

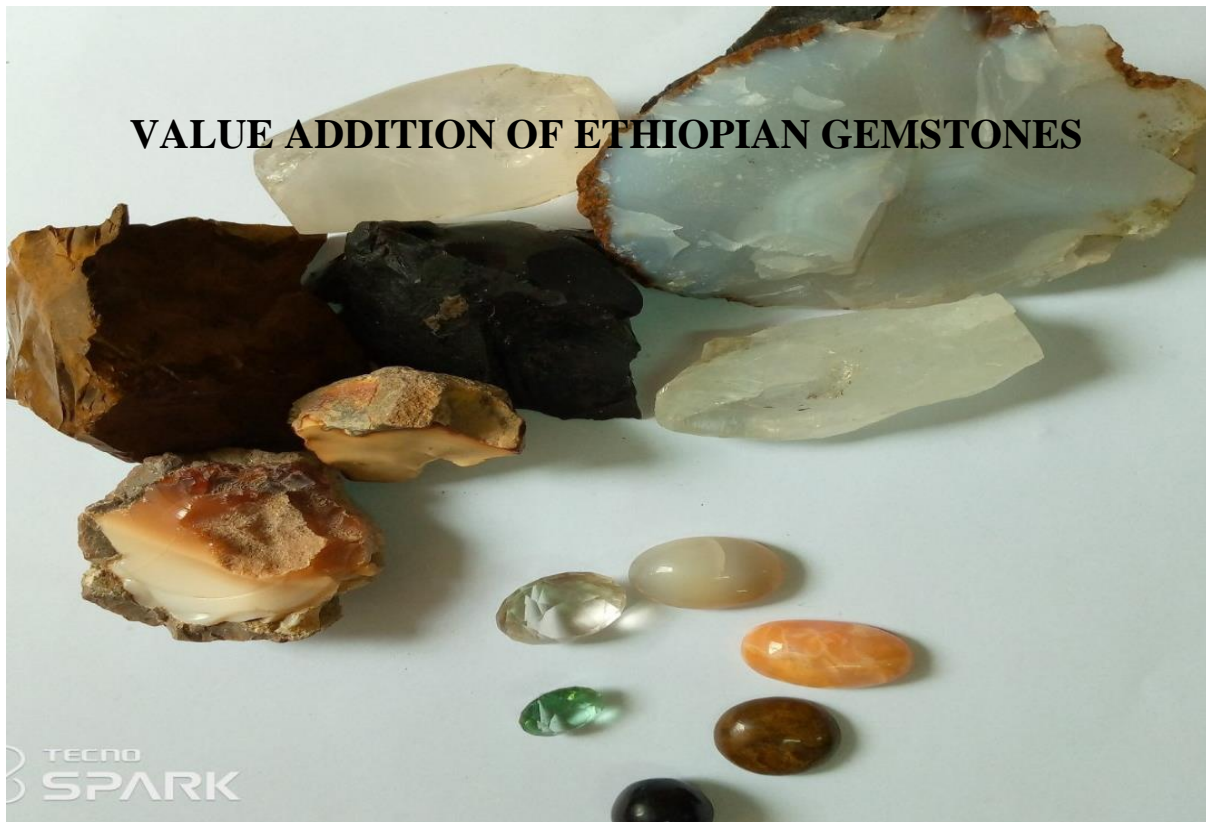


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Addis Ababa Institute of Technology, Center for Ethio-Mines Development (MEng in Mineral Processing)



MEHATEBE GEBREWOLD BIRHANESILLASE

A Graduate Project Work submitted to the Center for Ethio – Mines Development in partial fulfillment of the requirements for the degree of Master of Engineering in Mineral Engineering.

June/2023

Addis Ababa, Ethiopia

**Addis Ababa Institute of Technology,
Center for Ethio-Mines Development
(MEng Program)**

VALUE ADDITION OF ETHIOPIAN GEMSTONES

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A Graduate Project Work submitted to the Center for Ethio – Mines Development in partial fulfillment of the requirements for the degree of Master of Engineering in Mineral Engineering.

June/2023

Addis Ababa, Ethiopia

Declaration of Originality

I hereby declare that the project work is my own original master's degree work under the supervision of my Advisor Dr. Eng. Abubeker Yimam, School of Chemical and Bio Engineering, AAiT of AAU and Co-Adviser W/ro Aselefech Mitiku (MSc) from Ethiopian Mineral, Petroleum & Biofuel Corporation, at Center for Ethio-Mines Development, School of Chemical and Bio Engineering, AAiT, Addis Ababa University during the year 2023 of Academic Year. I further declare that this project work has not been submitted to any university or institution for similar purpose (award of any degree or diploma). All sources and materials used for the project work have been accordingly acknowledged by proper citations.

Signature

Date

Mehatebe Gebrewold Birhanesillase

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge and belief.

Signature

Date

Dr. Eng. Abubeker Yimam

Signature

Date

W/ro Aselefech Mitiku (MSc)

Approval Sheet

Value addition of Ethiopian gemstones, submitted in the partial fulfillment of the requirements for the Degree of Master of Engineering in Mineral Processing, complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Approved by advisors and examiner:

Name	Signature	Date
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Advisor: Dr. Eng. Abubeker Yimam	_____	_____
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Dr. Eng. Birhanu Assefa	_____	_____
Director of Center for Ethio-Mines Development		

