Lapidary Level-1

Based on Version 1, January 2014 OS and April, 2021, V1 Curriculum

Module Title: Acquiring Gemstones

LG Code: MIN LAP1M01 LO (1-2) LG-(1-2)

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Adama, Ethiopia

LG #1	LO #1- Collect or mine gemstone

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Introduction to gemology
- Identifying field equipment and prepared based on area geology and source material known.
- Labelling , bagging, and transporting material
- Identifying Occupational Health and Safety requirements of the field

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand about gemology
- Identify field equipment and prepared based on area geology and source material known.
- Label, bag, and transport material
- Identify Occupational Health and Safety requirements of the field

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, ask your trainer for further instructions or go back

to “Operation sheets”.

Information Sheet-1	**Gemology**

1.1. Introduction to Gemology

Gemology is the study of gemstones. Some dictionaries define it as the "scientific study of gemstones," but it is almost impossible to remove the scientific element from that of the artistic. There may be investors whose only interest is in the value of the stones, but if they ever need to distinguish one gem from another, they are dealing with science. There are many categories of gemologists. For the jeweler it is a key element of their business. They need to be able to answer their customer's questions and identify the gems brought into them. Another category of gemologist are the scientists. These are people with degrees in geology, chemistry and sometimes physics. While one of the smallest categories of gemologists, they are at the same time one of the most influential. At the heart of gemology is gem identification.

A **gemologist** is a person who has successfully completed recognized courses in gemology (the science and study of gemstones) and has proven skills in identifying and evaluatinggemmaterials.

A **lapidary** is a cutter, polisher, or engraver of precious stone or an art of cutting/ fashioning gemstones.

A **mineralogist** is a person who studies the formation, occurrence, properties, composition, and classification of minerals.

1.2. Introduction to gemstones

- **Basic terms on: gems, Gemstones, Rocks and Minerals**

Gem - is a **natural mineral or organic** substance that has substantial **beauty, rarity** and **durability-**

Mineral: is a naturally occurring, Solid, with definite chemical composition and an ordered atomic arrangement.

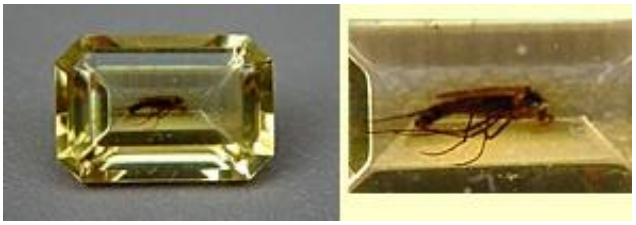
Rock –is a mixture of minerals .Example granite is a rock composed of minerals like silica, mica, feldspar

Organic gem- is one that was made by living things, present or past. Examples include pearls, coral, jet, ivory, shell and amber. Such gems consist of the molecules formed by the

organism, although these molecules may have been altered somewhat due to compression or other geological or chemical forces.

A) Cabochon and carved gems ***B) Faceted gems***

Fig1. Examples of gemstones



A) Coral and freshwater cultured pearl earrings ***B) Faceted amber (enlargement showing fossilized insect within the gem***

Fig 2 Organic gems

Gems such as "petrified dinosaur bone," "petrified wood" and many other "stony" fossil gems, are classified as mineral, rather than organic. Although it's true that bone or wood are organic materials, the reasoning involved is that the original organic molecules and structures of long ago have been totally replaced with mineral solutions such as silica. (This common geological process is called petrifaction).

A) Not classed as organic gems: agate, cabochon cut from a fossilized coral colony

B) petrified dinosaur bone

Fig-3 gems formed by petrification

- A **gem** is beautiful. Beauty, of course, is a subjective concept that has many aspects, and differs from viewer to viewer, but in general, the attributes of gems which excite our sense of beauty include, color, transparency, luster, brilliance, pattern, optical phenomena and, in some cases, distinctive inclusions.

A. Kunzite: color, transparency, brilliance

B. Jasper: color, pattern, luster

C. Ammolite: color, luster, iridescence (an optical phenomenon)

D. Rutilated quartz: transparency, distinctive inclusions

Fig-4 gems showing different characteristics of beauty

- A **gem** is **rare**. There are two types of rarity involved: relative and inherent.

***Relative*:** Many gem minerals occur in various locales and, often, in large deposits, but the vast majority of the material does not approach "gem quality". ***Inherent*:** Other minerals occur in only a few locations or in very small deposits. Inherently rare gems are *doubly rare* as the fraction of an already small amount of ore, which is gem quality, is very, very, small indeed.

- A **gem** is **durable**. It must be strong enough to withstand the stresses and forces

Involved in fashioning it, and its subsequent use as an ornamental object or in jewelry. Most everyone has heard of "hardness" and knows that harder is better, in terms of using gems for jewelry -- but in reality, hardness is only the beginning of the story. There are two other aspects of gem durability that are at least as important as hardness.

Three Aspects of Durability

1) ***Hardness*** is the ability to resist scratching. Commonly measured on the "Moh's" Scale of 1 - 10. Talc lowest (1), diamond highest (10). Soft gems, especially those below 7 will tend to become dull through abrasion with harder materials in the environment, and lose their surface polish and their crisp edges over time.

2) ***Toughness*** is the ability to resist breaking or chipping. This property is measured in relative terms rather than on a numeric scale: sphalerite is fragile, diamond is moderately tough and jade is exceptionally tough. The lower the toughness of a gem the more susceptible it is to damage by the kinds of blows and knocks that are inevitable with frequent wear and use.

3) ***Stability*** is resistance to changes caused by environmental factors such as temperature, chemicals and light. Apatite is temperature sensitive, pearls are chemically sensitive, and Kunzite's color is unstable in strong light. Unstable gems exposed to common factors of the natural or man-made environment are likely to break, change color, or lose their luster.

