Although the introduction of the Small Scale Gold Mining Law of 1989 has helped in improving small scale mining activities and minimized associated environmental hazards, the sector continues to face significant environmental, safety, health and security challenges. These challenges have partly been attributed to lack of involvement by professional engineers that have technical expertise to ensure efficient and safe operations. The absence of trained engineers in the small scale mining sector is believed to have contributed to poor safety standards, lack of environmental protection, and poor choice of mining methods, resulting in fatalities, damage to the environment, and significant ore losses or dilution. This paper reports preliminary findings of an ongoing study that looks at how professional engineers could be utilized to improve small scale mining activities in Ghana.

Keywords: small scale mining, engineers, mining techniques, safety and health, environment, hazards.

1 Introduction

Small scale mining (SSM) of gold has been practiced in Ghana for more than a century. It was legalized by the Small Scale Gold Mining Law of 1989 (PNDCL 218). The mining operation which traditionally involved use of rudimentary tools such as picks, shovels and spades to excavate mineral-rich bedrock and unconsolidated materials has evolved into the use of sophisticated mining machinery (e.g. excavators, drilling machines, dozers, and dump trucks) in recent times. Although small scale mining activities are reported to contribute significantly to socio-economic development of Ghana (Amankwah *et al.*, 2015; Tschakert, 2009; Yakovleva, 2007), there are more reported environmental issues that have been attributed to the mining practices (Aryee *et al.*, 2003; Babut *et al.*, 2003; Hilson, 2002; Bozongo *et al.*, 2003; Kwaansa-Ansah, 2010; Hilson, 2010). The environmental issues have included land degradation, water contamination, flora depletion, destruction of arable lands, and mercury contamination.

Safety concerns that have led to ground failures leading to fatalities and injuries have gained public attention in recent times. Examples include: the six small scale miners that were killed at Kyekyerere in the Ashanti Region of Ghana in early 2016, when a

pit wall collapsed; a collapse that occurred in 2015 killing 17 people at a small scale mine in the Central Region of Ghana; and many fatal accidents that have occurred as a result of failing benches or stopes.

Safety remains a major issue in small scale mining probably due to the predominant use of unskilled workforce. The small scale mining sector in Ghana is largely operated by non-professionals. As a result, the environmental and safety issues can partly be attributed to lack of involvement by professional engineers who have technical expertise to design appropriate mining methodology and adequate safety measures.

This paper therefore aims at investigating the expected contribution of professional engineers in the small scale mining sector in Ghana, with the view of mitigating environmental, health and safety, and security issues. Four small scale mining sites in the Tarkwa mining area of the Western Region of Ghana (Fig. 1) were used as case study. Interviews were conducted with owners/managers and some of the operators. Also, some officers of the Minerals Commission of Ghana, Ghana National Association of Small Scale Miners (GNASSM) and Accra Mining Network (a not-for-profit organization in Ghana) were interviewed for relevant information regarding their views on utilizing professional engineers in small scale mining in Ghana.

