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Review paper

Application of Lapidary Technology for a Sustainable Gemstone resource development in Ethiopia

Tsion Shumalem and Getahun Meseret*
Mineral Industry Development Institute, Ministry of Mines, Addis Ababa, P.O. Box 486, Ethiopia
getchgeo@gmail.com

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Abstract

Ethiopia is home to significant and diverse mineral resources. The country has over 40 varieties of colored gemstones, including emerald, tourmaline, opal, aquamarine, jasper, agate, Chrysoprase, peridot, and amethyst. The colored gemstone mining taking place in Ethiopia is commonly conducted by Artisanal miners. ASMs don't use lapidary technology for value addition and this is reported as being extremely challenging. Due to this fact, most of the business owners export rough gemstones. The main reason behind exporting of rough gemstone is due to the lack of lapidary technologies, lack of financial access and trained lapidariest and that can cut and polish gemstones with the target market demand.

Keywords: Lapidary, Technology, Sustainable, Gemstone, Resource development.

Introduction

Ethiopia is recognized for its mineral wealth and a variety of gemstones. Over 40 varieties of colored gemstones deposits including emerald, tourmaline, opal, aquamarine, jasper, agate, Chrysoprase, peridot and amethyst are now found in the country[1]. New discoveries are also on the rise, including the especially exciting discovery of the color-changing chrome grossular green garnet[2]. Opal, emerald, and sapphire are the top three gemstones for which Ethiopia is known to the world market.

Gemstone material that has not been extensively cut and polished is referred to generally as rough[3]. Rough material that has been lightly hammered to knock off brittle, fractured material is said to have been cobbled[4]. The process of cutting, shaping and polishing gems is called gem cutting or lapidary, while a person who cuts and polishes gems is called a gem cutter or a lapidary (sometimes lapidariest)[5]. Lapidary work is both art and business in the industry. During the manufacturing, the rough gemstone is transformed into a bright, radiant, geometric form depending on the property of the mineral and engineering characteristics of the particular gemstone.

In the history of Ethiopian mining industry, gemstones were not known as economic resource and were not part of the mining history for a long period of time. It was in the last decade that the world came to know that Ethiopia will be one of the gem producing country join gem market. For example, government figures report that there are 3,800 ASM workers involved in opal mining in the region of North Wello Delanta, out of which 3,668 are male and 132 are female. Ethiopia is known to be the second largest producer of opal in the world, next to Australia. In 2012 and 2011, Australia produced an estimated USD 41 million and USD 40 million of rough opal, respectively.

Figures from the United States Geological Survey (USGS) estimate that in 2012, Ethiopia produced 14,000 kg of opal and 13,839 kg in 2011. It attributes 750 kg of production in 2012 to one ASM location alone, Wegel Tena[6]. With the same trend, a considerable number of people went to the emerald mining area (Shakiso-Kintcha) to mine. Many people from neighboring regions and localities fled to the sapphire mining area (Tigray Marble District) to search for sapphire, the noble gem. These gemstones are mined and collected by individuals and organized groups that form associations. As a result most of the Ethiopian gemstones are exported in rough form and this would cause loose of a lot of foreign currencies. Due to this reason, this paper is intended to conduct on the application of lapidary technologies for the enhancement of value addition practice in Ethiopia.

Materials and Methods

In order to achieve the objective of the study, literature review is applied to understand the various sequences that occur during the lapidary work processes. Moreover, experts, lapidary workers and traders have been interview and consulted. Ethiopian gemstone industry stakeholders were formally interviewed in person: two government officials from the Ethiopian Entrepreneur Center; six lapidary license holders and exporters in Addis Ababa; two Ethiopian opal traders in Bangkok and Hong Kong; three lapidaries in Adiss Abeba; one government official from the Ethiopian Mineral and Biofuel Corporation; plus a group of enterprises in Adiss Abeba were included in the interview.