Abstract

Ethiopia is well recognized for producing gemstones. Numerous high quality gemstone varieties, such as opals, emeralds, sapphires, amazonite, amber, rubies, tourmalines, aquamarines, chrysoprase, peridot, chalcedony, obsidian, agate (scapolite agate), jasper, petrified wood, and various types of quartz, including precious quartz, are the main gemstones mined in the nation. However, the industry continued to generate little appreciable economic advantage because the country mostly exported rough gemstones with no added value. This project study intends to demonstrate the technology needed for adding value to various Ethiopian gemstones and the associated financial advantage. The following measures were taken in order to add value: Sorting the chosen gemstone by specie, selecting clean, color-full, large (excellent size to cut) pieces from the rough collection, cutting, polishing, and ultimately faceting of the chosen gemstone. The value added gemstones are then each given a physical description based on their Color, Clarity, and Cut. Finally, a price estimate has been generated for the gemstones with enhanced value. The project's findings showed that enhancing the value of the rough gemstone might produce earnings of up to 1,610,590 ETB/Kg of Opal, 293,560 ETB/Kg of Crystal Quartz, 213,040 ETB/Kg of Green Obsidian, 48,565 ETB/Kg of Jasper, 43,730 ETB/Kg of Agate and 43,675 ETB/Kg of Black Obsidian. As a result, small-scale gemstone business owners can profit from the high prices of their products and the country can increase the foreign currency revenues from selling the value-added gemstones by adding value to the rough gemstones through the use of relevant technology.

Key Words: Value Addition, Faceting, Polishing, Rough Gemstones, the Four C's (Color, Cut, Clarity and Carat), Cutting, Sorting and Jewelry.

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ACRONYM

AAiT	Addis Ababa Institute of Technology
AAU	Addis Ababa University
ETB	Ethiopian Birr
E.C	Ethiopian Calendar
EMPBC	Ethiopian Mineral, Petroleum and Biofuel Corporation
G.C	Gregorian calendar
GDP	Gross Domestic Product
GTP I	Growth and Transformation Plan First Phase
GTP II	Growth and Transformation Plan Second Phase
KG	Kilogram
SDGs	Sustainable Development Goals
USD	United States Dollar

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Gemstones were the first luxury item that man was aware of. The first items we selected and declared to have worth only due to their beauty are colorful stones (Collet et al, 2013). According to (Dan Green, 2016) it is defined gems as polished and cut mineral crystals. Due to their rarity and beauty, these stones are highly prized. Gemstones are organic or mineral substances that are found in nature and have significant aesthetic value, rarity, and durability. These priceless natural resources were naturally given to mankind and are now used to make various types of jewelry. The top-known gemstone-producing nations worldwide are China, India, Sri Lanka, and Thailand. Australia, Brazil, South Africa, Russia, Canada, the United States, Afghanistan, Pakistan, and East Africa (including Ethiopia) are a few countries that produce gemstones. Ethiopia is renowned for possessing high-quality gemstone resources, but there is currently little information on how much of it is really used appropriately. This is primarily due to it being sold or exported in its raw state.

So it is feasible to draw the conclusion that Ethiopia is well known as a country that produces gemstones, but without receiving a considerable amount of economic gain from the industry, based on the information and data from many published and unofficial sources. This is primarily due to the diamonds being exported in their raw state without any value adding. Gemstones should benefit the nation because they are rare and important natural resources that are not replenishable. It is common knowledge that neither nature nor lapidary can consistently produce flawless stones or art. Therefore, improvement is always necessary to raise quality and, as technology permits, to accommodate human (jewelry) demands. Jewelry refers to ornamental items worn for personal ornamentation and might include cufflinks, brooches, rings, necklaces, earrings, and pendants. These jewels could be fastened to the wearer's body or clothing.

From all of the aforementioned instances, it is clear that a solution must be found so that the concerned parties the producing company, the local population, and the nation as a whole can benefit from the diamond resources. The diamond resource will adequately benefit the stakeholders and be able to contribute its fair contribution to the economy of the nation through the value addition process. In order to do this, this paper provides a method for boosting the value of gemstones through the lapidary process, which entails cutting, shaping, and polishing the gems. This helps to use the gemstones as one of the inputs for manufacturing jewelry. In this article, the linked economic effects of gemstones' value addition were further examined.

Ethiopia is recognized for manufacturing gemstones, but because they are exported or sold in their raw state, the sector has not seen any appreciable economic advantage. Therefore, processing or value addition of gemstones is required before exporting or selling in order to alleviate this problem.

1.3. Statement of the Problem

As is widely known, Ethiopia is endowed with vast resources for various gemstones. However, simply having a natural resource does not automatically benefit the country. Utilizing knowledgeable labor and available technology should result in a methodical and sustainable use of the resources. The tendency in Ethiopia is improper gemstone consumption, with the majority of it being sold or exported in raw condition. Even though the country is well known for having a variety of gemstone resources, including high-quality gemstones, the industry is affected by these and other related issues, which makes the country's gemstones less well known and less expensive. As a result, people and organizations directly involved in the sector do not benefit nearly as much from the resource as they might from their involvement in mining and selling.

1.4. Objective of the Project

1.4.1. General Objective

The main objective of this project work is to investigate value addition of gemstones to upgrade their quality which in turn increases their value.

1.4.2. Specific Objectives

The specific objectives are:

- To collect different gemstones from site
- Sorting of
- To sort color-full, clean, large (excellent size to cut) pieces from the rough collection of the chosen gemstone according to criteria.
- To cut the selected gemstone
- To polish the selected gemstone
- To facet the selected gemstone
- To Characterize the value added gemstones and estimation of price

1.5. Significance of the Study

At the end of this project, the collaborating parties (producing business or miners, locals, and the nation at large) will be able to profit economically from the gemstone resources that have undergone value addition. Additionally, it can provide some insight or serve as a starting point for academics and researchers looking to add value to gemstones.

1.6. Scope of the Study

This project work is done at Ethiopian Mineral, Petroleum and Biofuel Corporation's (EMPBC) Gemstone Workshop Center. The project work is done mainly by focusing on some selected gemstones (Such as opal, crystal quartz, agate, jasper and obsidian) value addition (Polishing/Cabochon making and Faceting) to show how value addition of gemstone can be carried out.

CHAPTER TWO

2. LITERATURE REVIEW

The purpose of this literature review is to identify the current realities in Ethiopia's mining industry in general, the general overview of gemstones and their current status in all areas in particular, and the gaps in that sector's resource utilization in order to provide some scientific solutions and recommendations for additional research.