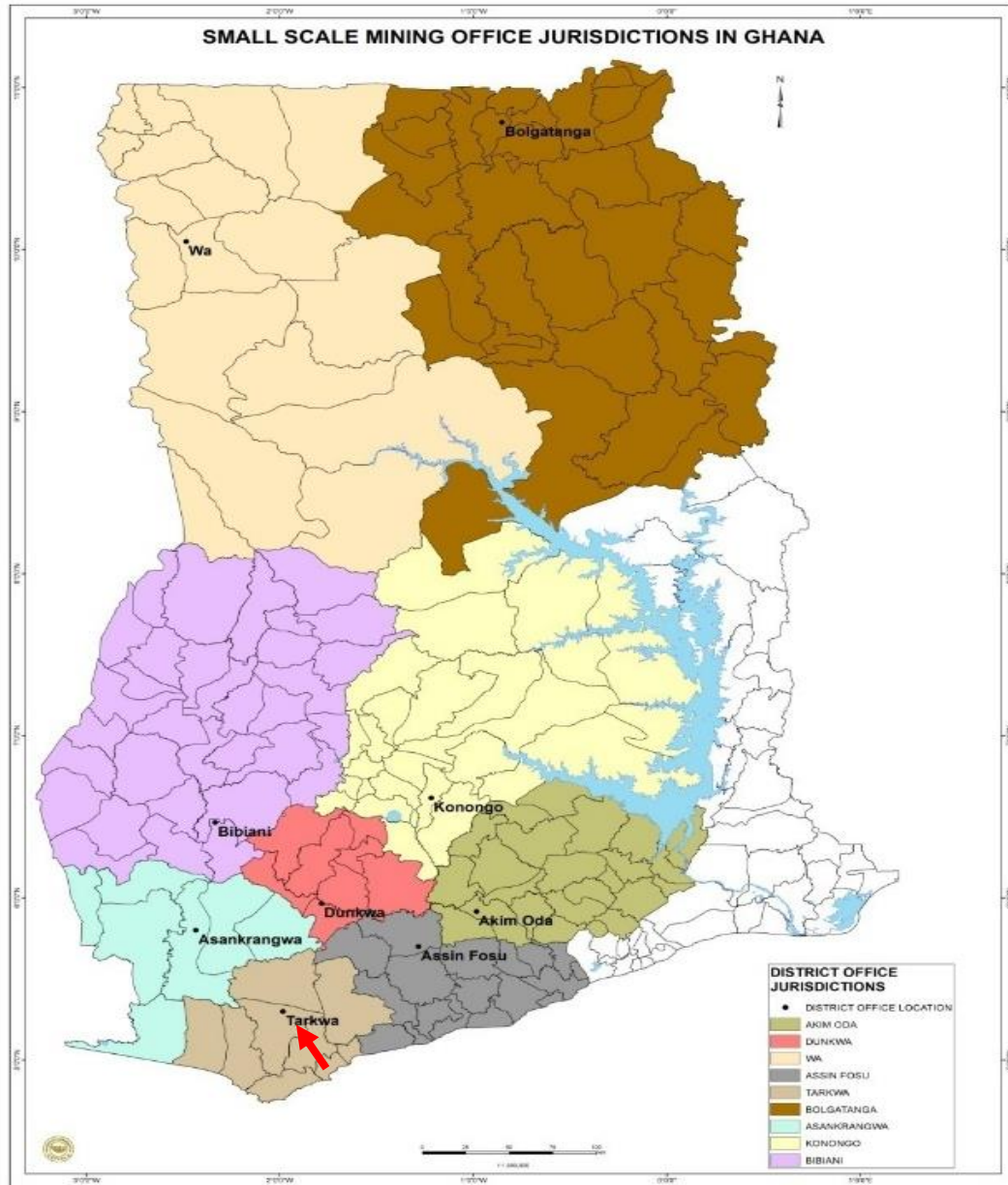


Fig. 1 Small Scale Mining Districts in Ghana showing Study Location (Source: Ntibrey, 2015)

2 Materials and Methods Used

The methods adopted in this study involve visits to small scale mining sites, interviews and interactions with mine owners and operators, visits to the small scale mining district office of the Minerals Commission, consultations with small scale district officers and interest groups such as the Accra Mining Network (a not-for profit organization), and online surveys.

2.1 Study Area and Methodology

Tarkwa is a historical mining town and hosts eight licensed small scale underground mines mainly operating in old abandoned underground mine openings. It also currently hosts three large scale

mining companies: Goldfields Ghana Limited, AngloGold Ashanti Iduapriem Limited, and Ghana Manganese Company Limited. It is the capital town of the Tarkwa-Nsuaem Municipal Assembly and is located on latitude 5.3000° N and longitude 1.9833° W. The 2013 census data put the population of Tarkwa at 34,941 with the main occupation of the people being mining.