1.3. Naming Gems

Similarly to the way organisms are named in biology, in gemology, each distinct type of gem has a species name.

Species: A gem species is a mineral that has a definite chemical formula and has a particular three dimensional structure. In regards to that structure, gems can have a crystalline (highly regular and organized) or amorphous (less organized) structure.

An example of a gem species is quartz. All quartzes, whatever their other characteristics, share the same chemical formula: SiO_2 and are members of the *hexagonal* crystal system. *(We'll be looking at the characteristics of the various crystal systems in a later lesson).* The species "quartz" encompasses many quite different looking gems, though, from amethyst and citrine, to agate and jasper, to rutilated quartz and tiger's eye.

Another example of a gem species is corundum (commonly known as sapphire). All corundum gems share the chemical formula: Al_2O_3 and are members of the *trigonal* crystal system.

Variety: A gem variety is composed of a sub-group, within the species, that shares distinct and notable characteristics, such as color, degree of transparency, inclusions, or optical phenomena with others of its kind. Not every gem species has multiple varieties, for example, there are no separate varieties within the gem species peridot.

Species quartz: Variety: amethyst

Species quartz: Variety agate

Figure-5 Quartz Gems

Amethyst is transparent, crystalline, purple quartz. Agate is translucent, usually banded or patterned, *cryptocrystalline (made of very tiny crystals in an aggregate)* quartz. Amethysts come in a range of purple colors from very light to dark, and agates come in a nearly infinite array of colors and patterns.

A. ***Species corundum:***

B. ***star sapphire***

C. 

Varieties: ruby, yellow sapphire,

Figure-6: Corundum Gems

Ruby is the variety name for red corundum, yellow sapphire is yellow corundum and star sapphire is translucent to opaque corundum that shows the optical phenomenon of *asterism (forms a star figure from reflected light)*. The only variety of corundum that is simply called "sapphire" without any modifier is blue sapphire, all other colors have their own variety name (like ruby) or use a modifier like star, yellow, pink, white, etc.

Groups: In some cases, a number of closely related mineral species are placed into a larger, more inclusive category, called a mineral group. Examples are the **garnet group** and the **feldspar group.**

The individual species of the group share membership in the same crystal system, but although the chemical formulas amongst group members are very similar, they are not **exactly** the same throughout the group. Typically, the formulas gradually change by substitution of a group of chemical elements from one end of a continuum to the other.

Garnet Group: All garnets, whatever their individual species and varietal designations, are members of the *isometric* crystal system and are metallic silicate minerals with various proportions of Ca, Fe, Mg, Al, Cr and Mn substituting for each other within a similar chemical formula.

Self-Check -1	Written Test

Direction1: Multiple choice 3pts each

Instruction1- Choose and write the letter of the correct answer on the space provided Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The science which studies about gemstones is called.
   A. Geology B. Lapidary C .Gemology D. Zoology
2. Which one is an organic gem?
   A/ amber B/jasper C/ amethyst D/ opal
3. The ability of the gem to resist scratching force is.
   A/ its toughness B/ its hardness C/ its brilliance D/ its stability
4. Which one of the following is not an aspect of durability?
   A/ hardness B/ color C/ toughness D/ stability E/None
5. Gemstone rarity can be divided into-----types. A/2 B/3 C/4 D/5
6. Which gemstone is not a variety of quartz species? A/ amethyst B/citrine C/jasper D/ruby E/agate

Information Sheet-2	Identifying field equipment and preparing based on area geology and source material known.

2.1. Field tools and equipment

Geological field tools and equipment determination is an important decision before going into field while collecting gems.

2.2. General field tools

Tools which are commonly used in the field are mentioned as follows:

Field notebook: This should be a write-in-the-rain style book with hard covers and not spiral bound. Do not get a spiral bound field book. Instead, get one that is bound like a book.

Good mechanical pencils: 0.5 mm point, bring several and extra leads. Use 2H or 3H lead, not HB as it is too soft and will smudge on your map. Extra erasers or an eraser stick.

Fine-point ball point pens: Good quality, black ink, a range of point sizes. These pens will be used for finishing your field maps and ball point and other types of normal writing pens are not acceptable.

Colored pencils: a box of 24 is your best bet, but 12 would probably work. These are for coloring your maps and your cross-sections.

Protractor: This should fit in or on your map case so you can use it in the field **Ruler**: Your protractor will probably have a ruler on one edge, but a full size ruler could be useful.

Hand lens/loupes/: Should use at least a 10x hand lens, but 16x will work also. The more expensive it is, the better the optics. Use a piece of string or a shoelace or a macramé cord your friend made you at camp as a lanyard so you can keep it around your neck and handy at all times.

Waterproof magic markers (aka Sharpies): at least two with big tips for marking any samples you collect.

White out: for correcting mistakes on the extremely neatly drawn maps, cross sections, and start columns.

Pencil sharpener: to sharpen your colored pencils.

2.3. Geological equipment

Rock hammer (required): I recommend an Est wing rock hammer with a hammer on one side and a pick (“rock pick”) or chisel end (“rock pick [chisel edge]”) on the other side. A 10 or 11 inch hammer should be sufficient. Some folks like the longer handles, but I think they get

in the way. Nylon or leather grip as you like. You do not need and probably will not want a mallet style hammer or crack hammer that has thick, heavy hammer ends on both sides. This is generally a hard rock hammer and will be heavy to tote around in the field. Claw hammers or framing hammers are not acceptable.