2.1. General Overview

As it is well stated by (Yohannes et al, 2018), the importance of mining to Ethiopia's economy as a shift away from agriculture cannot be overstated. Commodities like gold, precious stones, and industrial minerals are crucial to the nation's export-driven growth plan. Most of the necessary components for success as a mining nation are present in Ethiopia. It has an abundance of untapped natural resources, including untapped minerals, and is resource-rich. Additionally found resources include petroleum and diamonds. And there are many more. Of these, practically all gemstone resource types are found in abundance throughout the nation, albeit their levels of deposit are not well understood. A successful and lucrative mining industry will be ensured by the combination of such material richness and a knowledgeable and highly motivated workforce.

When a piece of appealing mineral is cut and polished, it is referred to as a gemstone or gem, sometimes known as a precious or semi-precious stone, and is used to create jewelry. Some biological materials, such as amber, coral, ivory, and pearl, are used as gemstones despite not having undergone mineralization. Some of the minerals used as gems include opal, aquamarine, garnet, olivine, tourmaline, topaz, sapphire, ruby, amethyst, agate, and jasper. Their worth is often determined by four factors: the stone's beauty, rarity, toughness, and expertise with which it has been cut and polished (Sentayehu et al, 2009).

The so-called "four C's" are the standards used to grade gemstones. Color, Clarity, Carat, and Cut are the four C's of gemstones (Mengich et al., 2019). Despite the complexity of colored gemstone supply chains, all gemstones go through the same steps from the mine to being sold as jewelry to the final customer.

2.2. Gemstones in Ethiopia and the Existing Utilization Trend

Opals, emeralds, sapphires, amazonite, amber, rubies, tourmalines, aquamarines, chrysoprase, peridots, chalcedony, obsidian, agate (scapolite agate), jasper, petrified wood, various types of quartz, including precious quartz, etc. are just a few examples of the high quality gemstones found in Ethiopia (*Sentayehu et al, 2009*). At least nine gemstones, including opal, corundum, beryl, garnet, peridot, quartz species, and tourmaline, are reported to have substantial deposits in the nation. Emerald, the most valuable of all beryls, was most recently found in Oromia Region's Guji Zone of Seba Boru district. The export prices for several rough gemstones from Ethiopia are updated in the table below.

Table 2.1: Export of Ethiopian Rough Gemstones at Unit Price (Source from unpublished documents),

1, Opal Families			
S. No.	Name of the Gemstone	Grade	Updated Export Price in USD Per Kilogram
1	Shewa Opal	A	250
		B	150
		C	100
2	Wollo Opal	A	5,000
		B	4,000
		C	3,000
		D	1,500
3	Black Opal	A	2,000
		B	1,000
		C	8,000
4	Afar Opals	A	1,000
		B	500
		C	200
5	Crystal Opal	A	1,500
		B	1,000
		C	500
2, Non Opal (Precious) Gemstones Families			
S. No.	Name of the Gemstone	Grade	Updated Export Price in USD Per Kilogram
1	Yellow and Green Amber	A	200
		B	150
		C	100
2	Fossilized Amber	A	600
		B	450
		C	250

Value Addition of Ethiopian Gemstones

3	Emerald	A	12,000
		B	8,000
4	Transparent Ruby	A	10,000
		B	5,000
		C	3,500
5	Sapphire	A	35,000
		B	20,000
		C	15,000
6	Ruby and Sapphire Corundum (Not Transparent)	A	100
		B	80
		C	60
7	Tourmaline Green and Pink Color	A	600
		B	500
		C	400
8	Black Tourmaline	A	10
		B	7
		C	4
9	Tourmaline With Multi Color	A	2,000
		B	500
		C	400
10	Aquamarine	A	500
		B	400
		C	250

3, Non Opal (Semi Precious) Gemstones Families

S. No.	Name of the Gemstone	Grade	Updated Export Price in USD Per Kilogram
1	Peridot	A	25
		B	15
		C	5
2	Topaz	A	100
		B	60
3	Amazonite	A	10
		B	8
		C	6
		D	5
4	Geode with quartz	A	20
		B	15
		C	10
		D	5
5	Amethyst	A	10
		B	8
		C	5
6	Rutile quartz	A	10
		B	8
		C	3
7	Smoky quartz	A	10
		B	8
		C	3
8	Chalcedony and Agate	A	2
		B	1

Value Addition of Ethiopian Gemstones

9	Chrysoprase	A	8
		B	3
		C	8
10	Citrine	A	8
		B	5
		C	3
11	Petrified wood	A	3
		B	2
		C	1
12	Garnet	A	50
		B	40
		C	30
13	Jasper	A	5
		B	3
		C	2
14	Black Obsidian	A	3
		B	2
		C	1

From the above table it is possible to understand as evidence that Ethiopia is exporting the gemstones in the rough form with very low price.

According to the report by (Anwar, 2019) since there are currently no well-documented studies on gemstone mineral deposits, we had to take a step back in our analysis and strategy. In order to get around this, we used production data from exports as well as export revenue to conduct our prioritization of the commodity. The mineral market development and value chain directorate of the ministry has provided a marketing report for the final eight months of the 2018–19 fiscal years. Therefore, in order to best respond to stated criteria on template, we rely on production statistics supplied on the eight-month report of the artisanal mining coordination and assistance directorate as well as global gold trade trend and online publications. According to the sector profile study, all of Ethiopia's gemstone mining is done by artisanal miners. Opal has dominated the gemstone industry in terms of income generation over the past eight months, outpacing all other gemstone types by a margin of around 50%. This demonstrates that opal is produced at a fast rate and that opal is in high demand globally. According to this research, opal predates the gemstone industry. Over 2757.7 kg of rough opal and 95.92 kilogram of polished opal have been exported during the past eight months.

Even though rough opal exports are carried out in greater quantities than polished opal exports, the earnings from the export is only marginally higher. This suggests that the strategy's top priority should be value addition.