The town has a small scale mining support center that provides technical and extension services to the small scale mining sector. There are over 300 licenses issued to small scale miners to conduct small scale mining in the Tarkwa mining district. However, only 15 licensed small scale mines are in active operations, of which five are surface operations and 10 are underground. Out of the 10

underground registered small scale mines in the mining district, four are located around the Tarkwa town, while the others are located in other parts of the mining district.

The process of mining adopted by small scale mining is similar to conventional mining, and involves exploration, development, exploitation and transportation. The following sections describe the methods employed by small scale miners in Tarkwa. The processes have been described by Bansah *et al.* (2016). The miners do not generally conduct exploration. Where exploration is done, it is typically not conducted in a manner consistent with standard practices. The miners arbitrarily sample the materials using simple handheld tools into sacks for confirmatory tests that involve pounding the materials into fines and subsequently washing with water to obtain gold concentrate (if any). Fig. 2 shows metallic mortar and pestle typically utilized during the confirmatory testing.



Fig. 2 Metallic Mortar and Pestle for Pounding Samples

The general concept of development is to make access to the mineralized zone and prepare it for excavation. Access to ore deposits are typically old abandoned adits constructed by the erstwhile State Gold Mining Corporation (SGMC), or adits created by the miners themselves. The old abandoned adits are mostly equipped with metallic rails to support the sides and roof of the openings. The adits created by the miners are manually constructed using simple tools such as chisel, hammers, picks and shovels. Figs. 3 and 4 show manually constructed and old abandoned adits respectively.

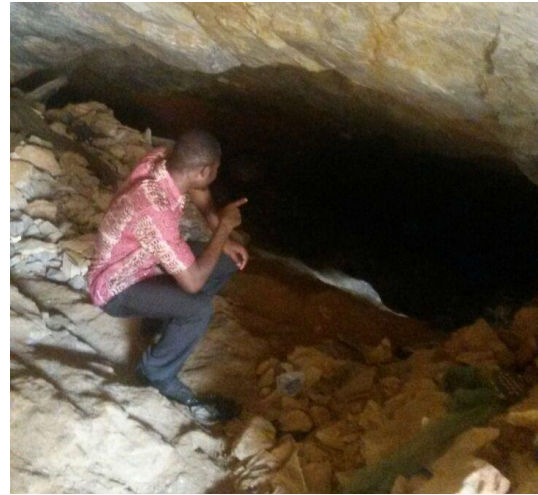


Fig. 3 Manually Constructed Adit



Fig. 4 Old Abandoned Adit with Metallic Support

In exploitation, the materials are typically fragmented using rudimentary tools such as chisel, hammers and picks. Where the rocks are harder to be handled manually, explosives are utilized to break the rocks into pieces. The broken rocks are excavated with shovels into sacks and carried on the head or back to the surface for processing. In the semi-mechanized operations, the materials are transported by wagons or wheelbarrows and pushed to the surface by the miners. The wagons may also be anchored to a hoisting rope and mechanically hoisted onto the surface. Figs. 5 to 9 show some techniques in the exploitation and transportation processes adopted by small scale miners.

Processing of broken materials generally involves crushing the rocks using changfa, and subsequently washing the rocks using sluice boards. The concentrate is further processed with mercury and borax to obtain marketable product with purity of 22.5 to 23 carat. Figs. 10 and 11 show changfa and sluice board respectively, while Fig. 12 shows a typical setup for retorting mercury.



Fig. 5 Excavation of Materials using Pick



Fig. 7 A Miner Carrying Broken Material out of a Stope



Fig. 6 Small Scale Miner ready to Transport his Sack of Load from the Stope



Fig. 8 Transporting Materials using Wheelbarrow



Fig. 9 Wagon and Winder Station in Semi-mechanised Operations





Fig. 10 Changfa



Fig. 11 Sluice Board



Fig. 12 Mercury Retorting



Fig. 13 Timber Support

Auxiliary activities include supporting mine openings, ventilation, mine drainage, safety inspection, water treatment etc. The underground openings are either supported or unsupported. In the unsupported stopes, the rocks are left to naturally support themselves, while supports such as timber (Fig. 13), bamboo and metal rails are used as artificial supports in some of the stopes. The miners mostly depend on natural ventilation, while underground water is pumped directly into the natural environment. Safety inspection is uncommon in small scale mining operations.