Belt or hammer loop (optional): You can get various types of belts or gear holders that you can attach to a belt to hold your hammer and even your notebook or Brunton compass or other small gear. I sually slip my hammer through my normal pants belt and put my notebook in my back pocket and clip my pencil to the neck of my shirt, but having a gear pack on your belt is handy too. If you cannot slip your hammer through your belt or don't have a hammer loop, you will basically have to carry your hammer around in your hand the whole time.

Map board: This can be more or less elaborate as you want. The simplest arrangement is a regular old clipboard. This is not really ideal as it does not have good places for attaching or holding pens and pencils and your field notebook. You can also buy fancier metal clip boards that are like a shallow box with a flip top and a clip at the top. The disadvantages of these is that they may not have a large enough area to have the whole mapping area visible at once, meaning you have to fold the map through the mapping area, and that the map cannot be covered while you are not working on it. This won't be a problem for our projects, but other fieldwork you do may have a larger map area. Another option is a couple rectangular pieces of plexi glass connected along the top with duct tape or some more permanent arrangement. This design also lacks places to hold other equipment, but it allows you to see the map while it is protected from dirt and rain. You should make the board12x15 inches so that it will be big enough to have the entire mapping area visible with the rest of the map folded underneath. If you go this route, be sure and round off corners and edges. Also, you can get all fancy and design and make your own customized mapboard.You might want to ask friends who have taken field camp already or grad students for more advice.

Watch with alarm this is required: Your cell phone is not an acceptable substitute for a wristwatch in the field. You are never certain about having service on a cell phone, not all cell phones have a clock that functions independently of cell service, and the charge on the batteries on a cell phone do not last as long as the battery in even the least expensive digital watches. You must always be aware of the time of day so that you can make field meeting times, know how much field time you have left each day, and know how long it takes to move from one area to another. Also, you will be responsible for waking yourself each day, so a watch with an alarm is handy and frees you from relying on anyone else.

2.4. Camping/hiking equipment

Tent: We will be camping for three weeks. A two or three person tent will be sufficient. Do not bring huge four person or family tents. If you do not have a tent and do not want to buy one now, team up with someone who already has one for the camping nights. Bring a ground cloth or tarp if you use one with your tent or want to sleep outside but not on the ground. Practice setting up your tent once or twice or more before we head out in June.

Sleeping bag: You will sleep in your sleeping bag while we are camping. You should probably have a bag that is good down to around 15° F at least just to be safe, but we probably will not have temperatures that low anywhere. That being said, we will be in the mountains and you never know.

Sleeping pad: Thermo rest or Ensolite are good brands that span a range of sizes, styles, and costs. These make camping more comfortable and help keep you warm at night.

Pillow: A pillow can make the longer van rides a little more comfortable and make you more comfortable for three weeks of camping!

Day pack: This will be for carrying your gear in the field every day. You do not need an expedition backpack to carry your food, water, rain jacket, extra clothing, and assorted other equipment.

Water bottles or camel bag for your pack: THIS IS A MUST: you must have AT LEAST two liter or quart sized water bottles or the equivalent in a camel back. This is an absolute must. If you get dehydrated, you will get a check minus. Flashlight or headlamp: This will be useful while we are camping. A headlamp is handy as your hands are free Pocketknife: a basic Swiss army knife or the equivalent is extremely useful for all sorts of things in the field and is a standard piece of field gear for most geologists.

First aid kit: THIS IS REQUIRED: you must have a back packer sized first aid kit with at least the basic gear (various band aids, disinfectants, allergy meds, aspirin or ibuprofen, tweezers, gauze, ace bandage, anything else you think you want to have). Generally, it is an immediate response in times of accidents.

Sunscreen: THIS IS REQUIRED. You will be outside all day at higher elevation than you are accustomed to and will often be in the sun all day. I strongly recommend at least SPF 30 strength sunscreen. The risk of skin cancer can be greatly decreased through use of adequate sunscreen. Also, if you get badly sunburned in the field you will get a check minus.

Bug dope: Probably won't have to deal with much in the way of skeeters, but it is always good to be prepared.

Sunglasses. These are good to protect your eyes on bright days and to make you look cool in the field.

Binoculars: Completely optional, but good for seeing far away things up close!

Camera: lots of world class, textbook outcrops and beautiful scenery and wildflowers.

2.5. Safety Clothing

Jacket: It will get cool to cold at night in the mountains and the mornings will usually be cool also. You can get an idea of the weather by checking out www.weather.com for Baker, NV, Elko, NV, and Black Hills, SD. You probably do not need a parka, but something you can wear over layers is good. A fleece jacket will probably do just fine.

Wool sweater: This is good for layering. I will bring both a sweater and a fleece jacket.

Long sleeve shirts: Long sleeve t-shirts or flannels or synthetics are good for layering. I will bring

One or two of each.

T-shirts: I will bring five or so t-shirts. White or bright colored t-shirts are much better than black or dark colored and are easier to see at a distance in the field.

Pants: I suggest long pants rather than shorts for field work, but that is just my personal preference. You may prefer more than over more of your body and advancing your risk of skin cancer. I prefer fewer cuts and scrapes from sage and rocks! One option is the ever hip lightweight pants with legs that zipper off. You will also want to have at least one pair of warm pants to wear at night if it is cool. I like blue jeans because they are sturdy and durable, but they do not dry quickly when they get wet. I will bring both pants and shorts.

Warm hat, gloves and/or mittens: it can get cold at night in the mountains.

Field hat: this is required for protection from the sun. A lightweight, light colored hat with a wide brim that shades your neck, ears, and face is best. Think protection, not style, unless you find the hat that combines both. That is a hat to hang onto!