CHAPTER THREE

3. THE PROJECT WORK METHODOLOGY

In this project work, Ethiopian rough gemstones are considered as the primary object on which value addition is conducted to enhance and improve their jewelry value, and so that expected to improve the unit cost of the gemstones. The naturally mined rough valuable gemstones are sorted, cut, and polished to make cabochon or faceted stone to obtain value added gem product. This is achieved by intensive literature review and gemstones processing methods.

3.1. Origin of the Rough Sample

The rough gemstones samples are collected as much as possible from Oromia Region around Negelle Borena and gem samples which are from areas of known gemstone resources in the country from the workshop center of the Ethiopian Mineral, Petroleum and Biofuel Corporation is the one on which value addition processing is done.

3.2. Processing Methods

3.2.1. Cabochon Making

For the cabochon making method the following materials are used:

- Rough selected Gemstone,
- Sawing Machine with Blade and Lubricants,
- Templates (Standard Shapes) or Molds,
- Trim Saw with Blade and Lubricants (gasoil or water),
- Dope stick (Wood or Metal),
- Grinding and Polishing Machine with different grit Polishing Wheels,
- Pencil, Ink Pen, Tracing Paper and Ruler (for drawing of different shapes using templates),
- Small Gas Cylinder or Torch, Glue, Cleaning Materials With Different Kinds of Pincers and
- Packing Materials.

3.2.2. Faceting

For the faceting method the following materials are used:

- Facet Rough Gemstone,
- Facet Cut Design Manual,
- Trim Saw Machine with Blade and Lubricants,
- Dope Stick,
- Appropriate Glue or Fixing,
- Faceting Machine with Different Plates and Water,
- Diamond Powder and or Olive Oil/Diamond Plate and
- Packing Materials

3.3. Processing Steps

3.3.1. Cabochon Making

The Cabochon making method of gemstones processing passes through the following sequential steps:-

- Sorting of the gemstones accordingly,
- Cutting of the rough gemstone (Boulder to slabs or pebbles to appropriate size),
- Using templates as standard reference cutting it further by trim saw,
- Then stick it on a dope stick (doping) and
- Grinding and polishing (this is done with six stages of different grits of grinding and polishing wheels starts from rough surface smoothing to final required polishing shinning stages).

3.3.2. Faceting

The Faceting method of gemstones processing passes through the following sequential steps:

- Grading and or sorting of the rough gemstones to get facet rough stone
- Cutting to the required size or removal of poor quality sources
- Doping
- Faceting and polishing the gemstone specimen (the top and bottom) by changing the discs as based on what is the final shape needed to end up with.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

The procedure for choosing rough gemstones from the collected gems is covered in the section that follows. The goals of this project activity have also been thoroughly examined. This section also includes the results of each particular goal.

4.1. Results

The table below includes a few images of the fundamental lapidary machinery for adding value to gems that were shot at the gemstone workshop center of Ethiopian Mineral, Petroleum and Biofuel Corporation when work was being done in part.

Figure 4.1: The Basic Gem Value Adding Machine



Sawing Machine



Polishing Machine



Sorting



Faceting machine with activity



Value Addition of Ethiopian Gemstones

The following table shows the value-added activities with their corresponding results for the chosen rough gemstones that were selected.

Table 4.1: The Value Added Gems are summarized

S. No.	Type of rough gems	Area of Sample Origin	Value Addition Process applied	Immediate Advantage (Change Noticed)	Photo of the Value added gemstones
1	Opal	Amhara Region (From EMPBC Workshop Center)	Sorting	Ease of access	
			Cutting	Sizing of desired amount and/or removal of poor quality sources	
			Polishing	Beauty or Remarkable Increased Level of Jewelry	
2	Agate	Amhara Region (From EMPBC Workshop Center)	Sorting	Ease of access	
			Cutting	Sizing of desired amount and/or removal of poor quality sources	
			Polishing	Beauty or Remarkable Increased Level of Jewelry	
3	Jasper	Amhara Region (From EMPBC Workshop Center)	Sorting	Ease of access	
			Cutting	Sizing of desired amount and/or removal of poor quality sources	
			Polishing	Beauty or Remarkable Increased Level of Jewelry	
4	Black Obsidian	Amhara Region (From EMPBC Workshop Center)	Sorting	Ease of access	
			Cutting	Sizing of desired amount and/or removal of poor quality sources	
			Polishing	Beauty or Remarkable Increased Level of Jewelry	

Value Addition of Ethiopian Gemstones

5	Crystal Quartz	Oromia Region Negelle Borena	Grading and or sorting	Used to get better surface rough stone to apply faceting	
			Cutting	Used to have required size or removal of poor quality faces	
			Faceting	Attractive shape and faces	
6	Green Obsidian	Oromia Region Negelle Borena	Grading and or sorting	Used to get better surface rough stone to apply faceting	
			Cutting	Used to have required size or removal of poor quality faces	
			Faceting	Attractive shape and faces	

4.1.1. Enhancing the value of raw gemstones

The process of value addition begins as soon as the diamonds are mined. The gemstones are put through a number of processes, each one attempting to raise the gem's worth and thus its price. The value-adding process begins with the grading and sorting of the gemstones. But artisanal gem miners currently don't do much to separate the gems across the nation. It is clear from the current situation that the primary activity of artisanal miners is sorting, which entails the physical separation of valuable gems from worthless stones. While the cooperatives dispose of the worthless stones, they sell the valuable gems straight to shops or brokers.

This project work suggests the use of polishing, cabochon-making, and faceting for grading to enhance the miners' value-adding process. The value addition method uses straightforward technology and reasonably affordable equipment as compared to the multiplied rise in cost of selling value-added gemstones over unpolished ones. The value addition has a favorable impact on gemstone prices. A gemstone that has undergone the process of value addition will be priced significantly higher.