The researchers also discussed lapidary technology in the gemstone industry with numerous experts from civil society and the private sector to gather background information and additional insights. In addition, tours of the main jewelry district in Addis Ababa as well as lapidary businesses were carried out to observe the type of jewelry being sold to the local market and the state and operation of the mines and training facilities. And also, Cost benefit analysis on the rough and processed gemstone is made to examine the implication of the value addition of the gemstone and profit effect on it.

Origin of the Sample: A rough gemstone samples collected from the Oromia region around Negelle Borena is used to conduct the lapidary work for the purpose of this study. And the Ethiopian Mineral, Petroleum, and Biofuel Corporation's workshop center is where the place that the process of value addition is carried out.

Processing Methods: Lapidary Making**:** For the lapidary making method the following materials are used: i. Row samples of obsidian, agate and jasper, ii. Sawing Machine with Blade and Lubricants (gasoil or water), iii. Templates, iv. Trim Saw and Lubricants (gasoil or water), v. Grinding and Polishing Machine with Polishing Wheels.

Processing Steps: Lapidary Making: The lapidary making method of gemstones processing passes through the following sequential steps: i. Analyzing the Gemstone's Character, ii. Cutting of row sample, iii. Pre-forming by using templates, iv. Pre-polishing and polishing.

Results and Discussion

Lapidary technology and techniques: In lapidary technology, there are so many processes and machinery that are used. The machine and the process are listed below.

Sawing: Slabbing: A slab saw is used to slice raw stone into slabs of the specified thickness. A standard slab saw is made for sawing big pieces of minerals (such as agate, jasper, lapis lazuli, sodalite, and jade, among others) into slabs or blocks for further processing, with the exception of diamonds[7]. A turntable clamp is used to hold the stone to be worked so that the depth of cut can be doubled.

Trimming: The trim saw is used to shape stones into cabochons, faceted stones, tiny plates, etc. for further processing[8]. With petroleum oil as a coolant, diamond saw blades (150 or 250 mm in diameter) can cut any kind of stone. To saw the stone into the required shape and size, the stone is physically directed toward the blade. After cobbing and fine knocking, rough gemstones of the more precious variety are typically tiny enough to be sawed by a trim saw without being slabbed first.

Grinding and Polishing: Grinding: The abrasive procedure of grinding is used to give rough forms to gemstones. The phrase describes the use of abrasive wheels in lapidary operations[9]. The most popular wheels come in a variety of sizes and forms, are manufactured of silicon carborundum, and use abrasive grains of various sizes depending on the wheel's intended use. Many grinding wheels used in modern practice have diamond grains attached to a metal or plastic matrix. A gem cutter uses grinding wheels to shape cabochons and to preform rough for faceted gems, as well as to grind bevels on flats, shape carvings, profile pieces for inlay work, and many other tasks.

While fine grits are utilized if the abrasive action needs to be slower and smoother, coarse grits are employed to manufacture wheels that remove material quickly. The numbering of grit sizes for loose grains and abrasive wheels in grinding equipment indicates the degree of fineness of the particles; for example, 100 grit is considered coarse and 1200 grit is considered very fine. Table-1 lists the grits used in lapidary work, including coated and loose grain.

Table-1: Grit Size from[10].

Grit Size	Micron Size	Purpose
60	400	Rough grinding and Tumbling
100	150	Rough grinding and Tumbling
220	60	Fine grinding, lapping, and sanding
325	45	Very fine grinding, lapping, tumbling, and fine sanding
600	30	Very fine lapping and fine sanding
1200	15	Very fine lapping and prepolishing.

Grinding Wheels: Depending on the sort of machinery being used, carborandum wheels for gem cutting come in a number of diameters. The typical diameters range from 150 to 250 mm in diameter and 20 to 50 mm in thickness. Shaft holes are offered in sizes with diameters ranging from 20 to 30 mm to fit different equipment brands. The most common grit for rough shaping is 120, which is a medium-soft grade. A 220-grit wheel in a medium-hard grade works best for fine grinding when the goal is to smooth surfaces rather than remove a lot of material[11].

