Occupational Health and Safety in Gemstone and Graphite Mining Industry - Sri Lanka

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Abstract - Sri Lanka is one of the famous countries for gorgeous gemstones and graphite. According to the historians, the gem industry in Sri Lanka has been existence for more than 2500 years. Various and quality gemstones are found in Sri Lanka, which has widespread demand worldwide. For the graphite, Sri Lanka has rarest and valuable vein or lump graphite. The purpose of the study is to explain the mining process, hazards, and risks in the mining industry and safety and occupational strategies in the mining industry.

Index Terms - Gemstone, Graphite, Hazardous, Mineworkers, Occupational Health, Risk.

1 INTRODUCTION

The gemstone mining industry has a long history in Sri Lanka. In the pages of history, many explorers claiming that this country had the best gems on earth. Still, Sri Lanka has very demanded mountaintop for world-famous gemstones such as sapphire, tourmaline, ruby, chrysoberyl, topazes, and blue-sapphire. Gemstone mining places are situated in Ratnapura, Okkampitiya, Monaragala, Kamburupitiya, Elahera, and Balangoda [1]. Gemstone mining is a complicated process that requires much time, a considerable workforce, equipment, and knowledge. Generally, gemstone mining can be divided into two categories those are,

1. Surface Mining
2. Underground Mining

Surface mining methods are divided into six categories those are hydraulic mining, river panning, open-pit mining, strip mining, mountain top removal mining, and quarrying. Underground mining methods are divided into five categories those are borehole mining, drift mining, shaft mining, slope mining, and hard rock mining. Graphite is a natural form of carbon. It has good electrical conductivity and heat resistance. It can use for lubrication purposes—graphite used in many thermal intensive applications. In the graphite mining industry, Sri Lanka is one of the countries which produce commercially usable vein or lump graphite. The vein or lump of graphite is the rarest and valuable form of graphite [2]. Lump graphite has the highest degree crystalline of all conventional graphite material due to its highest degree of crystalline vein graphite has higher thermal and electrical conductivity [2]. It can easily mold and can be formed into solid shapes. The fundamental uses of natural graphite are foundry facings, steel making, pencils, lubricants, and crucibles. Amorphous and flake graphite is used for brake pads, in the steel industries graphite crucible used to hold molten metal, However, and Lithium-ion batteries require a graphite electrode. Industrial demand for graphite markets is forecast to grow continuously; however, the growth possible for the graphite industry to expand due to emerging application and inventiveness in nuclear energy, fuel cells, and semiconductors. Sri Lanka has three major graphite mines those are, Kahatagaha graphite mine, Bogala graphite mine, Kolongaha graphite mine.

2 MINING PROCESS

Gemstone mining can be categorized into two categories those are 1: surface mining, 2.Underground mining. Firstly surface mining was always done. If there are no results, then underground mining was done [3]. But underground mining takes long working hours, requires advanced equipment, and costs extra money to pumping, digging, electricity, etc (Fig.1).

Fig. 1. Pit Mining [4]

2.1 Surface mining

It used to obtain gemstones from the rocks. It has six different types of mining.

Hydraulic mining: Powerful jets of water used to loosen the gem material from the overburden. The water pressure splits down the rock and washes a large piece of it downhill. It used between 1800 and 1960. It stopped due to its disastrous consequences [3].

River panning: In this gemstones collected while that they are gravels from the river in the mining area. A large pan with water and shaking it back and settle heavy materials from the bottom of the pan. This is a huge time-consuming method and the success rate is very low [3].

Open-pit mining: It is done under an experienced gemologist. Layers of land removed after the other till rocks are visible. The rocks are removed and the gems are searched for the rocks. It is performed only when the surface of the land and the rocks are between closer [3].

Strip mining: It is a similar process to pit mining. Trees and bushes are removed from the mining site firstly. Small holes are drilled distant from one to another through the rock. They are blasted and the gemstones are getting [3].