Sturdy hiking boots: You do not need mountaineering or expedition style boots, but you want a good, sturdy hiking boot or trail shoe that has tough soles and good ankle support. You will be hiking around all day on uneven terrain. If you have new boots, be sure to wear

them for a few weeks before we go so they are broken in. If you cannot go into the field because your feet are covered in huge blisters from your brand new boots, you will get a check minus for the day. Gaiters to keep rocks and dirt and snakes out of your boots are optional. Some folks use them and like them; I never have.

Hiking socks: Bring at least three pairs of good hiking wool or wool/cotton blend socks. I like Smart wool brand. You can get good hikinsocks at Midwest Mountaineering or REI or other outdoor stores.

Rain jacket and pants (no ponchos; cannot work in them): We will work through light rain, so you will want to have a shell or poncho with you in the field at all times.

Bandana: Good for all sorts of things while doing field work or camping. Bathing suit: optional. You might have the opportunity to swim in rivers once or twice.

Bath towel.

Biodegradable soap: Since we will be camping the entire time, we will bath in the rivers and creeks. You will be allowed to use only biodegradable soap, preferably unscented.

Luggage: The best thing to pack your clothes and camping and field gear into for travel is a duffel bag as that is the easiest thing to stack into the back of the vans. The next best thing is a backpack. We will not be doing any backpacking, so a backpack is not really necessary but it is basically a duffel bag. The worst option is a regular hard suitcase. These are bulky and harder to pack into the van.

2.6. Cooking and personal gear

Utensils: bring fork, knife, and spoon (or a Spork)

Cup or mug, plate, bowl: Something suitable to eat your gruel in while we are camping.

Chap stick: You probably should have Chap Stick with sun protection also. Personal hygiene items of a suitable sort.

Medications: If you take medications regularly, be sure and bring an adequate supply for our three week trip.

Music: You might want a disc man or I-Pod or some such and headphones. The vans have tape or cd players, so if you have a tape adapter or radio transmitter for your music gadget that might be handy. Bear in mind that I will be the final arbiter of good musical taste at all times in my van!

Money: You will want some spending money for the trip out and back and for any trips into Dillon on grocery runs or for one or two evenings of fun or on the days off. The Birch Creek Center has coin operated laundry machines (we will supply soap), so bring some quarters. Several flavors of cash machine are available in Dillon.

A good attitude. This is an absolute MUST!

Figure-7 geological hammers

Figure-8 Loupe (magnifying tool)

Self-Check -2	Written Test

Direction 1: Short answer items 2pts each

Instruction1- Read the following questions and give answers for each.

Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Mention at least 5 camping equipment used in the field?
2. What is the use of handling first aid kit?
3. What is the importance of loupe?
4. What is the appropriate shape of geologic/rock hammer?

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

Answer Sh5eet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-3	**Collecting and/or mining labelling, bagging, and transporting gem material.**

1.1 Collecting /mining gem material

Before directly going into collecting, it is very important to identify gems and their properties.

Methods to identify gemstones

Geologists identify minerals using tests based on the following 11 physical and chemical properties of a mineral:

- crystal form
- luster
- hardness
- cleavage
- fracture
- streak
- color
- texture
- density
- specific gravity
- special properties

A. Hardness

Definition: a measure of how easily a mineral can be scratched

Table 1. Moh's Scale of Hardness

Mineral	Hardness	Hardness of Common Objects
Diamond	10	

Corundum	9	
Topaz	8	
Quartz	7	**streak plate = 7**
Feldspar	6	**steel file = 6.5**
Apatite	5	**glass = 5.5**
Fluorite	4	**iron nail = 4.5**
Calcite	3	**piece of copper = 3.5**
Gypsum	2	**fingernail = 2.5**
Talc	**1**	

B. Crystal Form

Some mineral form such distinct crystals that they are immediately recognizable.

Examples:

i. Halite – perfect cubes
ii. Quartz – double-pointed ends and six-sided

However, perfect crystals are not always formed, so identification based only on crystal form is rare.

C. Luster

Definition: the way that a mineral reflects light from its surface

There are two types of luster:

a. Metallic
   i. Examples of minerals with this type of luster are: silver, gold, copper, galena, and sphalerite
b. Nonmetallic Luster
   i. Terms used to describe these are: dull, pearly, waxy, silky, or earthy
   Luster should usually be used in combination with other physical characteristics to identify a mineral.

D. Texture

Definition: describes how a mineral feels to the touch

What are some of the terms used to describe texture? Smooth, rough, ragged, greasy, or soapy

E. Cleavage & Fracture

Definition of Cleavage: the manner in which a mineral breaks along planes where atomic bonding is weak

How do geologists determine cleavage? Geologists count the number of cleaved planes and study the angle or angles between them.

Definition of fracture: when a mineral breaks into pieces with arc like, rough, or jagged edges

What is conchoidal fracture? Fracture with arc like patterns resembling clamshells

F. Streak

Definition: the color a mineral is when it is broken up or powdered

Non-metallic generally have a white streak.

Metallic can have streaks that are different than their appearance color.

Streak tests can only be used on minerals that are softer than a porcelain plate because the mineral will need to become a powder to form a streak.

G. Color

What generally causes color in minerals? The presence of trace elements or compounds within a mineral

In general, color is one of the least reliable clues of a mineral's identity.

H. Density

Density formula:

$$D = \frac{m}{V}$$

Where D = density in g/cm^3, m = mass in g, and V = volume in cm^3

Density reflects the atomic mass and structure of a mineral.

Because it is NOT dependent on the size or shape, it is a useful characteristic for identifying minerals.

I. Specific Gravity

1.2 Labelling gem material

Once gem materials are identified, the next step will be tagging all the necessary information of the material. That is what we call gem material **labelling** .The information has to be written by nonerasable ink on the water proof hard paper. Common data to be written include the following:

- Date when the material is found
- Name of the place where the material is found
- Type of material
- Size of the material etc.