Grinding Powder: When employing diamond laps is not available, grinding powder is utilized in tumbling mills, vibrators, surface grinding machines, and for cutting facetted stones. For coarse and medium work, carborandum is used in grit sizes 80–320; for fine and very fine work, it is used in grit sizes 400–1200[12].

Sanding: Strong fabric coated in a coating of silicon carbide grit is the most typical sanding material[13]. Only two or three types of grit are typically required, ranging in size from very coarse to very fine. 220grit is frequently used for coarse sanding, whereas

400 or 600 grit is frequently used for finer sanding. The glue used to create standard sanding cloth is water-soluble. Another kind is resistant to the effects of water because it is saturated with plastic resin adhesive. Depending on the machine, sanding cloth comes in disk, strip, and belt forms. Water is used in almost all grinding, sanding, and polishing operations on gemstones.

Polishing: The final step in the pre -preparation of gemstones is polishing[14]. The brilliant and radiant smooth surfaces typical of polished gems are produced by pressing the shaped stone with considerable force against yielding materials such as felt, leather, cloth, or wood that have been charged with polishing agents. With the exception of diamond, most polishing agents are oxides of metals[10]. i. aluminum oxide, 0–1 micron or finer, ii. chromic oxide, iii. ferric oxide, iv. chalk or the finest marble dust, v. tin oxide, vi. Tripoli = finest diatomite, vii. zirconium oxide, viii. diamond (powder or paste), 0–2 micron. There are two types of general polishers: those for polishing cabochons, flats, spheres, and other work demanding little accuracy; and those for polishing geometrically flat surfaces, such as on faceted gems[15]. The first type embraces buffs constructed from yielding materials, such as fabric and leather, but also harder materials such as wood, which are less yielding.

Lapidary techniques: It takes specialized equipment, lapidary arts skills, and a lot of practice to turn raw materials into jewels. Several of these procedures call for the use of tools or machines that, if handled without the right expertise, could harm you or your gemstone. Before attempting to use any machine or technique, you should get more training in it.

Step 1: Analyzing the Gemstone's Character: The project must be first determine the materials' worth for it. The shape that will yield the best value for the project should guide how can choose to prepare the ore. The cut must be chosen first for the majority of gemstones. Processed three samples—obsidian, agate, and jasper—in the best manner while also considering the caliber and characteristics of the raw materials. Step 1.1: Observe the characteristics of the gemstone, determine whether it is transparent, translucent, or opaque, and look for flaws. Step 1.2: Examine the hue of the gemstone and evaluate the caliber of your raw materials using a channeled source of light.

You can choose the best processing method by looking at the characteristics of the gemstone. i. Faceting techniques are frequently used to treat transparent gemstones without defaults. ii. Cabochon procedures are suitable for transparent gemstones with inclusions that are translucent, opaque, or have an optical impact.

Step 2: Assessing the Gemstone's Color: Positioning the gemstone dome in order to create an appealing cabochon is the first stage in determining the grinding and shaping of the cabochon. When choosing how to grind and shape a gemstone, we can use a source of light to identify the best and most vivid color play, or color band. Typically, this is accomplished in three easy steps: i. Step 2.1: Using a bright source of light, find the optimal orientation of the color band (or the best color for stones without play of color) to identify the best and most obvious play of color; ii. Step 2.2: The optical effect should be centered at the top of the face-up dome. iii. Step 2.3, which also involve positioning it so that the best color formation is aligned with it.

Step 3: Cutting: Sawing is the action of separating or cutting large stones into smaller ones or eliminating extra material from large, rough stones. Lapidariest must put on safety gear, including masks and goggles, when performing this procedure, which involves using sawing machine. In general, the process goes like this: i. Step 3.1: Detect the part of the stone to be removed or sliced. ii. Step 3.2: Draw a sawing line. iii. Step 3.3: Double-check the water or gasoil level of the sawing machine. iv. Step 3.4: Saw carefully along the line that you have marked out.

