



Assessment of mine ventilation systems and air pollution impacts on artisanal tanzanite miners at Merelani, Tanzania



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ABSTRACT

This article assesses mine ventilation systems and air pollution impacts on 4000 artisanal tanzanite miners at Merelani. Concentration of carbon monoxide (CO) in five selected mines averaged 66.2 ppm (with maximum of 102 ppm) which is 2.5 times higher than the maximum concentration specified by Ontario Ministry of Labour (2015). The average level of respirable dust was 8 mg dust/m³ air, which is 4 times higher than the allowable American guidelines for mines. Suffocation accidents consists of 29% of the total accidents in Merelani which claimed lives of 44 miners from 2005 to 2014. About 82% of the suffocation accidents were caused by unauthorized entry in temporary stopped or abandoned mines. Many miners suffer from silicosis and other lung diseases and 6.6% of miners have tuberculosis (TB). Based on the results of field studies it was found that small compressors being used for both drilling and ventilation are capable of providing 11.4 m³ of air/min in average. Usually 100 to 120 miners per shift are working in the mining fronts and this air quantity is not adequate to provide enough fresh air and comfort to workers and to dilute contaminants to a safe concentration. Interviews with managers of 50 mining fronts revealed that dry drilling is used by 92% and only 10% of miners wear masks. The study highlights the need of forced fans, dust control strategies, use of dust mask, pre and post medical checks, gas monitoring, training and abiding to safe mining practices as the measures to improve health and safety of the miners at the area.

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1. Introduction

1.1. Artisanal mining definitions

The term artisanal and small-scale mining has been widely used to refer to those miners using rudimentary mining techniques, but not always small miners use artisanal methods and not always artisanal miners have small operations (Veiga et al., 2014a, 2015). The term artisanal mining is preferred to express small, medium, large, informal, legal and illegal miners who use rudimentary technology to mining and processing minerals (Veiga, 1997). However in some countries, like Tanzania, the term artisanal mining is ill-defined in the legislations and associated with the size of the operations or with the level of formalization (Veiga et al., 2014a). Artisanal mining occurs in over 70 developing countries where approximately 30 million people are directly involved extract more than 30 different minerals (Garcia et al., 2015). Nearly

100 million people worldwide depend on this economic sector (Buxton, 2013; McDaniels et al., 2010). Artisanal mining accounts for 80% of global sapphire, 20% of gold and 20% of diamond mineral production supply (World Bank, 2013). According to Buxton (2013) and Mwakaje (2012), artisanal mining are operations which employ rudimentary technologies, require low levels of capital, are labor intensive, have low mineral recoveries, have poor access to markets and support services, employ low standards of health and safety and generate significant impacts on the environment. However, the characteristics of artisanal mining vary dramatically from one continent to another. In South America, for example, it has been observed an increasing evolution in processing plants for gold extraction, whereas in most African countries, the large majority of the artisanal miners are still using manual methods for mining and processing (Veiga et al., 2014b; Seccatore et al., 2014).

Artisanal mining activities have been a source of livelihood for many Tanzanians in rural areas and it is estimated that more than 1,000,000 people are employed in this mining sector (Mwakaje, 2012). The artisanal operations involve mining of gold, gemstones, salt, limestone, construction and building materials (Mutagwaba et al., 1997). Despite the limitations of the

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miners to evolve, artisanal mining is still considered an important poverty alleviation activity when compared with other employment opportunities in rural areas of Tanzania (Fisher et al., 2009). Differently from conventional mining, that establish reserves before the exploitation phase, artisanal mining flourish at early stage of discoveries. At this time, miners can easily access subsurface minerals at low cost. When mineral deposits become deeper, miners tend to migrate to another deposit to avoid complexity of dewatering, hoisting of materials and ventilation requirements and tasks. This habit of shifting from one place to another is observed in many countries and it makes useless the efforts of governments of developing countries in demarcating areas for artisanal miners and many mines become abandoned without proper rehabilitation (Veiga and Hinton, 2002).

Despite the efforts of the Tanzanian government in transforming artisanal miners into small-scale legal miners by providing them with Primary Mining Licenses, their mining practices remain very rudimentary (Mwaipopo et al., 2004). Without education it is very hard to implement a sustainable formalization process to transform their rudimentary working habits (Veiga et al., 2014a).

1.2. Tanzanite in Merelani

Tanzanite is a rare gemstone found in 1967 in Merelani, located in Manyara Region, Northeastern Tanzania, approximately 70 km Southwest of Mt. Kilimanjaro, between the town of Arusha and Mos

(Fig. 1). This is the only known tanzanite deposit in the world with size of approximately 7 km² (Olivier, 2006).

Tanzanite is blue zoisite Ca₂Al₃Si₃O₁₂(OH), named after its country by Henry Platt, Tiffany's Chairman in New York. This mineral has a blue to bluish purple color, hardness of 6.5, refractive index of 1.691–1.700 and S.G. of 3.35. Traces of vanadium causes the blue/violet color and this can be enhanced by heating (Olivier, 2006).

Tanzanite is a precious gemstone due to its beauty, rarity and durability. Its value is determined by color, clarity, cut and carat weight. Tanzanite shows two different colors blue or violet, when viewed from different direction and angles. The deeper the blue color, the higher the value. The inclusions in the tanzanite affect the clarity and decrease the value of the stone. Poorly cuts affect the brilliance and the beauty of the stone hence lower the price. Tanzanite value is measured by its weight in carat. The large stones, above 5 carats are more marketable with prices per carat around USD 400. For a clear and premium color stone the price can go up to USD 800/carat (Tanzanite Jewelry Designs, 2015). About 80% of all mined tanzanite is sold in US for making: rings, earrings, necklaces and bracelets (Geology.com, 2015).

The Merelani tanzanite deposit is located within a sequence of banded gneisses and marble that have been metamorphosed and deformed during metamorphic events. The tanzanite bearing unit zone, Juu ya Watu Zone (JWZ) is named after one of its discoverers Juu ya Watu, a Maasai tribesman. The mining and recovery of tanzanite take place in the JWZ which is divided into



Fig. 1. Location of Merelani (Pardieu et al., 2008).

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