A typical thin section is a glass microscope slide on which is glued a thin slice of rock ~3 cm long, 2 cm wide, and 0.003 cm (30 μm) thick. At this thickness, most minerals are transparent, so minerals can be easily seen and studied in great detail.

This thin section is of an Iceland basalt, with the minerals plagioclase feldspar (white and gray), olivine (greenish), and pyroxene (yellows and reds). The plagioclase and olivine crystals have straight edges and sharp corners, indicating that they grew from the basalt magma just before solidification. The pyroxene crystals are more rounded, indicating that they were dissolving into the liquid at the time of eruption. The matrix to the large crystals is a fine-grained mat of tiny plagioclase, pyroxene, olivine, and magnetite crystals. The matrix was liquid at the time of eruption.
Geologic projects are undertaken to solve important geologic problems. During the course of a project, such as trying to figure out how a large body of gabbro formed, many things are done. The rocks may, for example, be mapped on different scales. Many questions will arise during this work regarding the rock mineralogy, how particular rocks formed, and what the rocks can tell us about the conditions of formation.

This photo is of a tiny part of the Skaergaard intrusion in east Greenland. It is a large gabbro pluton (a large body of coarse-grained, slowly cooled basalt magma). The pluton itself extends into the mountains in the distance. This small area in the foreground is obviously complex, with brown gabbro that is slightly layered, some very dark rock, and an oddly shaped patch of light rock. It is impossible to figure out what is going on just by looking at the rock surface. Thin sections are needed.
Samples are carefully selected and collected to answer a specific question or set of related questions. In this photo, the brown gabbro has a lot of cracks cutting through it. The rock around the cracks is lighter colored, and contains black material.

- Why is the surrounding gabbro brown?
- What is the mineralogy of the surrounding gabbro?
- How did that mineralogy change around the cracks?
- What is the black stuff in the cracks?
- Why did this change take place around the cracks?

These are some questions that thin sections can help answer.
Step 3: Make the thin section

Basic steps:

1. Decide how to cut the rock to get the best information.
2. Cut the rock to make a thumb-size rock chip.
3. Grind the rock chip flat on one side.
4. Glue the rock chip to a glass slide.
5. Cut off the excess rock chip from the slide.
6. Grind the remaining rock on the slide to 30 μm thickness.
7. Glue on a glass coverslip.

Each of these steps requires some judgment and skill, as well as appropriate tools. My first thin section took 7 hours of work to make. After considerable practice, I can mass produce high-quality thin sections at a rate of ~50 minutes apiece for easy samples.
This sample is a schist, a metamorphic rock formed from shale. At the high temperatures and pressures at which it formed, the rock was sheared and partially melted. It is layered with mica- and garnet-rich parts, and with coarse-grained feldspar- and quartz-rich parts. In this case, the object is to see both in one thin section.
The diamonds are only the size of fine sand grains, and are black in color. The blade itself is steel, and the diamonds are fixed in a bronze alloy layer around the rim. Most of the cost of the blade is in manufacturing. Less than half the cost is of the diamonds themselves.

Cut the rock with the big diamond saw

This saw blade is 24” in diameter, studded with industrial diamonds. The rock is clamped in a vise to hold it steady.

Water is pumped to both sides of the blade. This keeps the blade cool, lubricates the blade, and washes away the rock cuttings.

The vise is moved toward the blade by an automatic mechanism, involving a ratchet, gears, and a screw drive.

Ultimately, the saw finishes the first cut and the rock end falls off.
Flat slabs make finishing the thin section easier. Sometimes, if the sample is small or needs to be preserved, only the one previous cut is made.
Mark the area you want for the thin section

With a pencil and a template the size of a thin section, mark off the part of the slab you want.

More than one area can be marked on large slabs.

Pencil tends to show up best on a wide variety of rock colors.
Diamond saw blades can be gently touched with the skin while they are running with no harm. The diamonds are not sharp and they simply push aside the rubbery skin. They do cut fingernails and other brittle very fast.

Trim the slab to make a thin section chip

The small diamond saw is used to cut the slab along the pencil markings. The diamond blade is not sharp like a wood saw and will not cut fingers. Generally four cuts are needed for each of the four sides of the chip.

Several chips can be cut from large slabs.
Plate glass is used because it is generally flatter than common window glass, and it is safer to use because it does not break as easily.

Grind the chip surface smooth

Though the saw-cut chip surface looks smooth, it is still too rough for microscopic examination.

The chip surface is ground with grit slurry on a sheet of plate glass.

The grit is usually made of silicon carbide or aluminum oxide. These ceramics are much harder than any common mineral.

Two or more grit sizes are usually used in sequence; a coarse grit to remove pits and saw marks, then a fine grit to make a smoother finish.
The best curing temperature for the epoxy varies with the epoxy type. This epoxy sets best at ~170°F. It is considerably harder and stronger than the typical epoxy you can buy at a hardware store, but it will not set properly at room temperature.

Cement the chip to a glass slide

The chip is put on a hot plate to warm up and dry.

A high-strength two-part epoxy is mixed for gluing the chip to the slide.

Epoxy is smeared on the ground chip surface.

The glass slide is put onto the chip and the bubbles worked out using a pencil eraser.

The chip is left on the hot plate to cure the epoxy.
The vacuum chuck is used because the blade cannot cut accurately enough if it is held by hand.

Trim the excess chip from the glass slide

A special small diamond saw cuts most of the chip from the glass slide.

The slide is held onto a flat metal chuck by a vacuum.

