The Art of cutting stone

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SCOPE:

To review pre- 1400's techniques in cutting and polishing cabochons. We will also review how to shape and polish cabochons using modern non-machine abrasives to demonstrate techniques.

Introduction : There are several sources that make reference to cutting and polishing stones. Examples include " Plineys Natural History", Mappe Clavicula" and "Theophilus's Diverse Arts". Between three and a few other resources we can get an idea of how a stone is cut and polished. We will be referring to Theophilus as our primary source as he has the most complete description on how to shape and polish gemstones.

Some geology definitions:

Lapidary: The art of cutting gems and a term used to describe the person that cuts and polishes the gem.

Mineral: A crystalline solid, with unique characteristics and definite chemical composition, Examples include quartz, diamond, sapphire, feldspar, fluorite, and ice (yes… I said ice).

Rock: An aggregate of minerals, Examples are sandstone. Sandstone is a sedimentary rock made of quartz crystals. Another example is Granite, a metamorphic or igneous rock made up of quartz, hornblende, mica, and feldspar where the individual crystals are smaller than one inch. If the crystals are one inch or larger then it's called a pegmatite. As a side note, pegmatites can be used as a marker for gemstones such as aquamarine.

Sand: when we think of sand we normally associate it with quartz. Sand, however, is defined as a particle size, not a type of material. In fact if you look closely at beach sand, you will find other materials mixed in. A good example of sand that is not quartz is the black basalt beaches in Hawaii. Sand measures from $1/8^{th}$ mm to 1mm in size (Jackson, 1970).

Grit: Size or mesh of the material used for polishing or sanding.

Hardness: The resistance that a clean non-weathered smooth surface of a mineral offers to scratching, is its hardness. In other words, how easily a mineral can be scratched. Hardness is dependant on crystalline structure. Minerals that have a stronger bond between the atoms are harder (Hurlbut).

Mohs hardness scale: This scale is a relative measure of hardness. 1 is the softest and 10 is the hardest. Diamond (10) can scratch anything from itself down to a mineral with the hardness of one. Corundum (9) can only scratch itself and down to talc (1). Corundum cannot scratch diamond. Feldspar (6) can only scratch itself and down to talc (1) but not anything 7 or above.

1) talc
2) gypsum finger nail about 2.5
3) calcite copper about 3
4) fluorite
5) apatite steel about 5
6) feldspar glass 6-7
7) quartz emery 7-9 garnet 6.5-7.5
8) topaz
9) corundum ruby, sapphire
10) diamond

Hardness plays a significant role in cutting and polishing the stone. If a stone contains more than one mineral, the hardness may vary throughout the sample and you could erode the softer mineral before the harder mineral, leaving pits or undercuts (an orange peel type texture). If you try to grind or polish a stone with feldspar with gypsum then the only thing that you will accomplish is making your gypsum wear away.

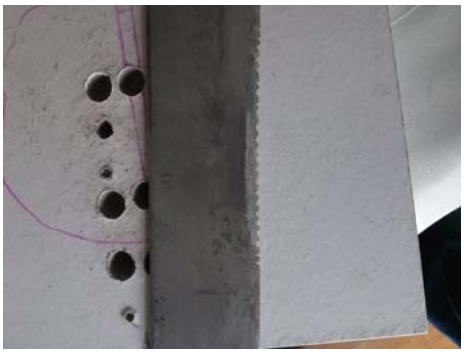
Period procedure:

This section is just an overview of how a cabochon is made. In the next section I will describe in detail how to form a cabochon by hand. Even though the materials I will be using are modern, the techniques have not changed.

Theophilus describes the following procedures for cutting what he calls crystal. He describes crystal as " Water that has hardened into ice. The ice of many years hardened into stone." (Dodwell on Theophilus, 1961).

Cutting the crystal: Theophilus states "take a stone and place it between four pins on a bench. Place two pins above, and two pins below the stone so that an iron saw just fits. Have two people sand by, one to draw the saw and the other two to add water and sand." (Dodwell on Theophilus, 1961).

As an experiment I built a small trim saw based on Theophilus's description. I made a small handsaw blade out of steel. I then drilled two rows of holes in a flat board so that rows were spaced no farther apart that the width of the blade. The reasons the pins are so close together is to prevent the blade from wobbling side to side or move around. The blade should only move back and forward and back. I did have a little play but by putting tension on the pins using wire, the pins held the blade in place. I was able to move the blade without wobble. There are several holes in each row is to accommodate varying sizes of rock. I took one of my slabs of stone and placed it on the saw, added some sand on top of the stone and then got the sand and stone wet. I found I could saw into the rock. Below left is a picture of the saw blade and base. Below right is a picture of the saw assembled without the sand/water or tension strings.