Step 4: Pre-forming: The back and dome of the gemstone will be shaped by the lapidariest during the pre-forming phase. During this phase, lapidariest must put on safety gear, including masks and goggles. Usually, there are three steps in the procedure: i. Step 4.1: Use 80 mesh and 220 mesh wheels to flatten the rear of the gemstone, bend the dome, and produce a chamfer. ii. Step 4.2: Use a template and a copper or aluminum pencil to draw lines to make the ideal shape; and finally, iii. Step 4.3: Focus on ensuring a symmetric and proportionate curved dome.

Step 5: Pre-polishing and polishing: A lapidariest will polish the gemstone to perfection at this step. Lapidariest are required to put on safety gear during this phase, like masks, goggles, and earplugs. The processing process ends with this stage. The goal is to get a sparkling surface because a smooth, well-finished gemstone will only sell well. Two steps are normally involved in this: i. Step 5.1: Using the 280, 600, 1200, and 3000 wheels, create a chamfer on the dome and the back of the gemstone. To reach the optimum outcome, process the data step-by-step, refining the pre-publish using progressively finer tools. ii. Step 5.2: Use a polishing pad to buff or a piece of felt with cerium oxide to polish jasper, agate or obsidian. Last step will be getting beauty full, polished and gilt samples of the ore.

Challenges of Ethiopia's Gemstone Industry: A shortage of raw stone supply and a market for cut stones were the two main issues raised by the respondents in this study as reasons for the demise of numerous lapidaries. Contrary to popular belief, Ethiopia has never experienced a shortage of stones; rather, the lapidary operators have been offering extremely low prices for purchases, which has caused the miners to avoid them in favor of middlemen and the international market.

A more comprehensive view of the situation in Ethiopia's gemstone sector reveals that the issues now plaguing the lapidary sector can be pinpointed as described below.

Lack of a Local Market for Gemstones: Most industries only start to grow into international trade once their product line has completely saturated the local market. The lapidary sector in Ethiopia has never experienced this. Since the expatriate population began to decline, the sector has always focused on international markets. Insiders in the business have expressed dissatisfaction over the weak local market for gemstone products. In terms of economics, gemstone products are categorized as luxury commodities, and demand for them is correlated with the presence of discretionary income, which is essentially nonexistent for the great majority of Ethiopians. As was previously mentioned, poverty is to blame for this. This explains why the few remaining lapidaries are held by foreigners who have links to markets abroad and can afford to travel there.

Over-liberalization of the licensing system: There is no qualification process for applicants seeking a license as a gemstone dealer under the new liberalized economy. In the previous centralist economy, to be authorized to trade in gemstones, one had to be the owner of a mine, lapidary, or jewelry store. Unrestricted access to the gemstone trade has led to the emergence of "authorized" intermediaries. These intermediaries roam the mine sites, purchasing carefully chosen stones of high quality while excluding low-grade stones that even lapidaries cannot afford. This is one of the reasons why some lapidaries complain about the lack of stones. The stones are typically bought in this way and then illegally exported from the nation.

Lack of Capital in the lapidary industry: Typically, the lapidary business doesn't have the financial resources to give miners fair prices for rough gemstone acquisitions. This helps to explain why large mines have developed export markets whereas small-scale miners sell to middlemen, who typically provide slightly higher pricing.

Lack of an Established Gemstone Exchange: The development of the gemstone business in general and the lapidary industry has been impeded by the lack of a Gemstone Exchange. International buyers prefer a single location to conduct all of their transactions, which Ethiopia now lacks. In order to negotiate their own market conditions, individual miners and lapidary business owners travel abroad. The small-scale miners sell their produce to middlemen since they cannot afford to travel. If there were a Gemstone Exchange facility, miners who are unaware of the value added when a rough gemstone is cut would be drawn to cut and polish their produce since they would be aware of the price differences between the two. As a result, a gemstone exchange would aid in the successful development of the lapidary business since producers would be encouraged to cut stones in order to boost profitability and cash flow.