2.2 Online Survey

Ten questions were structured in Google Forms and floated around to respondents that include members of Accra Mining Network (AMN), members of the Ghana National Association of Small Scale Miners (GNASSM), a wide range of trained engineers, and small scale mining district officers of the Minerals Commission. The link to the questions was shared with respondents through social and professional media platforms including WhatsApp, Facebook, LinkedIn, and emails. The questions were built to receive preliminary responses upon which a more structured questionnaire could be developed. The following questions which were used for the online survey, ASM is defined as artisanal and small scale mining.

1. Will professional engineers make a greater impact in ASM?
2. Which type of engineers will be more valuable to ASM?
3. Do you think involving professional engineers in ASM will help mitigate environmental and safety concerns?
4. Will professional engineers help to improve resource recovery?
5. Do you anticipate that such engineers will cause an increase in revenue from ASM operations?
6. Why are the engineers not involved in ASM?
7. If the response in question 6 is cost, is it not possible to hire them as temporary consultants/advisors?
8. Why is the ASM sector not taking the opportunity to hire from the growing number of unemployed graduate engineers?
9. Are you satisfied or comfortable with the mode of operation in ASM in Ghana?
10. What is your general perception/suggestion(s) on utilizing professional engineers in ASM?

3 Results and Discussion

Preliminary results show that small scale mining activities are poorly conducted and show potential significant safety challenges. As reported by Bansah *et al.* (2016), small mining operations are inundated with unsafe acts and conditions resulting in fatalities, injuries and environmental contamination. Underground workings in small scale mining are poorly supported. Direct discharge of mine water into the natural environment without any form of treatment can potentially contaminate surface water resources. Other conditions include poor housekeeping and inadequate safety precautions. The improper handling of mercury can result in losses that can contaminate water and soil resources and be injurious to miners.

Responses received from 60 respondents on the 10 questions suggest that everyone is dissatisfied with small scale mining activities in Ghana. About 45% of the respondents believe that mining engineers would be most valuable to the small scale mining sector (see Fig. 14). Other engineers suggested

include geological, mineral, geomatic, safety, and environmental engineers. Involving trained engineers “will make tremendous difference in exploration, mining processes and environmental management”, according to one respondent.

Additionally, all the respondents are of the opinion that involving professional engineers will make a greater impact in the sector, mitigate environmental and safety issues, improve resource recovery and cause an increase in revenue. However, small scale miners are of the view that it is more expensive to hire a trained engineer, while engineers also argue that small scale mining activities are unattractive and unorganized. Furthermore, the respondents are of firm belief that it is still expensive to temporary hire professional engineers. Tables 2 and 3 contain responses on two significant questions in the ongoing research. Some of these responses are slightly edited to correct for typographical and grammatical errors, and jargons. A great number (more than 60%) of perceptions held by respondents are consistent with findings from field visits and interactions with mine operators.