Dop stick: A dop stick or wooden dowel is attached to the bottom of the stone and is used as a handle when shaping the stone. To attach the dop stick to the stone, Theophilus calls for a pitch like material called tenax which is also used for repouse work. "Heat up the tenax and use it to fix the stone to a stick" (Dodwell on Theophilus, 1961).

Shaping the crystal: Rub the stone on a wet sandstone until it takes on the shape you want. For a cabochon we are looking for a dome.

Polishing the crystal: Rub the stone on another wet sandstone that has finer crystals until it becomes smooth (finer grit) Next take a sheet of lead and place some moistened tile. Grind the tile into the lead. Use this as the next step in polishing, The last step is to take the tile rubbings (finer grit) and place them on a clean goatskin stretched and anchored to a wooden board. Carefully rub the crystal on the goatskin until it sparkles.

Theophilus also suggest taking fragments from the crystal and making a fine powder. Mix the powder with water and place it on a smooth board of lime wood to polish the crystal.

For Amethyst he suggests using emery (a mixture containing corundum), placing it ion a sheet moistened copper (the Mappe Clavicula suggests lead), and shaping the crystal this way. Take the washing and let it settle out and dry. Place this on a wet board of limewood and polish.

The Mappe Clavicula also describes emery stone (chapter 133), how make emery plates, (chapter 145), polishing soft and hard stones (chapters 146 b, c, e), and dop sticks (chapter 146f).

Harder stones such as corundum or topaz, were shaped by rubbing one stone against the other (such as corundum against topaz). Diamond was also used to shape stones.

Diamonds were rarely shaped. The diamond has a natural shape of an octahedron. In other words, two four sided pyramids connected base to base. Prior to the 1400's a diamond was in cut in half and mounted to show a pointed stone known as the diamond point cut (Campell, 2009). The table cut was simply a point cut with the point cleaved off. In the late 1400's the technology for faceting became available and diamonds could be shaped. Louis de Bequen was given credit for creating the first brilliant cut in 1476 by using a horizontal table and diamond dust suspended in oil.

Making the cabochon

In this section I will describe how to cut, shape, and polish a cabochon by hand.

Normally I would use a trim saw designed to cut stone and cabbing machine, but for this project I trimmed the stone using the hand saw I made and described earlier, and replacing the sandstone, tile, emery, and crystal fragments with varying grits of sandpaper, and a polishing paste (cerium oxide).

To start with, I chose piece of raw material and drew the shape of my cabochon and my trim lines on the slab.

I trimmed the slab using my Theophilus based trim saw, down to size. Please note that the stone pictured above is not stone used in this project but is cut from the same rock slab.

It is important to note that a lot of localized heat is built up when grinding so we need water to help keep the stone cool to avoid thermal breaking. Keeping he sandpaper wet also prevents dust from floating in the air. Quartz dust has been linked to silicosis (a form of lung cancer), so besides keeping your work wet you might also want to wear a mask.

We will be using four types of sand paper. 100, 320, 400, 600 grit wet/dry silicone dioxide sandpaper. The wet/dry sandpaper has a stronger backing and will be able to withstand the constant rubbing of the stone.

Regular backed sand paper will fall apart when wet. Been there, done that, cleaned up the mess. Remember to keep the sandpaper and stone wet at all times while grinding.

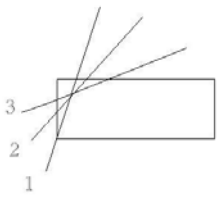
Please remember that in any of the steps using the sandpaper it is important that you use a light touch and check your work frequently. It is easier to remove material than it is to add it. So be careful while grinding.

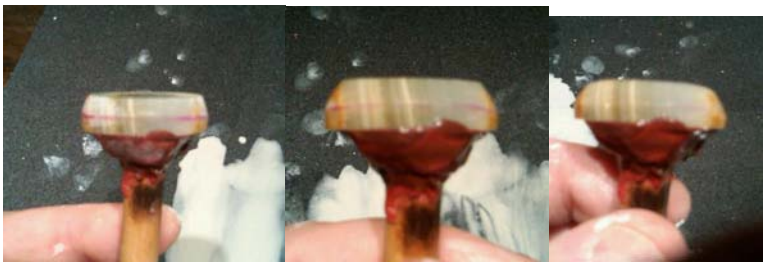
100 grit (replaces course sandstone)

1) Determine which side of the stone is the top and the bottom, then mark it. Grind down the edges to proper shape such as an oval or circle. To grind the stone, hold stone on edge and rub it on the wet sandpaper constantly rotating the stone on is edge to get a uniform shape.