Mountaintop removal mining: Mountain top cleaned by cutting shrubs and cutting trees. Then the top of the mountain blasted for making the vein. It gives huge blocks of a mountain to get the gemstone. Trashes are dumped in the valley with the help of machinery [3].

Quarrying: It is less hazardous to the environment. Rocks were drilled to use the cement and blasted with dynamite to get the rocks [3].

2.2 Underground mining

It is done when the surface mining is not possible. Precious gemstones are discovered in this method. Miners make underground rooms for the bigger diggings.

Borehole mining: In this mining holes are drilled deeply inside the land or rock. Then water was pushed down and it hits the rocks and breakdown them. Wanted water is sent out of the rocks and it is processed for the rocks [3].

Drift mining: It is done on the sides of the mountain. It is done by making horizontal tunnels through the mountain rocks. It is done with the help of gravity so the gem materials are come out easily. It is an environmentally friendly method and shifting equipment is very easy [3].

Shaft mining: Vertical tunnels are created in this mining. Tunnels are reaching the rock that has gems. These tunnels are used to blast the rocks after mining tunnels are refilled with muds, dirt, and cement [3].

Slope mining: In this shafts are made slant, and then they are made parallel to the ground. It is done when the straight tunnels are not possible. It is also called as slope mining [3].

Hard rock mining: In this mining, tunnels are made inside the grounds. In deeply floors are created and one is completed after one. It is a dangerous gemstone mining method. These rocks are broken into small or medium pieces. These gemstones are mostly used in jewelry pieces [3].

Graphite mining can be categorized into two types those are

1. Open-pit method (Surface quarrying)
2. Underground mining

2.3 Open pit method

This method is used when the ore is closed to the earth, and the surface material covering the deposit is thin. To take graphite by breaking the rocks by drilling or using dynamite explosives to cut the rocks and compressed air or water to split it. This drilling and blasting method is used to release large-sized graphite flakes on hard rock. The borehole mining method is a standard mining method in open pit and underground mining. Drilling a hole to reach the ore and making slurry using water after pumping it back to the water and mineral to a storage tank for further processing [5].

2.4 Underground mining

This method is done when the ore is in the highest depth. Shaft mining, drift mining, slope mining, and hard rock mining are unique to underground mining and are engage in graphite extraction (Fig. 2).

Fig. 2. Inside tunnels at the Kahatagaha Graphite Mine - Sri Lanka [6]

3 HAZARDOUS AND RISKS IN THE MINING INDUSTRY

The mining industry has been among the most hazardous occupation in the world. The hazards of working in mines will vary with some factors such as the type of mineral mined, geological formation, mining techniques, and health condition of workers. Here I am going to discuss risks in this industry, current occupational health and safety methods in progress, and a way to reduce risks in this industry. In the mining industry, workers have to face some hazards and risk agents that can be categorized into three types. Those are physical agents, chemical agents, and biological agents [7].

3.1 Physical agents

When workers working in deep underground work due to the high-temperature workers suffer from,

- Heatstroke
- Heat cramp
- Anxiety
- Lowered morale

Due to cold workers suffer from,

- Frostbite
- Trench foot
- Aggravated Raynaud's disease

When working in deep underground mines atmospheric pressure will change due to change in atmospheric pressure works suffer from,

- Joint pain
- Chest pain
- Air embolism
- Neuralgia
- Toothache

Due to poor lightning workers suffer from,

- Loss of visual acuity
- Giddiness

When workers work with drilling machines and without proper ear protection due to the high decibel noise workers suffer from,

- Occupational deafness

When workers work in narrow seems and controlled position due to limited working space workers suffer from,

- Beat disease
- Displacement and dislocation of joints

3.2 Chemical agents

When workers working with mineral dust both in and out of the pit workers suffer from,

- Pneumoconiosis
- Induced and aggravated the respiratory disease
- Poisoning by lead, mercury, manganese

When mining workers blasting minerals rock with explosives or due to inadequate ventilation may create oxygen deficiency so, works suffer from,

- Gas poisoning (CO, CO_2, NO_X, SO_2, CH_4)
- Anoxia

Due to the underwater in the mine pit workers suffer from,

- Occupational dermatoses

3.3 Biological agents

When the workers work in the pit where parasites and fungi grow easily owing to high humidity and poor sanitation workers suffer from,

- Ankylostomiasis
- Sporotrichosis
- Weil’s disease

In this section, a brief introduction about some of the hazards and risks in the mining industry are briefly discussed.