1.3 Techniques of bagging and transporting gem materials

While bagging and transporting gem materials, it very important to know the basic properties of gem materials specially hardness of the material. In general, gemstones with almost similar hardness values have to be bagged together. This is because if materials with different hardness values are bagged together, the material with the greater value will damage softer materials and thus, creates wastage during transporting. Having used the right way of bagging, the materials bagged should not undergo relative motions. The reason here is to restrict the probability of collisions with one to another during transportation.

Self-Check -3	Written Test

Direction 1: Short answer items 2pts each

Instruction1- Read the following questions and give answers for each.

Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Mention at least five physical properties of gematerials?
2. What is hardness of gemstones
3. What is the disadvantage of bagging gemstones with different hardness within a bag?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-4	Identifying Occupational Health and Safety requirements applied on field.

4.1

ccupational health and safety guidelines

HEALTH AND SAFETY IMPACTS

The poor technology used in extraction of gemstones, the inability to invest in safe working equipment and tools, the lack of technical know-how and the poor sanitary conditions in the mining camps, are some of the factors that threaten the miners health and safety.

Health impacts in mines

Lack of adequate sanitation facilities and scarcity of water increase miner'shealthhazards. Poor ventilation in deep underground pits leads to accidents due to lack of adequate air circulation. Poor circulation of fresh air leads to depletion of oxygen and the buildup of other toxic gases. Suffocation from accumulation of toxic gases like carbon monoxide, hydrogen sulphide, sulphur dioxides and others, are common incidents.

In areas where drilling is carried out using drilling equipment, e.g. jackhammers, thereare rarely any measures to suppress the dust. In correct usage, drilling equipment for underground work is provided with a special connection for water that is used to suppress dust and for cooling. Most miners use machines designed for surface work underground, where ventilation is limited and thus are exposed to large amounts of dust. The dangers from dust exposure are made worse by the fact that miners usually lack protective equipment, in this case, dust masks. The introduction of mining equipment such as jackhammers, crushers and grinding mills without provision for protective equipment is bound to have negative effects on the miner's health and safety. Apart from exposure to dust, which has been discussed above, noise from such equipment is a health hazard to their operators. Drillers in the underground pits usually work in very confined spaces without any ear protectors. Hearing problems are very common amongst underground drillers. Loose morals and the spendthrift atmosphere in mining settlements make women vulnerable to sexual abuse, and communicable diseases, including sexually transmitted diseases spread easily. This has been found to affect mostly young girls and single women with no permanent attachments. Safety in mines Accidents in most working areas can be attributed to poor technology and lack of technical know-how. Lack of adequate scaffolding leads to accident from collapsing

walls and tunnels. Stabilizing the deep streams/quarries require engineering knowledge and the willingness and ability to take adequate measures.

4.2 Environmental Issues

The tools and extraction methods employed by small-scale miners are very basic. The basic technology employed usually results in low rates of recovery that in turn leads to poor earnings and an inability of most miners to invest in appropriate technology. These results in a poor market, returns, working conditions, and a vicious cycle, which most miners find difficult to break. The mode of operation affects their ability and willingness to invest in proper mining methods. The basic negative impacts include land degradation and air pollution

A. Land degradation.

Most of the tanzanite mining activities are carried out underground, through deep streams. During both stream development and mining, a substantial amount of waste is excavated and piled in the vicinity of each shaft. The excavated shafts and piles of waste rock left behind after mining ceases have been identified as a severe, but localized, land degradation, which results in mine disasters e.g. flooding in wet season. The excavated quarry and piles of waste rock also leads to accelerated erosion from both wind scour and surface runoff erosion. The topography of the area seems to determine the extent of the erosion.

B. Air pollution

The impact of mining on air quality comes from the emission of dust, hydrocarbons and vapor during underground blasting. In almost all mining areas, dust is emitted in to underground air polluting the working places. Underground drilling, ore loading, surface crushing and grinding, are all dry processes generating a lot of dust. Where jackhammers are in use for underground drilling, water is rarely used for dust suppression. Long exposure to any respirable dust is very dangerous to one's health. The exposure to graphite dust can cause serious lung diseases. In confined spaces like underground workings, this is a problem, as observed in many of the miners, which have black graphite complication safter the underground works.

C. Noise and vibration pollution

The use of explosives in most mining areas is a major contributor to noise and vibrations. In confined areas with a large number of shafts, blasting is not coordinated such that blasts can

be heard one after the other. This is the cause of many mining injuries and deaths among miners. Government regulations require explosive to be handled only by trained and licensed experts, but the regulations are not enforced although there is a code of practice in Swahili language approved by Ministry of Energy and Minerals for the miners.

Self-Check -4	Written Test

Direction1: True/False items

Instruction1- Write true if the statement is true and false if the statement is false.

1. Mineral collecting/mining does not have any environmental impact.3pts
2. Mining pollutes the environment.3pts
3. while mining, occupational health and safety have to be taken in to account.4pts

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Operation Sheet-1	Collecting and storing gem material

Steps for Collecting and storing gem material

Step 1: Identify and fulfill OHS requirements

Step 2: Identify field equipment based on area geology and source material known.