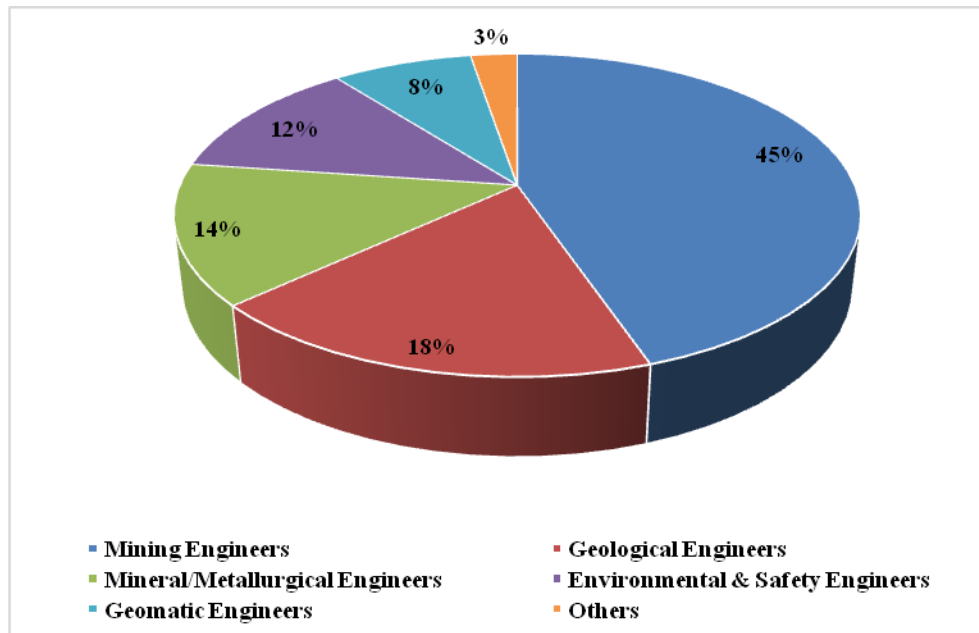


Fig. 14 Response to which Type of Engineers will be more Valuable to ASM

Table 1 Responses to Question 6

No.	Response
1	Cost
2	Cost
3	The general impression that it is illegal because of the so called description
4	They are not organized. Pay less and its poses a very high risk
5	Because large scale has always been available to employ them
6	Because most engineers prefer to work for larger mining companies with high pay rather than getting involved in ASM
7	Cost and fear

8	Due to mostly illegal activities of ASM's
9	Better alternatives available, Capital is lacking, Credibility problems associated with ASM etc.
10	Engineers see the ASM sector as an area reserved for unskilled professionals and also relatively more expensive to employ an engineer in ASM
11	They are only focusing on the Large scale operations such as Newmont and Goldfields
12	Safety and cost
13	Lack of proper structures and they are mostly one-man business
14	ASM operators are not ready and willing to pay for the extra value an engineer will bring to the table. They are content with the meager revenue they make
15	Because managers of ASM think engineers are expensive
16	Because it is not well regulated
17	Low salaries, public rejection, not dignified
18	Because their services maybe expensive for the ASM operators
19	The pay they will receive as compared to what they earn from large scale mining. And also the life of the mine with respect to their future
20	They prefer large scale mining where they earn more
21	They see ASM to be unattractive
22	ASM owners do not have proper structures to accommodate engineers
23	They are not involved because the pit owners always want cheap labour

Table 1 Responses to Question 6 (cont'd)

24	Cost
25	ASM owners prefer cheap labour
26	Ignorance on the part of the engineers and the image of ASM in general
27	Cost
28	Industry not structured and poor work conditions
29	Because no engineering design is used/needed and the cost of hiring engineer is high
30	It is not regulated
31	Most of them especially the recent graduates find ASM not to be lucrative and also see it as a demeanor to their status and qualifications. Plus the owners of the ASM see it as costly employing these engineers
32	Low salaries and other superstitious believes that there is a lot of black magic ("juju") in ASM
33	Insufficient capital
34	Because the government needs to get them involved and other stake holders else they will not always be part
35	They think engineers are expensive
36	Engineers are expensive
37	The fear of losing their certificate because a lot of these ASM are not registered by law
38	Cost
39	Less direct investment
40	Cost
41	Lack of experience engineers and attractive salary
42	No legal requirement
43	Cost
44	Because it currently has no prestigious packaging and does not pay much
45	Because of the cost of hiring them
46	Cost
47	Lack of structures in organizations engaged in ASM which prevents competitive remuneration and compensation for such professionals

48	Poor regulation
49	Most of the engineers think ASM is below their scope
50	They charge higher
51	Because we do not have enough mining engineers in system
52	They are not organized. Pay less and its poses a very high risk
53	They are not organized and poses high risk
54	Because they have not been invited to deal with the situation
55	The engineers have not been invited
56	Lack of capital, less knowledge about the potential of ASM, ASM is a very high risk venture
57	It could be due to lack of motivation
58	Resources
59	Low income