Heatstroke or sunstroke: It is a condition caused by the human body, and it is a result of the physical exertion in high temperature or prolonged exposure. It happens when your body temperature rises to 104°F/40°C or higher than that temperature. It is the most common condition in the month of summer. It needs emergency treatment if it is not; it can damage your brain, kidneys, heart, and muscles. If there is no treatment for a longer time, it will be increasing your risk of severe and may be caused to death [8].

Heat cramp: It is involuntary spasms of muscles that are occurring in a person. It is affecting humans who are physically active in humid or hot water. They are also associated with dehydration. Major muscles that are being stressed in the healthy environment are usually affected by the heat cramp. In this situation, muscles are thigh and leg, and the core muscles and arm muscles. It is quickly affecting young children and elder in many ways. It is identified by reviewing the patient history and the muscle groups that are involuntarily in spasm. Cooling the body, stretching the muscles that are cramping, and hydration are the treatments for heat cramp. Avoid excessively in a heat day, resting in the shade, and drinking a lot of water to avoid heat cramps [9].

Anxiety: It is your body's response to stress in a natural condition. It is a feeling of apprehension or fear about what is to come. Going to a job interview for the first time, the first day of school, doing a presentation, giving a speech to a crowd, etc. if the anxiety lasts for over six months, you may have affected the anxiety disorder. Some symptoms help to identify the anxiety. They are uncomfortable feelings of sorry, increased irritability, sleep difficulties such as problems in falling or staying a sleep [10].

Frostbite: It is an injury caused by the freezing of the underlying tissues and the skin. When it affects your skin becomes very cold and red, then numb. Hard and pale. It is most commonly on the nose, ears, cheeks, toes, and chin. Windy weather is cold, and skin in the cold are the most vulnerable reasons to frostbite. It can occur on the skin covered by clothing or gloves. It is a milder form of cold injury that is not permanent skin damage. There are first aid treatments, such as re-warming the affected skin. It must have medical attention because it may damage the skin tissues, muscles, and bones [11],[12].

Trench foot: It is a severe condition that results from your feet that is wet for a more extended period. It was firstly identified in the First World War. It is also known as immersion foot syndrome, which leads to swelling, pain, and sensory disturbances in the feet. It can also lead to damage to the blood vessels, nerves, skin, and muscle. Nowadays, trench foot is not the same as tissue loss as the soldiers that they experienced in the First World War [13].

Aggravated Raynaud’s disease: It affects some parts of your body like toes and fingers etc. it makes feel numb and cold that responds to cold temperatures or stress. In this disease blood circulation areas are affected and limiting the blood circulation. Smaller arteries that are supply blood to your skin narrow are affected by this disease. Most women are affected by this disease rather than men. It is also called Raynaud's phenomenon or syndrome. It commonly appears in the people that they are living in colder areas of the world [14].

Joint pain: It means discomfort, aches, and soreness in any of the body's joints. It is a common complaint. It doesn't need hospital treatment. It causes the result of an illness or injury. Arthritis is also a type of common

cause of joint pain. It can also be due to other conditions or factors. Arthritis is the most common factor that is the cause of joint pain. The two main forms of arthritis are osteoarthritis known as OA and rheumatoid arthritis known as RA. OA is affecting adults over the age of 40. Wrists, hands, hips, and knees are the most commonly affected parts of the human body [15].