Step 3: Go to field, identify and collect gem material

Step 4: Label gem material

Step 5: Bag gem material

Step 6: Load and Transport gem material

Step 7: Unload and store the material

LAP Test 1	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Use all necessary tools, equipment and materials that you require to perform the following tasks **8 hours**

Task 1: Collect and store gem material

LG #2	LO #2- Grade gem stone

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Preparing tools and equipment
- Sorting materials by type, size, clarity and color.
- Weighing and/or measuring materials to determine stock.
- Cataloguing materials by type, size, clarity, color and weight to determine stock.
- Pricing materials based on cost of acquisition or current market value

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Prepare tools and equipment required as per need of the particular job. .
- Sort materials by type, size, clarity and color.
- Weigh and/or measure materials to determine stock.
- Catalogue materials by type, size, clarity, color and weight to determine stock.
- Price materials based on cost of acquisition or current market value as fit to the need of the owner.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets .Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check self-checks 1,2,3,4.and 5 in pages 8,13,16,18 and 21 respectively
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

Information Sheet-1	**Preparing tools and equipment required as per need of the particular job.**

1.1 Tools and equipment

Grades of gemstones are values assigned to gemstones depending on their various characteristics. Grading is the process of identifying, sorting and assigning values for. These characteristics are measured by using various tools and equipment designed for those measurements. Tools and equipment commonly used here include:

- Loupe and microscope
- refracto meter and polarizing filter
- Polariscope
- Dichroscope
- spectroscope
- U.v. light source
- Hydro-static scale and/or specific gravity fluids
- Hardness pencil
- Weight balances
- Veinier Callipers

Each instrument investigates one or more of the properties of the gemstone.

I. Microscope

The microscope can look into a transparent or semitransparent gemstone. The observer can see and classify inclusions (if there are any).

- If the stone contains any natural inclusions, that is proof of natural origin
- If a double image is seen, known as “doubling of the back facets”, this is proof of double refraction (DR)

Fig-1 use of microscope

II. Refractometer

- The refractometer measures refractive index but has limitations.
- Critical angle is reached in the optically denser medium, which must be the refractometer glass, not in the fluid or the gem
- The practical limit on the RI reading is 1.80
- There are several species with an RI above the limit - also useful information
- The polarizing filter allows the two rays of a doubly refractive stone
  To be measured independently

- Measuring and plotting how the refractive index varies with direction can also reveal the birefringence and optical character of the gemstone
- The polarizing filter allows the two rays of a doubly refractive stone to be seen and measured independently
- Measuring and plotting how the refractive index varies with direction can also reveal the birefringence and optical character of the gemstone
-

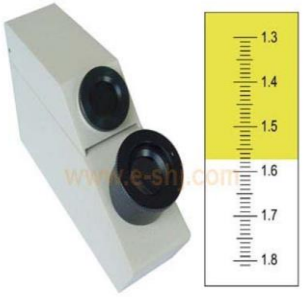


Fig-2 Refractometer

III. Polariscope

- The Polariscope uses cross polarized filters
- gives reactions for SR, DR, and AGG
- gives an indication of optic axis
- gives an indication of optic character isometric (SR) – cubic uniaxial (DR) – tetragonal or hexagonal biaxial (DR) – orthorhombic, monoclinic, or triclinic

Polariscope

IV. Spectroscope

- Scientists analyze the surface of the sun by the wavelengths absorbed from the light emitted
- The spectroscope analyzes the wavelengths absorbed from the spectrum by elements in the gemstone

- The jade merchant tells you the jade has not been dyed. A spectroscope may tell you it has!

Three types of Spectroscope

Table-top

Hand-held

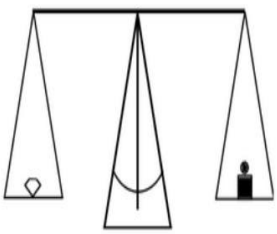
Table-top

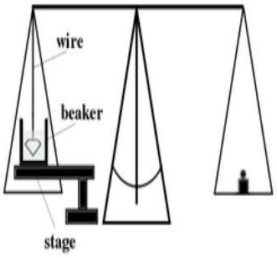
Absorption spectrum for almandite garnet

Measurement of Specific Gravity

- Specific gravity is defined as the ratio of the weight of the gemstone divided by the weight of an equal volume of water

Hydrostatic Balance





Specific gravity = $\frac{\text{weight of gemstone in air}}{\text{weight in air – weight in water}}$

Digital caliper used to measure size of gemstones

Weight balance to measure weight of gemstones

Self-Check -1	Written Test

Direction 1: Short answer items

Instruction1- Read the following questions and give answers for each.2pts each

1. What is gemstone grading?
2. List at least 5 equipment that are used to measure properties of gemstones for sorting them.
3. What is the use refractometer?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-2	Sorting materials by type, size, clarity and color

2.1 Sorting gemstones

Identifying gemstones and sorting them by their different characteristics very important for many reasons. Those characteristics are type, size, clarity and color.

A gemstone is identified as to group, species and variety as the result of a process of elimination and confirmation

- Observation through the microscope gives the most information about the stone
- Observations with the refractometer gives the most precise information but has some limitations and drawbacks

❖ The procedure for identifying the gemstone is set out in the “Project Worksheet”

Measurements and characteristics may give conflicting indications. Results can be rechecked and confirmation tests performed. If testing at a higher level of technology is required, the Gemologist must send the gemstone to a lab

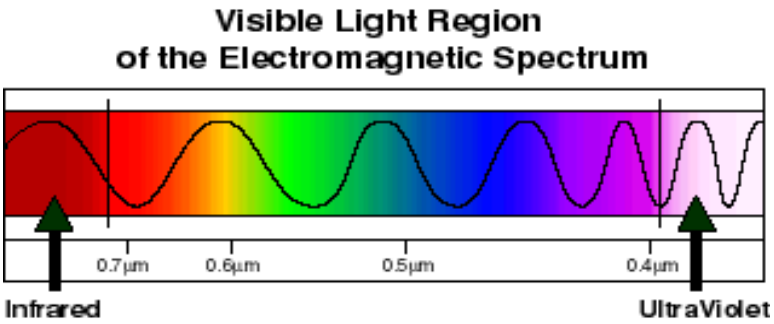
❖ Gemological Institute of America (GIA) operates labs in many countries. GIA reports

Can identify the gemstone, its grade, its country/region/mine of origin, undisclosed treatments, presence of foreign matter, natural or synthetic, etc. GIA has the high-tech equipment, the expertise, the leading edge research. Gemology may be a pseudo-science. Its instruments and procedures look scientific. It borrows scientific principles from several scientific disciplines.