Table 2 Responses to Question 10

No.	Response
1	The engineers must be provided role to play
2	A way to start to sanitize the industry, bring some professionalism to bear, remove the negative impression and urge financiers to take a second and critical look at the industry for funding.
3	ASM should be made attractive
4	It needs to happen to help change SSM for the better
5	Using professional engineers will help mitigate the negative impact of ASM on the environment and society
6	I think ASM should rather be done by professional engineers because they will know how to mine safely and still keep the environment safe for the community.
7	It will be great If they are integrated into ASM operations
8	The government must lead the way in terms of policies, support financially and reward adequately
9	Involving engineers in ASM would help promote sustainability in the sector
10	The first step is that the university should have some modules in small scale or artisanal mining. There should be a course like Small Scale Mining Principles. Because the knowledge required for small scale mining is different from that of large scale. I am a graduate professional in the field doing small scale mining and I must confess, before any graduate can be useful to small scale miners, we need to train him or her on these principles. All they learn in school is focused on large scale mining
11	It would be a great idea provided the cost will not outweigh the profit.
12	The Mines Department must make it mandatory for ASMs to have engineers in their operations before they start operation. Monitoring must be enforced to ensure compliance. The operations should be shut for failure to comply with regulations as is done with large scale operations.
13	They must be utilized. The sponsors should sit back and let the engineers manage the operations
14	It will help boost their production and control the environmental issues
15	Their involvement will help ensure a safer and more controlled extraction
16	Professionals should make themselves available to the ASM sector
17	Graduates can come together to form a consultancy firm that gives advice at a minimal cost to ASM operators.
18	It would improve recovery and make operations environmentally friendly
19	It will make ASM more safe to practice and increase their revenue
20	I think it will change the image of ASM and make their operations conform to best practice
21	ASM activities would see a facelift in operations if engineers are utilized in the sector
22	Professional engineer's in ASM will help in tracing and mining the orebody, but workers with no knowledge in mining will have to mine arbitrary
23	They should be actively involved

24	Workshops should be held for the ASM sector to educate them on the value of having an engineer on site, its significance on production and impact on revenue
25	Very important to involve them, but they must take their time to study the dynamics of the sector to enable them position themselves properly to render good service. Also, they should own small scale mines themselves and practice what they can do for others in the sector
26	It will promote environmentally safe and sustainable mining practices
27	The Minerals Commission should come in with a policy that all ASM should have qualified engineers to supervise their operations. They should be regulated by same policies and environmental specifications used for the multinational companies. This will make the ASM sector employ qualified engineers to handle their projects
28	Professional engineers in ASM will understand health and environmental impacts of their activities and will device engineering/technical control to mitigate the impacts
29	The professional engineers are “book long”
30	Engineers should be made aware of this in their training and there should also be some kind of platform where the owners and engineers can meet to clear the perceptions about ASM.
31	Engineers should be used mostly as consultants but they should be willing to charge lower prices

Table 2 Responses to Question 10 (cont’d)

32	Great idea to use engineers
33	I think utilizing professional engineers will help in maintaining the scope of the environment and also educating the people involved about the processes
34	It will help increase recovery
35	Revenue will increase
36	It is a great initiative to involve engineers
37	To cause increase in revenue, help mitigate environmental and safety concerns.
38	Good to involve engineers
39	Proper safety protocols and environmental protection
40	ASM should employ young engineers and groom them through training to help improve their operation.
41	There should be a legal requirement
42	Engineers should be involved to help streamline the various stages of the project, thereby eliminating illegal issues and maximizing profit through effective and efficient systems.
43	Professional engineers should be involved to make the ASM a sustainable venture and increase its returns with effective and efficient operations.
44	Professional engineers will help reduce the environmental impacts
45	The best thing that could happen to the mining industry
46	ASM should be restructured to attract such professionals.
47	Good idea! Professionals generally make better decisions, all things being equal.
48	There is more room for improvement
49	It will help improve environmental problems
50	I suggest that students mining engineers be made to do their national service in ASM to help address some of the challenges in ASM before being employed into the large scale mining companies.
51	ASM should be made attractive
52	Involving them is the best solution to the problem because that is what they are trained to do
53	Professionals can make a better impact in ASM
54	It would be good because their skills and experience will make ASM's operation more efficient, safe and environmentally friendly
55	A group of engineers should come together, create a group, make impact, and the artisans will then see the need
56	Great idea to involve engineers