Neuralgia: It affects the trigeminal nerve in a chronic pain condition. That carries sensation from your face to your brain. If you affected by neuralgia you have felt heavy pain while brushing your teeth. Neuralgia may cause longer, more-frequent bouts of searing pain. People that they are over the age of 50 are mostly affected by this disease [16].

Pneumoconiosis: it is one of a group of interstitial lung disease that is caused by breathing in certain kinds of dust particles. That particle may damage your lungs [17]. It is also called as occupational lung disease. Pneumoconiosis usually takes years to develop. Because your lungs can't get rid of all these dust particles, they cause inflammation in your lungs that can eventually lead to scar tissue.it is caused by working in a dusty workplace [18].

Weil's disease: It is a disease of a severe form of leptospirosis, which is a type of bacterial infection. It's caused by a bacterium called Leptospira. It affects a human that contacts the urine, blood, or tissue of animals infected with the bacteria such as pigs, dogs, rats, cattle, etc. Contact with soil or water also the reason for this disease. You can also contract it from contact with contaminated soil or water. It causes mild flu-like symptoms, such as headache and chills. If the bacteria infect some specific organs, there may be a more severe reaction such as lungs, kidneys, heart, brain, and liver, etc [19].

4 SAFETY AND OCCUPATIONAL STRATEGIES IN THE MINING INDUSTRY

Nowadays many strategies and technologies were introduced by the governments and agencies that specifically regulate mining safety to reduce hazards and risks mentioned above [20]. The strategies and technologies make sure that miners are working in a safe condition those are,

1. Wear face protection which includes a respirator to protect their mouth, throat, and lungs.
2. Protecting workers' faces using a special face shield.
3. Using goggles to prevent eyes from dust particles and stone particles especially for gemstone grinding workers.
4. Wearing helmets always while their working in the mine.
5. Always wearing heavy-duty clothing and boots to protect their body.
6. Sharpness and projecting objects are properly labeled or removed to avoid unnecessary injuries while working in the mine.
7. Using an extensive lightning system to increase visibility.
8. Holes are covered or labeled so gears or people don't fall.
9. Electrical wirings are properly connected, covered, and labeled according to the wiring regulation.
10. Install proper RCCB and MCB to prevent electrical shock.
11. Avoid working alone in the mine.

12. Giving the telecommunication facility to communicate with each worker to inform about anything abnormal.
13. Installing a poisonous gas indicator in suitable places.
14. Continuously monitor air quality to ensure none evidence for toxic gases.
15. Take concern to supply oxygen for employees.
16. Mine ventilation systems are checked regularly.
17. Teach mining employees to work safely.
18. Keep employees inform about hazards and identify every hazard in the working area.
19. Use an electric vehicle for light-duty load transport in the mine.
20. Making a proper exhaust system for diesel vehicles or equipment.
21. Add water spray for reducing dust on the wall.

To achieve zero risks, improve success, and improve the health and safety of the mining workers in this industry some essential action must implement those are shown below.

1. Evaluating the water spray for reducing dust on the wall.
2. Evaluating the working condition of dust eliminators on wall shearers.
3. Implement an advanced filter element system for use in diesel vehicles or equipment.
4. Evaluating to prevent uncontrollable high-level diesel exposure equipment in mines.
5. Providing essential medical facilities to the mineworkers.
6. Doing routine medical checkups to the mineworkers.
7. Implement advance and automated control systems to control specific tasks in mining. Example: control air exhaust and inlet automatically for continuous flow without any interrupt.
8. Investigating the lower dust exposure method.
9. Appointing an officer who has a good knowledge of occupational health and safety. He can train all the workers in the mine and he should the responsible for the workers' physical safety.