4.1.2. Cutting and polishing of gemstones

This project work describes the gem-cutting technique of faceting. Faceting is the process of shaping beautiful raw gemstones into finished ones with a pleasing appearance. A facet rough crystal serves as the starting point for cutting. The jewels are different sizes and shapes. Some minerals may be found in their native state, while others may have been shattered during the mining process. A gem's beauty can be enhanced through cutting, shape, and polishing, which significantly affects the price. Cutting requires a high level of competence since it is important to enhance the size of the finished gem while minimizing weight loss.

4.1.2.1. Faceting

At this point, the cutting process becomes more intense. This is done by employing various discs for cutting and polishing, with much finer discs covered in diamond paste or diamond powder mixed with olive oil. On the stone, the facets are positioned at highly accurate angles. The cutter uses the Height, Angle, and Index triangles on the portable faceter to regulate the depth of the cut, the plane of the facets, and the positioning of facets around the gem.

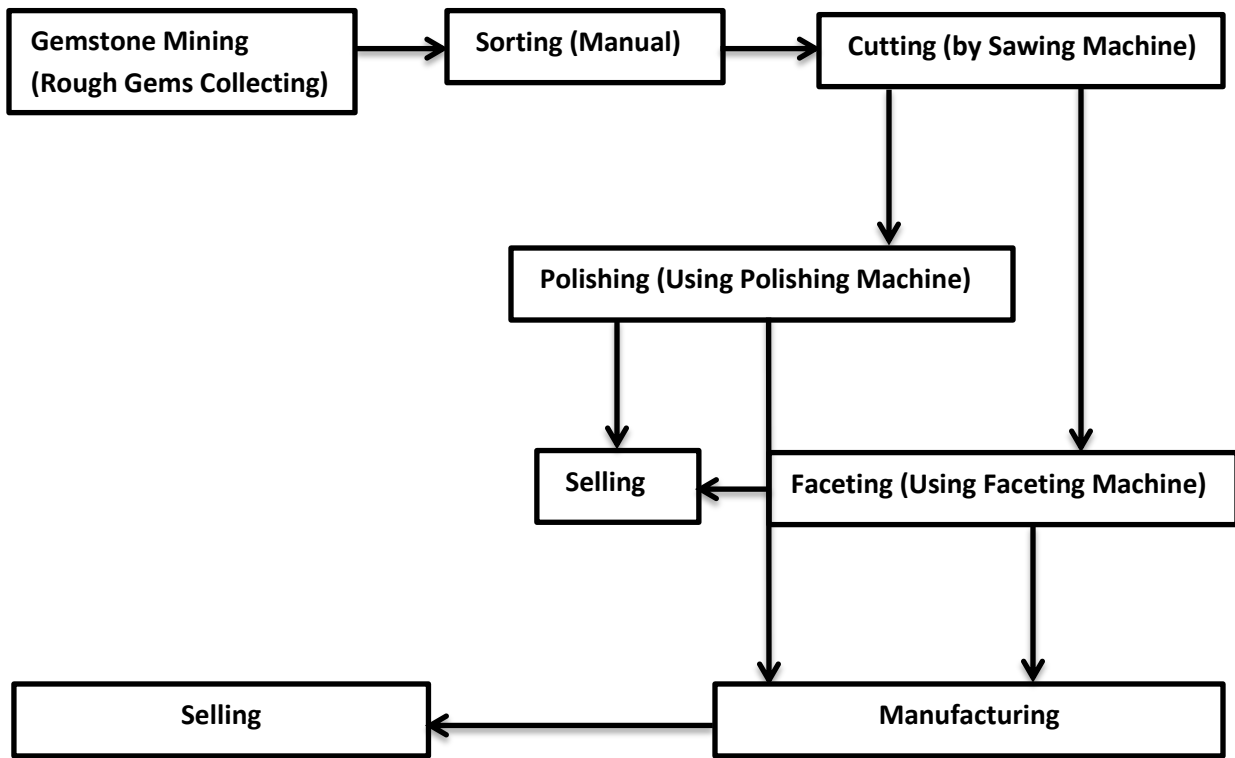
In particular, there aren't any standard angles that are applied to every gemstone. Due to the multiple critical angles, each gem has unique requirements. The smallest angle at which a facet may reflect light back into the gem is known as a critical angle. To avoid any unintended light leakage, the critical angle for each gem should be understood. When the light strikes the facet at an angle other than the crucial one, something happens.

4.1.2.2. Polishing (Cabochon Making)

This is the last step in the faceting case. It uses a finer, specialized polishing wheel covered in diamond paste or diamond powder mixed with olive oil. Each facet is polished separately, creating a mirror-like sheen that helps light reflect off the stone's surface.

Grinding and polishing of gemstones is required while creating cabochons, and is done in six phases using varying grits of grinding and polishing wheels, starting with rough surface sanding and progressing to the final required polishing stages.

Figure 4.2: Generalized conceptual flowchart showing gemstones value addition process
(Source: designed by the researcher)



4.1.3. Characterization of the Value Added Gemstones

Characterization of the value-added gems' physical characteristics from the views of the four C's of gems: color, clarity, carat, and cut. Based on personal observation and interviews with the gemologists (gem technicians at EMPBC Gemstones Workshop Center), this is described as follows: Of these four C's criteria of gemstones, the Color, Clarity, and Cut are used to describe the value added gemstone samples individually but carat for all in general.

4.1.3.1. Opal

Opal rough has been subjected to value-adding processes such manual sorting, cutting, and polishing (cabochon manufacturing). Machines like sawing and polishing machines are utilized in the value-adding process. During the adding value, there are noticeable improvements that include grading, the removal of undesirable parts, and greater appeal or beauty of the opal.

4.1.3.1.1. Color

One of the factors used to grade gemstones is color. Therefore, it is best to pay attention to color variety first and then value addition. In this instance, the opal's color has improved, going from a rough that wasn't particularly colorful to one that is now colored but initially appeared quite yellowish and attractive.