- Gemology seizes on technological advances in physical, chemical and optical disciplines, especially in the areas of gem identification, and the revelation of undisclosed gemstone treatments, through spectroscopy and chemical analysis

2.2 Color Descriptions in Colored Gemstones

Color: The color of a gem is determined by *selective absorption* of some of the wavelengths of light. We know that what appears to us as white (or colorless) light is actually made up of light of various colors. Issac Newton was the first to demonstrate this back in the 17th century.



There are three aspects to a formal colored stone color description: *hue, tone, and saturation*. Using these three descriptors, very detailed and nuanced color discriminations can be made, and communicated, between gemologists, jewelers and gem buyers. Let's take them each in turn:

Hue: The hue of a gem is its basic position in the color spectrum: red, orange, yellow, green, blue or violet--> but it also includes all the possible intermediates like slightly yellowish orange, or moderately bluish green.

Tone: The tone of a gem, basically how light or dark the color, is independent of its hue and ranges from so light as to appear virtually colorless, to so dark as to look black.

Saturation: The least commonly quantified aspect of gem color is "saturation", which is a measure of the purity of color, that is, the relative presence or absence of modifying grey or brown hues. It turns out that in most cases, as long as the hue and tone are reasonably nice, it is the degree of saturation of color that is the prime value setter in gemstones.

You might ask, why does color description need to be so formalized. The main reasons are listed below:

- Small color differences mean big dollars:

2.3 Sorting by clarity

Clarity - Transparent colored stones are divided into three type classifications depending on crystal growth characteristics, and then graded within their type class, for clarity.

The G.I.A*(Gemological Institution of America) system for colored stones lists clarity type classifications as Type I, Type II, and Type III. The classifications are defined as follows:

Type I- These are gems that grow extremely clean in nature and usually have no eye-visible inclusions. An example is Aquamarine.

Type II- These are gems that typically grow with some minor inclusions in nature and the inclusions may be eye-visible. An example is ruby.

Type III -These are gems that typically grow with many inclusions in nature and the inclusions are usually eye-visible. An example is emerald.

Geological field tools and equipment determination is an important decision before going into field while collecting gems.

The table below is published by the guide-reference manual, and explains the clarity grading

Guide Grades	1-2 Lower Commercial	3-4 Middle to upper commercial	4-6 Good	6-8 Fine	8-10 Extra Fine
GIA GRADES	**Severely Included**	**Heavily Included**	**Moderately Included**	**Slightly Included**	**Eye-clean**
Type I	Inclusions are prominent and have a severe effect on appearance, durability, or both.	Inclusions are prominent and ha a negative effect on appearance or durability.	Minor inclusions somewhat easy o see with the unaided eye.	Minute inclusions difficult to see with the unaided eye.	The stone appears clean to the unaided eye.
Type II	Inclusions are prominent and have a severe effect on appearance, durability, or both.	Inclusions are prominent and ha a negative effect on appearance or durability.	Noticeable inclusions apparent to the unaided eye.	Minor inclusions somewhat easy to see with the unaided eye.	The stone appears clean to the unaided eye.
Type III	Inclusions are prominent and have a severe effect on appearance, durability, or both.	Inclusions are prominent and ha a negative effect on appearance or durability.	Obvious inclusions very apparent to the unaided eye.	Noticeable inclusions apparent to the unaided eye.	The stone appears clean to the unaided eye.

system as it applies to the classifications of transparent colored stones

Self check2	**Written Test**

2.4 Sorting by size

- Sorting by size is a very important in grading gemstones. This is because gemstones with different sizes will have different grades. Fashionable sizes are usually more expensive or higher grade than very smaller sizes.

2.5 Sorting by type

In this type of sorting , gemstones with the same variety, group or family should be sorted and placed in a category .If possible, identical gemstone should be in sorted and put in a container. Sorting by type is very crucial because of the following reasons:

- Reduces damage of stones because of their different hardness values
- To make decisions on the inventory on hand
- It simplifies grading
- Reduces the time for searching the type etc.

Direction 1: Short answer items

Instruction1- Read the following questions and give answers for each. 2pts each

1. Mention the four characteristics of gemstones which are used to sort them.

2. What is clarity?

3. How can the size of gemstone affect its grade?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-3	**Weighing and/or measuring materials to determine stock.**

3 Weighing gemstones

3.1 .The carat scale

In the early history of gem marketing, depending on the geographic location, one of two common items, familiar to both buyers and sellers, was used to measure the amount of gem material being bought and sold**:** the wheat grain and the carob seed. Each of these commodities was known for being particularly uniform in size and weight. We see remnants of this early system in today's terms: **"carat"** the international metric unit used for gems, and "grain" a unit sometimes used in selling pearls, and also in today's system of apothecary measure.

Carat: The carat, pronounced like the vegetable, carrot, and abbreviated "CT" is 0.2 grams. So, there are five carats per gram. The metric system is the basic international standard used for gem commerce. The ounce, a familiar English unit of weight, equals approximately 142 cts. There really isn't an appropriately small unit in the English system which could be easily applied to gem weights. [To illustrate: a 1.0 ct. gem weighs 0.007 oz.].