Inadequate Government Policy on Downstream Processing: Although processing minerals is mentioned in the existing mining strategy, exporting raw materials benefits their significant offshore commercial interests. It is obvious that in order to Change this scenario, suitable legislative action would be needed.

Lack of Financial Resources: Many lapidary business owners lack the working cash needed to purchase the rough stones in the quantity and quality necessary for profitable operations.

In adequate Valuation Skills: Many gemstone miners are not skilled in appraisal. They typically rely on middlemen who determine the prices and clearly take advantage of their ignorance. This is due to a number of causes, including: i. Lack of gemological skills and, ii. Inadequate access to marketing information on trends in pricing on international markets.

Inadequate Lapidary Skills: Highly specialized training is necessary for the Ethiopian lapidary industry to assert itself, reach international gemstone markets, and favorably compete with the more than century-old skilled gem cutters of India, China, Thailand, and Israel. High-quality stones are painstakingly cut by experts, many of whom spend many years honing their craft. Regarding the need for national manpower development, the government has applied a double standard. Similar organizations were created to support agriculture. Despite Ethiopia being a large producer of gemstones, no parallel training was offered for the sector of gemstone processing.

Economic and Social impact of lapidary technology: Economic impact of lapidary technology: i. Ensuring optimal utilization of scarce resources; preventing waste of the nation's resources; and getting the most out of available resources. ii. A multimillion-dollar industry will be established, creating huge job opportunities in the country. iii. Stimulate other economic sectors, such as tourism, and foreign tourists and local buyers will be attracted. iv. Generate foreign currency due to the exporting of goods. v. Art and craft shops will be opened in the country. vi. There will be more investors in this lucrative business. vii. The contribution of the sector to the GDP growth of the country would be tremendous. viii. Increase in the productive capacity of the economy. ix. protection against economic risks (e.g., unemployment, destitution in old age).

Social impact of lapidary technology: i. It creates and develops knowledge, local skills, innovations, and opportunities for those who are engaged in these activities. ii. There will be a transformation from manual work by smiths to industrial technology. iii. A safe and conducive investment environment will be created to attract foreign investors. iv. A clean, green, and safe operation will be created. v. A big market link or chain will be created between the raw material supplier and industries. vi. The present notation of undermining the resources, especially gemstones, will be corrected. vii. A legal and readily accessible supply chain for raw gemstones must be established.

Conclusion

Gemstones are produced in large quantities and in a wide range in Ethiopia. The development of an enduring lapidary sector is justified by this, along with a secured global market for cut stones. This sector has a lot of potential. Supportive legislation should be implemented in order to safeguard the industry and allow a successful gemstone cutting and polishing industry to thrive.

The gemstone industry is in ruins as a result of inadequate legislation and policies, as well as a complete lack of support for the lapidary sector in particular. It is impossible to expect the government to act with complete disregard toward the regulation of natural resources of this size and worth in a struggling economy. This is what has caused the current issues the lapidaries, and ultimately the economy, are having.

The lapidary business can be revived by enacting comprehensive regulations and rules that are appropriate, as well as by creating an independent gemstone exchange. The lack of such a structure explains why the lapidary sector has not seen any notable activity despite the favorable investment climate that the country currently enjoys, as guaranteed by the Investment Act. Comparatively speaking to base metal refining, setting up a lapidary does not require significant capital investments.

To operate a lapidary legally in Ethiopia, one must be a citizen of Ethiopia and obtain the necessary license from the MoMPNG. Licensed lapidary holders are by law allowed to buy gemstone cutting and polishing machinery duty-free; however, this law needs to be communicated more effectively by the government to the lapidary operators.

In contrast to the ease with which lapidaries can meet legal requirements, setting up an operational lapidary business was reported as being extremely challenging. The most commonly reported challenge was finding sufficiently trained staff for cutting and polishing gemstones and then further training them in order to bring their skill levels up to an internationally competitive standard.

The second most commonly mentioned challenge raised by interviewees in relation to establishing a successful lapidary business was accessing the necessary finance. And this is the most critical problem that should be solved for long lasting.

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