4.1.3.1.2. Clarity

Clarity in gems often examines the presence of geologically induced inclusions in the diamond. Inclusions are anything that typically prevents light from shining freely through a faceted gem. On the other hand, some inclusions enhance a gem's visual appeal. The inclusions in the value-added opal scatter the light that passes through them, adding to its beauty.

4.1.3.1.3. Cut

The term "cut" describes the gemstone's form. One of the most crucial elements in gem grading, the cut also greatly affects how a stone appears. A gemstone may be cut into a variety of shapes depending on the desired form of jewelry to be used as well as the best way to obtain the greatest quality gemstone. In this instance, the opal stone has been cut since it is combined with others to make a ring and a necklace.

4.1.3.2. Agate

The rough gemstone of agate has undergone the value addition activities such as: manual sorting, cutting and polishing (cabochon making). For the value adding process

machineries such as sawing machine and polishing machine are used. During the value addition activity there is a remarkable sort of changes noticed i.e. grading, removal of unwanted part and there is attractiveness or increased beauty.

4.1.3.2.1. Color

Color is one of the criteria used for gemstones grading. So it is advisable to notice the color variation primarily and after value addition. In this case there is an increment of beauty in color banding of the agate from which the rough was not clearly colorful but after value addition it shows color banding which physically appeared dull whitish and attractive relatively.

4.1.3.2.2. Clarity

In gems, clarity usually checks on the occurrence of inclusions in the gem which result from geology. Even though inclusions can be defined as anything that usually interferes with the free passage of light in a faceted gem but in the case of agate there is color banding and the value added agate has some color banding which as a result enhance its beauty.

4.1.3.2.3. Cut

The term "cut" describes the gemstone's form. One of the most crucial elements in gem grading, the cut also greatly affects how a stone appears. A gemstone may be cut into a variety of shapes depending on the desired form of jewelry to be used as well as the best way to obtain the greatest quality gemstone. In this instance, the opal stone has been cut since it is combined with others to make a ring and a necklace.

4.1.3.3. Jasper

Jasper has been subjected to value-adding processes such manual sorting, cutting, and polishing (cabochon manufacturing). Machines like sawing and polishing machines are utilized in the value-adding process. At the time of adding value, there are noticeable improvements that include grading, the removal of undesirable parts, and greater appeal or beauty.

4.1.3.3.1. Color

One of the factors used to grade gemstones is color. Therefore, it is best to pay attention to color variety first and then value addition. In this instance, the jasper's color has become more beautiful despite the rough stone's lack of obvious color. After value addition, the stone now exhibits color beauty that first appeared to be chocolate and attractive in comparison.

4.1.3.3.2. Clarity

Clarity in gems often examines the presence of geologically induced inclusions in the diamond. Even though inclusions are anything that typically prevents light from passing freely through a faceted gem, jasper has an attractive color on its own and is valuable because it is unique in that it combines the colors of various natural and man-made objects to further its beauty.

4.1.3.3.3. Cut

The term "cut" describes the gemstone's form. One of the most crucial elements in gem grading, the cut also greatly affects how a stone appears. A gemstone may be cut into a variety of shapes depending on the desired form of jewelry to be used as well as the best way to obtain the greatest quality gemstone. In this instance, the jasper stone has been sliced since it is combined with others to make a ring and a necklace.

4.1.3.4. Obsidian (Both the Black and Green Obsidian)

The black and green obsidian rough gemstones have undergone value-adding processes include manual sorting, cutting, and polishing (cabochon manufacturing), as well as faceting for the green obsidian. Machines like saws, polishers, and faceters are employed in the value-adding process, along with the corresponding chemicals and consumables. While the adding value, there are noticeable improvements that include grading, the removal of undesirable parts, and greater appeal or beauty. The faces created by the faceting machine give the green obsidian, which has undergone faceting, further beauty, making it appear incredibly alluring.

4.1.3.4.1. Color

Color is one of the criteria used for gemstones grading. Therefore, it is best to pay attention to color variety first and then value addition. In this instance, there is an improvement in the obsidian's color beauty, which was previously dull and uniformly dark when it was in its raw form, but which has since undergone value addition to reveal color beauty. In the case of green obsidian, this improvement is also very pleasing to the eye.

4.1.3.4.2. Clarity

Clarity in gems often examines the presence of geologically induced inclusions in the diamond. Even though inclusions are anything that typically prevents light from passing freely through a faceted gem, in the case of black obsidian there is an alluring dark, shining color on itself, and the faceted green obsidian exhibits a clear, light transparent color that makes it look impressive. The black obsidian with added value has a consistent color, but it is special in that it combines the colors of natural and man-made things, enhancing its attractiveness and allowing it to be used for various jewelry

4.1.3.4.3. Cut

The term "cut" describes the gemstone's form. One of the most crucial elements in gem grading, the cut also greatly affects how a stone appears. A gemstone may be cut into a variety of shapes depending on the desired form of jewelry to be used as well as the best way to obtain the greatest quality gemstone. In this instance, the obsidian stone has been chopped and combined with others before being utilized as a necklace and ring.

4.1.3.5. Crystal Quartz

The unpolished crystal quartz stone has undergone value-adding processes such manual sorting, cutting, faceting, and polishing to enhance the appeal and sheen of the faces. Machines like saws, polishers, and faceters are employed in the value-adding process, along with the corresponding chemicals and consumables. During the adding value, there are noticeable improvements that include grading, the removal of undesirable parts, and greater appeal or beauty. The faces created by the faceting machine provide the crystal quartz, which is being processed, further beauty, making it appear incredibly alluring.

4.1.3.5.1. Color

One of the factors used to grade gemstones is color. Therefore, it is best to pay attention to color variety first and then value addition. Even though the rough crystal quartz in this instance was transparent, clear, and colorful, after value addition it reveals color beauty that physically appeared attractive demonstrating beauty in light transferring color and highly attractive relative to other materials.