4 Conclusions and Recommendation

This paper reports preliminary findings of a study that looks at how trained engineers could be involved in artisanal and small scale mining in Ghana. Visits were made to the Small Scale Mining District Office of the Minerals Commission to interact with the District officer. Visits were also made to small scale mining sites to observe operations and obtain information on mining processes and environmental and safety issues. Ten questions were also structured in Google Forms and administered to target respondents including small scale district officers, engineers, members of Ghana National Association of Small Scale Miners, and members of Accra Mining Network. Preliminary results show that involving professional engineers would help mitigate environmental and safety issues, improve resource recovery, and increase revenue. However, cost of hiring such professional engineers poses a significant challenge to small scale miners. Further work includes building a more structured questionnaire derived from the preliminary responses, and expanding the scope of respondents to cover all stakeholders of the artisanal and small scale mining sector in Ghana.

4 Acknowledgements

The authors are grateful to all the respondents for sacrificing their time to respond to the questionnaires. Contributions from members of Ghana National Association of Small Scale Miners, Accra Mining Network and the Minerals Commission, Tarkwa Office are well acknowledged. Much appreciation also goes to the owners/supervisors who allowed the visits to their mine to observe operations and conduct interviews.

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Authors



Kenneth J. Bansah is a Graduate Research Assistant and PhD Candidate at Missouri University of Science and Technology, Missouri, USA. He holds an MPhil Degree in Mining Engineering from the University of Mines and Technology, Ghana and BSc. (First Class) in Mining Engineering from the Kwame Nkrumah University of Science and Technology, Ghana. Since July 2010, Kenneth has been the Director and Chief Consultant of Safety & Environmental Research Consultancy Limited providing consulting services in environmental and safety issues. His current research areas include blast optimization, artisanal and small scale mining, environmental and engineering applications of geophysics, occupational health and hygiene, safety and environmental management issues. He is a member of SME, CIM, SEG, NSBE, EAGE and AEG.



Akuba Bezeba Yalley is an MPhil Mining Engineering student at the University of Mines and Technology. She holds a BSc (First Class) in Mining Engineering from the University of Mines and Technology. She has worked with AngloGold Ashanti, Obuasi Mine, an Underground Mine in

Ghana as a Mine Planning Engineer. She has also worked with African Mining Services (Adamus Resources), an Open Pit mine in Ghana. Her research interests include underground design and planning, artisanal and small scale mining, surface mine planning and design. She is currently a member of AMRS.



Nelson K. Dumakor-Dupey holds BSc in Mining Engineering from University of Mines and Technology. He is currently a Teaching and Research Assistant in the Mining Engineering Department of the University of Mines and Technology, Tarkwa, Ghana. Areas of his research

interest are Modelling and Simulation of Mining Systems, Sustainable Mining and Mine Reclamation. He is a graduate member of AusIMM.



Georgette Barnes Sakyi-Addo is a mining entrepreneur having consistently founded and managed startups and small and medium business entities in the West African mining sector. She has also established her own locally-owned Mining & Exploration supplies company, Georgette

Barnes Ltd, representing known sector brands such as Australian Mud Company, Breithaupt, RIDGID and Westernex. In 2015, she received a certificate in Mining Law and Policy from University of Ghana. She holds certificates of Proficiency in Principles of Mining Engineering and Surface Mining Operations. Georgette established and volunteers for Women in Mining - Ghana, and the Accra Mining Network. Her interests include local content in the mining sector, small scale mining and diversity in the sector.