2) Attach doping stick (I use a dopping wax instead of tenax).
Warm up your stone as you melt the wax (special hard wax for lapidary work). If the stone is not warm then the wax probably wont stick. Scoop up some of the wax on one end of the dop stick. Place the waxed end of the stick on to the bottom of the stone in the center. Press the wax into a cone shape with the widest part on the stone. Let it cool.

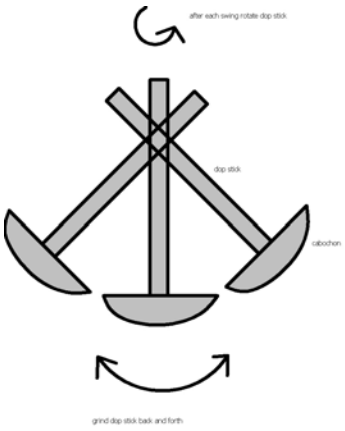
3) Grind down the top to form a basic dome.
What we will be doing is grinding down around the edges of the cab. First start with a steep angle then each pass around the cab the angle will get shallower. Imagine you are peeling layers off an onion. See diagram below. Using the same grit sandpaper, hold the stone by the dop stick near the wax. Hold the stone at an angle and work your way around the edge. Increase your angle and grind again. Keep this process up until your cab is domed.





4) Once the basic shape is made, smooth out the dome by rocking the stone on the sandpaper like a pendulum, turning the stone a bit after each series of strokes. See diagram below. Keep doing this until the stone is nicely domed. At this point you need to determine if your stone is going to have a girdle or not. A stone that is does not have a girdle is completely domed from top to bottom. These stones are good for claw setting and thin bezel setting.

   A stone with a girdle is only partially domed. The sides remain relatively flat. These flat sides are known as the girdle. A girdle is good for a high bezel as it allows the bezel to grip the metal without covering up too much of the stone. A stone with a girdle is also good for a wire wrap setting. The flat sides give the wire a surface to form to. In this particular project I am making a girdle for a bezel setting.



<u>Rinse the stone.</u>

320 grit (replaces fine sandstone) – first round of polishing. Use the same pendulum strokes as before to remove deep scratches.

<u>Rinse the stone.</u>

Use the steps as you did with the 320 grit sandpaper for the 400, 600 and finer sandpapers (replaces tile or emery on lead). Each grit takes you closer to your final polish by making the scratches smaller and smaller.

There are two very important things you need to remember while working on your stone.

1) Use the same type of pendulum strokes while grinding and polishing to avoid unwanted flat spots (sometimes flat spots are good depending on the type of look you are going for), and to maintain a nice even surface.
2) Remember to rinse your stone thoroughly when changing to a smaller grit. If you have particles of the larger grit on your stone then you will continue scratch your stone at the larger grit and contaminate you next size grit. Also it is a good idea to keep your sandpapers separate for the same reason.

Final polish: At this point we are ready to add our final polish using a slurry of cerium oxide. This replaces rubbings on goatskin. Place some cerium oxide on the rough side of the leather and add a little water. Rub the stone on leather/cerium oxide hard using the same pendulum strokes as before. Rub really hard. The idea is to build up heat on the surface of the stone and to move around the very top layer of molecules or Beilby layer (Drake, 37).

If your stone builds up too much heat then you risk softening the wax and the stone separating from the dop stick. Every so often stop and the stone cool a little bit. The leather (goatskin, or soft wood) is a pliable surface, so when you rub your stone on it, it cushions the stone and helps maintain a nice round surface.

If you did everything correctly your cab will be smooth and take on a nice polish. To remove the stone from the dop stick, run the stone/stick under cold water or put it in the freezer for a bit. The wax becomes brittle and will pop off the stone. Clean off the remaining wax with alcohol. Your stone is now ready to be set.

One of the down sides of doing all of this work is that sometimes there are hidden faults in the stone that don't come out until you are done. Such was the case for the stone I used in this paper. If you look at the picture above, there are two dots of light on each side of the stone by my thumb. They just happen to be over a line that ended up being a fault line in the stone. When I removed the dop stick, the stone split in half along that line.

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