4.1.3.5.2. Clarity

Clarity in gems often examines the presence of geologically induced inclusions in the diamond. Given that inclusions are anything that often prevents light from passing freely through a faceted gem, the faceted crystal quartz has a clear, light translucent color that makes it appear stunning. As a result, the crystal quartz outcome with additional value increases its beauty for usage in various jewelry

4.1.3.5.3. Cut

The term "cut" describes the gemstone's form. One of the most crucial elements in gem grading, the cut also greatly affects how a stone appears. Depending on the desired end use for the jewelry and the best way to obtain the greatest quality gemstone, a gemstone may be cut into a variety of forms. In this instance, the crystal quartz was mostly carved into rings and necklaces by mixing it with other materials.

4.1.3.6. Carat Weight

The weight of a gem is measured in carats. A carat weighs 200 milligrams, or one fifth of a gram. Given that the majority of gemstones are only available in smaller sizes, larger gemstones are in higher demand and therefore cost more per carat. As a result, a gemstone with the same color, clarity, and cutting grade but a different carat will be priced differently, meaning that the gemstone with the higher carat will be more expensive than the gemstone with the lower carat. This makes it clear that a gem will cost more the heavier it is. However, if a huge gem becomes too enormous to be used in jewelry, its value may be significantly diminished. The carat weight varies with each type of gemstone, which is significant. Despite having same dimensions, two gems may weigh significantly. This is as a result of their various specific gravities. As a result, the processing of the value-added gemstones (opal, crystal quartz, agate, jasper, and both black and green obsidian) takes this requirement of the gem's carat measuring into account.

4.1.4. Limitations

Due to the rarity of an acceptable sample of the rough gemstones and the value of the gemstones, limitations are encountered during project work. A field trip to have technical observation of the sites and at the same time to collect samples is not entirely feasible since the resources are spread out across the nation and because of the temporal instability in terms of peace (due to a lack of peace) within that region. These and other relevant restrictions have an impact on the project's outcome.

4.1.5. Costs of gemstones

The cost of gemstones varies according on the extent of value addition, as is easily understood. Ungraded rough gems are less expensive than graded ones, which are less expensive than finished gems that have been expertly cut and polished. In addition, the price of value-added gemstones will be significantly higher if they are hybridized and turned into jewelry for final usage.

Table 4.2: Shows Estimated Operational Costs for Value Addition Process (**Source from Unpublished Documents**).

S. No.	Detail Descriptions of types of the Expenses	Types of the Rough Gemstones Considered					
		Opal	Agate	Black Obsidian	Jasper	Green Obsidian	Crystal Quartz
		Expenses for Cabochon Making (Birr/gram)				Expenses for Faceting (Birr/gram)	
1	Salary, Pension and Incentives	9.06	9.06	9.06	9.06	9.06	9.06
2	Safety Materials and Uniforms	1.06	1.06	1.06	1.06	1.06	1.06
3	Machineries Depreciation Cost	5.19	5.19	5.19	5.19	5.19	5.19
4	Spare Parts (for machineries)	5.32	5.32	5.32	5.32	6.82	5.32
5	Electric Power, Water and chemicals	0.96	0.96	0.96	0.96	2.75	1.04
6	Insurance	14.57	14.57	14.57	14.57	14.57	14.57
	Total Operational Costs	36.16	36.16	36.16	36.16	39.45	39.45

The following table shows the prices of rough gemstones versus the one that has undergone value addition. In the table the units are converted to the same unit for convenience. The prices are taken from Ministry of Mines for Rough gemstones and the

updated prices of the value added gemstones are from Ethiopian Mineral, Petroleum and Biofuel Corporation. And the costs are by considering the current exchange rate of USD to Ethiopian Birr.

Table 4.3: Comparison prices of the rough gemstones with that of the value added ones.

S. No.	Name of the Gemstones	Updated Rough Gemstones Selling Price ETB/ Kg	Estimated Operational Costs ETB/Kg	Total Expenses ETB/Kg	Updated Value Added Gemstones Selling Price ETB /Kg	Estimated Net Earning ETB/Kg
1	Opal	400,000	36,160	436,160	2,046,750	1,610,590
2	Crystal Quartz	550	39,450	40,000	333,560	293,560
3	Jasper	275	36,160	36,435	85,000	48,565
4	Agate	110	36,160	36,270	80,000	43,730
5	Black Obsidian	165	36,160	36,325	80,000	43,675
6	Green Obsidian	330	39,450	39,960	253,000	213,040

From table 4.3: it is understood that value addition is very economic than that of selling the rough gemstones. As it is shown in the table it is possible to have estimated earnings of 1,610,590 ETB/Kg of Opal, 293,560 ETB/Kg of Crystal Quartz, 213,040 ETB/Kg of Green Obsidian, 48,565 ETB/Kg of Jasper, 43,730 ETB/Kg of Agate and 43,675 ETB/Kg of Black Obsidian, based on which it is possible to estimate the approximate fold of increases like 4 folds in the case of opal, 533 folds in the case of crystal quartz, 645 folds in the case of green obsidian, 176 folds in the case of jasper, 397 folds in the case of agate and 264 folds in the case of black obsidian as compared the earnings of the estimated net price of the value added gemstones with the updated rough gemstones selling prices.

4.1.6. Economic Effects of Gemstone Value Added

4.1.6.1. Gain foreign currency

As by the Reference (*Sentayehu et al, 2009*) and additionally, according to the Ministry of Mines' most recent estimate of the price of Ethiopian rough gemstone exports, the exportation of Ethiopian gemstones can be viewed as a source of revenue for the nation. However, the amount obtained is incredibly small because the majority of the exported diamonds are uncut. Adding value to the gems raises their selling price significantly from

the price valuation. Even when compared to the value-added gemstones, the export price of rough gemstones appears to be given away. Additionally, because of the increase in value of the gemstones, the tourism industry will benefit. The foreign currency that the tourist brings into the country is exported. Therefore, increasing the value of gemstones will help generate foreign currency.