5 Conclusion

Gemstone mining industry and graphite mining industry are the valuable industries in Sri Lanka. The main purpose of this purpose is process of gemstone mining and graphite mining, hazardous and risks in mining industry, and safety and occupational strategies. Mining industries have several risks and hazards that can be categories as physical agents, chemical agents, and biological agents. These risks and hazards may create temporary or permanent disease, but these risks and hazards can be easily reduced through proper occupational health and safety methods. Currently, many mining industries flow proper occupational health and safety methods to reduce the hazards and risks to ensure their workers' health and safety.

References

[1] Neelanjana Ghosh, GEM MINING IN SRI LANKA, https://www.jewelinfo4u.com/gem-mining-in-sri-lanka ,2016[Accessed date 04/06/2020]

[2] WHAT IS GRAPHITE, https://lankagraphite.com.au/graphite/what-is-graphite/ ,[Accessed date 04/06/2020]

[3] Sheweta Dhanuka, GEMSTONE MINING METHODS, https://www.jewelinfo4u.com/gemstone-mining-methods ,2016[Accessed date 04/06/2020]

[4] Armil Sammoon, A. P. Jayarajah, Tao Hsu, Pedro Padua Andrew Lucas, Sri Lanka : From Mine to Market Part 1, https://www.gia.edu/gia-news-research-sri-lanka-mining-part1 ,2014[Accessed date 18/06/2020]

[5] David Steward, How Is Graphite Extracted, https://sciencing.com/graphite-extracted-10041885.html ,2017[Accessed date 04/06/2020]

[6] Kahatagha Graphite Mine, http://amazinglanka.com/wp/kahatagaha-graphite-mine/ ,[Accessed date 18/06/2020]

[7] K. S. Cho, S. H. Lee. Occupational health hazards of mine

[8] workers Heatstroke, https://www.mayoclinic.org/diseases-conditions/heat-stroke/symptoms-causes/syc-20353581 ,[Accessed date 13/06/2020]

[9] Benjamin Wedro, Heat Cramps, https://www.medicinenet.com/heat_cramps/article.htm#heat_cramps_facts ,[Accessed date 08/06/2020]

[10] Kimberly Holland, Everything You Need to Know About Anxiety, https://www.healthline.com/health/anxiety ,2020[Accessed date 10/06/2020]

[11] Frostbite,https://www.mayoclinic.org/diseases-conditions/frostbite/symptoms-causes/syc-20372656#:~:text=Frostbite%20is%20an%20injury%20caused,is%20most%20vulnerable%20to%20frostbite ,[Accessed date 10/06/2020]

[12] Steven Doerr, Frostibite article, https://www.medicinenet.com/frostbite/article.htm ,[Accessed date 09/06/2020]

[13] Kristeen Cherney, What Is Trench Foot?, https://www.healthline.com/health/trench-foot ,2019[Accessed date 10/06/2020]

[14] Raynaud's disease, https://www.nchmd.org/education/mayo-health-library/details/CON-20022916 ,2015[Accessed date 11/06/2020]

[15] Symptoms of Joint pain, https://www.mayoclinic.org/symptoms/joint-pain/basics/causes/sym-20050668 ,2019[Accessed date 12/06/2020]

[16] Jamie Eske, What do you know about neuralgia, https://www.medicalnewstoday.com/articles/325331 ,2019[Accessed date 14/06/2020]

[17] Pneumoconiosis, https://www.hopkinsmedicine.org/health/conditions-and-diseases/pneumoconiosis ,[Accessed date 13/06/2020]]

[18] Mining Topic: Respiratory Diseases, https://www.cdc.gov/niosh/mining/topics/RespiratoryDiseases.html ,[Accessed date 14/06/2020

[19] Leptospirosis (Weil's disease), https://www.nhs.uk/conditions/leptospirosis/ ,2017[Accessed date 13/06/2020]

[20] Mary Mcmahon, WHAT KIND OF SAFTY PRECAUTIONS DO MINERS TAKE, https://www.wisegeek.com/what-kind-of-safety-precautions-do-miners-take.htm ,2020 [Accessed date 04/06/2020]