3.2 Special weighing techniques

i. Pearls

Pearl Grain: The pearl grain, is .25 grams, so one gram is equal to 4 pearl grains. Thankfully, the only remaining use of this once important measure, is sometimes seen in the sale of natural pearls by weight. Because there is very little commerce today in natural pearls *(virtually all pearls on the market are cultured)*, it is fast becoming obsolete. Many cultured pearl wholesalers still sell bundles of pearls in units called "momme" which, historically, weighed 75 pearl grains.

Cultured pearls are sold by *diameter* (millimeters) if round, or near round, and by carat if they are oddly shaped (baroque).

9 mm. round cultured pearl, 8.4 ct. baroque cultured pearl

ii. Melee & Total Weight

Melee: Gems weighing .20 ct. or less are referred to in the gem market place as "melee". They are most often not sold by weight, but rather by girdle diameter: 2 mm. 3.5 mm. etc. Such stones are generally used as accents, or in pave' work.

Total weight: When a jewelry piece has more than one stone, such as a center stone and accents, the total carat weight, is to be used: abbreviated as "ct. Tw."

Ring with diamonds and Tsavorite pave' melee of .70 ct. tw. Pendant with rubellite tourmaline and diamonds: .66 ct. tw.

iii. Big Items

Gem rough, and in some cases, carvings and ornamental objects are sold by the gram, (gr) or kilogram, (kg) as the carat is an inappropriately small unit for such goods. Occasionally, you see such wares with simply a *per piece* price without any weight measure listed at all.

Self-Check -3	Written Test

Direction 1: Short answer items

Instruction1- Read the following questions and give answers for each. 2pts each

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the difference between carat and karat?
2. What is Melee?
3. What do we mean by total weight?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-4	**Cataloguing materials by type, size, clarity, color and weight to determine stock.**

4. Cataloguing materials

4.1 definition of cataloguing

Catalogue is the registration and object numbering form on which all the necessary information of the object is to be registered. In addition to labeling, cataloguing of gem material is very essential to easily manage access on the time of request. Thus, **cataloguing** is documenting all the necessary parameters of gems as per indicated on their label.

Catalogue is a store house for knowledge about the collected materials as well as tool for managing material information and for helping administer the collection.

4.2 Basis of material classification

While using a catalogue, basic descriptions or properties of materials are to be used to classify them in to different groups for ease of management. Those important descriptions or properties of gem materials include the following:

I. type of gem material
II. Clarity of material
III. Size of material
IV. Weight of material

Self-Check -4	Written Test

Direction 1: Short answer items

Instruction1- Read the following questions and give answers for each.

1. What is cataloguing?
2. .what is the difference between size and weight of a material?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-5	Pricing materials based on cost of acquisition or current market value as fit to the need of the owner

5.1 pricing of gem materials

Price is a policy to be set depending on the expenses paid to own the material. But the price of the material may depend on the current market value regardless of the outlays paid for the material.

5.2 ***Factors that affect prices of gem materials***

Even though there are many reasons for variations in prices of gemstones, their price may basically depend on the following:

- **Carat** (weight) of the gem material
- **Cut** (shape and proportions) of the gem material
- **Color** (colorlessness) of the gem material and
- **clarity** (lack of inclusions) of the material

I. Color

Color -is typically the most important value-setting factor for gemstones. All gems have a preferred color or a relatively small range of preferred colors. The more a specimen's color varies from this range – lighter or darker, more or less vivid – the less valuable the stone is.

II. Cut

The **Cut** refers to the shape or design of a stone, arrangement of facets, as well as the precision of the stone's proportions and finish. The cutting process reveals the beauty of a gem.

III. Carat Weight

Carat- is used to designate the weight of a gemstone. The size of a gemstone is measured, not by its dimensions, but by weight. One carat, the traditional unit of measurement for gemstones, is equal to approximately 0.2 grams. Up to a certain point, the larger a stone is and the rarer it is, the higher the price tag it will have.

IV. Clarity: a gemstone's **clarity** grade is directly related to its rarity. Clarity refers to a gemstone's relative freedom from clarity characteristics (which are undesirable). Clarity characteristics include inclusions, which lie within the stone, or blemishes, which lie on the surface of a gem. The fewer clarity characteristics, the more valuable the gemstone.

a. Sample Grading by type, color, clarity and cut

The following table shows grading of gemstones as per gemstone industry standards. The same technique is used for other stones.

Gemstone Grade Chart		
Gemstone	**Grade**	**Description (industry standards)**
Alexandrite	A	Light green to greenish blue, included, weak to low color change.
Alexandrite	AA	Green to greenish blue, slightly included, moderate to medium color change.
Alexandrite	AAA	Deeper green to bluish green, clean, bright to high color change.
Amethyst	B	Light purple, eye clean to slight imperfections, little or no color zoning, good cut & polish.
Amethyst	A	Med/light purple, eye clean to slight imperfections, little or no color zoning, good cut & polish.
Amethyst	A+	Med purple, eye clean to slight imperfections, little or no color zoning, good cut.

Amethyst	AA	Med dark to dark purple, eye clean to slight imperfections, little or no color zoning, good cut.
Amethyst	AAA	Deep purple, eye clean to slight imperfections, little or no color zoning, good cut.

Self-Check -5	Written Test

Direction 1: Short answer items

Instruction1- Read the following questions and give answers for each.

1. What are 4Cs of a gem material that can affect their price?
2. How can style cut affect the price of the material?
3. What is the difference between price and cost of a gem material?

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

List of Reference Materials

1- **WEB ADDRESS(www.gemsociety.org/article/gem-formation)**

2- **https://www.gia.edu/gem-education/course-gem-ident**

3- **https://olliuci.files.wordpress.com/2010/11/sc-214-week-2-presentation-gem-identification**

4- **Gemstone Identification Guide | Search For Info & Results**

WB-Ethiopia-Gemstones-

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