4.1.6.2. Participation in the GDP

As it is well known from numerous unpublished sources, the GDP contribution of Ethiopia's minerals sector is less than 1%, and gold is the principal mineral exported from the nation. This contribution is extremely small when compared to the nation's capacity for natural resources, particularly the gemstones that are the focus of this project's effort. Youths will so find employment in lapidary shops as a result of adding value to the gemstones, and taxes will also be collected. Through its center, the government can register value-added stones; as a result, when the precious resources are sold on domestic or international markets, the associated industries are required to pay taxes and royalties to the government. As a result, the value addition will raise the country's net GDP.

4.1.6.3. Realization of the Sustainable Development Goals (SDGs) and Vision 2025

According to the Investor Guide for Mining in Ethiopia by the Ministry of Mines and Petroleum, mining reform is a top priority for the leader, who wants mining to account for 10% of the nation's Gross Domestic Product (GDP) by 2025. Ethiopia has received praise from around the world for its remarkable and sustained economic growth. To do this, the leader of the country has introduced the "Homegrown Economic Reform Agenda," which aims to undertake the macroeconomic, sectoral, and structural changes. As it is well stated by (*Tesfaye et al, 2017*) GTP I was a strategy that paved the way for Ethiopia to achieve the status of middle-income nation within 15 years, or by 2025, by clearing the way and preparing the ground. Likewise, it is anticipated that the ongoing GTP II will lead the country in a historically novel direction. The nation aims to adjust its economic orientation under the GTP II from an agriculturally-led to an industrially-led economy. Thus, the role of industries in this development trend is highly desirable. This necessitates industrial transformation, and it is expected that our industries will work

together to realize this economically necessary objective. The manufacturing sector's role occupies a prominent position on the development and transformation agenda when it comes to that particular sector of industry.

The reforms and transition from an agricultural-led to an industrial-led economy are the main goals of the Vision 2025 strategy and approaches. A major national priority has been achieving these reforms. It is strongly advised to help the country's economic transformation through increased value addition to gemstones. Ethiopia's Vision 2025 intends to develop Ethiopia into a newly industrialized middle-income country that offers its population at least a medium standard of living, as stated in the Investor Guide for Mining in Ethiopia by the Ministry of Mines and Petroleum. Encourage value addition throughout all of the country's economic sectors to achieve the political, social, and economic characteristics that make up the three primary pillars of any nation. The addition of value to gemstones can help Ethiopia achieve the Sustainable Development Goals (SDGs), which include eradicating poverty, delivering better healthcare, and ensuring environmental sustainability. By doing this, the local miners will be able to cash in on their exploits, take out health insurance, and meet their basic requirements.

4.1.6.4. For Achieving of Eradicating Unemployment

It makes perfect sense that the gemstones industry might be one of the primary possibilities for deploying different manpower as means of support for their families, themselves and the country, youth and women in particular may find the field appealing as a career because it requires patience, especially when adding value. Additionally, if it reaches the end users of jewelry, it will provide new job opportunities and, economically, there will be a clear factor of rising gemstone prices.

4.1.6.5. For Introducing New Technology

Since it is only recently that it is mined and sold in raw form, the gemstone resource riches is not as well recognized as Gold and other precious minerals in our country. Selling or exporting rough materials is not cost-effective, as was already explained. Value must be added in order to obtain the exact value. The correct technology must be used, and the machines must be operated by qualified personnel, in order to add value. In this instance, local adoption of the technology is necessary not only for value addition but also for maintenance, modification, and fabrication (of the machines and their spare parts) in order to increase the likelihood of the lapidary machine manufacturing industry's development. This will consequently lead to the creation of a new job opportunity.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The approaches used for the project work are rough gemstone collection, sorting, cutting, polishing, faceting, and characterization of the gemstones with added value, as well as price calculation. These techniques provide useful data to address the research's goal. The following are the study's main conclusions:

1. This project work report discovered that Ethiopia's gemstone resources face a number of difficulties, including market and price exploitation. In order to contribute to the country's overall sustainable development goals, including the 2025 Vision, starting value addition on the gemstones is essential.
2. Ethiopia is well endowed with a variety of massive gemstone resources that can serve as the foundation for the nation's development, according to the project work findings, which concur with the literature review. Economic contributions from gemstone mining should not be disregarded because of their value in helping to fight poverty in the nation.
3. Establishing a value-added facility that will only deal with the preparation of gemstones for sale and training people in value-added technologies will make it easier to sell gemstones locally or internationally in ways that generate the most money for the government and the direct participants. Therefore, the country's appropriate legislative frameworks that forbid the trafficking of raw gems should be declared, making the value addition on gemstones a must.
4. Through the value addition, the nation will be able to generate foreign exchange, increase the sector's contribution to the net GDP, support the achievement of the 2025 Vision, and aid in playing its own part in eradicating the unemployment issue.

5.2. Recommendations

The Ethiopian government and the relevant sectors are advised to do the following based on the project's work findings.

- ❖ There has to be a scientific evaluation of the nation's current gem resources because there is no accepted method for assessing the resources, including deposit quality and quantity (no estimation or evaluation of the jewels).
- ❖ We have a variety of gemstone varieties in Ethiopia, but there are currently no gemstone professionals available, and there is no experience-sharing specifically in gemstones. Therefore, mining companies and all other sectors with direct ties to the gemstone business are advised to invest in capacity building.
- ❖ To eliminate both the sale of rough gems and the involvement of brokers, value-adding facilities for gemstones should be established at or close to the locations where these resources are found.
- ❖ If practicable, it should be required of all gemstone miners to add value to their extracted gemstones before selling them domestically or internationally. If this is not possible, it should be required that they sell their extracted rough gemstones to the organized local gemstone value add centers.
- ❖ Invite overseas investors and encourage them to begin adding value to the nation's jewels while also instructing the populace on how to use them.

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