As with the larger saws, this saw blade is also cooled and lubricated with water.

This saw can cut the chip leaving only 0.5 mm of rock left on the slide.
The spinning cup wheel has a flat ring of diamond compound, seen in the movie, that the rock is slowly ground against. This machine can grind the thin section to 40 to 50 μm thick.

Machine grind the excess rock on the slide

The remaining rock on the slide, 0.5 to 1 mm thick, is still too much for a thin section. Thin sections are usually 0.03 mm (30 μm) thick.

The slide is held by a vacuum on the chuck of another machine. This one has a cup wheel instead of a thin blade.

The rock is advanced manually with a hand wheel, which is connected with a fine screw drive to the vacuum chuck where the slide is mounted.
Periodically check thin section thickness

During grinding, the thin section thickness has to be checked occasionally with a polarizing microscope.

If you are not careful, you can grind the rock slice too thin, or even grind it completely off the slide.

The thickness is determined by looking at the interference colors of known minerals such as quartz and feldspar.

Examples of interference colors are shown at the end of this slide show.
This step is where the most skill is required. Frequent checking of the thin section thickness is necessary at this stage.
This is the final step in making a thin section. The Canada Balsam fills in the microscopically rough surface on the top of the thin section, making it appear clear and transparent.
The finished thin section is a work of skill and patience. It represents a carefully prepared sample that was selected to answer geologic questions. Every thin section is different because every rock is different in detail. Again, it takes a beginner several hours for the first thin section. On the equipment shown, a skilled thin section maker can mass produce on average about 1 every 50 minutes. It is still a considerable time investment.
These are plane polarized light examples of four thin sections.

**Sandstone:** Feldspathic sandstone, probably derived from a mudflow, from the Jurassic red beds of the Connecticut River Valley. Minerals include quartz, feldspar, and several rock fragments in a hematite-rich matrix.

**Limestone:** Shell limestone, with a large sectioned bivalve in the middle. This is from Devonian rocks in western New York. Almost everything seen here is calcite or aragonite, with some small unobtrusive crystals of dolomite. The dark colors are mostly caused by scattering of transmitted light by small crystal fibers in the shells.

**Basalt:** Lava flow from southwestern Iceland, probably a few thousand years old. The grain in the center is pyroxene, as are many of the light brown small crystals. The colorless crystals are plagioclase. The matrix is mostly made up of glass and small crystals of pyroxene, plagioclase, and magnetite.

**Granite:** Hornblende granite from Cape Ann, Massachusetts. This granite contains large clear crystals of quartz, somewhat dingy crystals of potassium feldspar, and dark crystals of hornblende. In plane polarized light the hornblende is different colors in different orientations. The orange blobs are small olivine crystals that have been altered by water to serpentine and orange iron hydroxide.
These are plane polarized light images of four thin sections.

**Schist:** This is a mica schist from southern Maine. It is formed from the metamorphism of shale. The yellow mineral at the bottom is staurolite, the grayish mineral at the top center is garnet, the brown is biotite, the thin hairy fibers are sillimanite, and the white is quartz and muscovite.

**Amphibolite:** This is a metamorphosed basalt lava from central Massachusetts. It has green hornblende, dark brown biotite, colorless plagioclase feldspar, and grayish-green cummingtonite. Cummingtonite is another amphibole, like hornblende, named after Cummington, Massachusetts, in the Berkshires.

**Marble:** This sample is from the marble from the stream above the small park at Cascade Lakes, on the west side of Cascade Mountain in the Adirondacks. The mineral with the colored lines is calcite, the green mineral is spinel, and the clear, colorless mineral is olivine.

**Metallurgical slag:** This is a metallurgical slag, collected from the floor around a smelting furnace. The white crystals are mostly aluminum oxide, and the black matrix is an iron- and manganese-rich glass.
These are plane polarized light images of four thin sections.

**Triassic tree root cells:** These are some rare cells found in petrified tree roots in Triassic rocks in Argentina.

**Impact melt vein, lunar gabbro:** The lunar highlands are made up of a variety of coarse-grained rocks. This example is a gabbro, made up of white to gray plagioclase, with some brownish pyroxene on the right side and in the bottom left corner. The irregular black band is a glass-filled fracture. The fracture and hot silicate liquid (now glass) were formed during a meteorite impact of the lunar surface, and the liquid was infected into the fracture. The round things are gas bubbles in the glass.

**Petrified wood cells:** This is Cretaceous petrified wood from Montana (collected with permission). The long, horizontal cells are the vascular channels that carried sap up and down the tree. The rounder cells are called ray cells, and among other things they give radial strength to the wood.

**Wood in a dino poop:** This is a thin section of a dinosaur coprolite (fossil poop). The fragment is a chunk of wood with obvious, probably annual, growth rings. This dino obviously did not chew its food very well.
This is a pair of photos of a mica schist from southern Maine. As labeled, it has staurolite, garnet, biotite, muscovite, and quartz. The mica layers are aligned parallel to one another, and the growing staurolite crystal disturbed the alignment by pushing crystals aside as it grew. The rock looks completely different in cross polarized light. In this view, the colors are partly caused by interference of light of different colors as they pass through the thin section. This is one way to look at thin sections to get more information out of them. Other ways include:

- Microscopic techniques for determining mineral chemical composition.
- Microscopic techniques for determining mineral ages.
- Mineral fluorescence.
- Mineral absorption spectrum of transmitted or reflected light.

In summary, thin sections are powerful tools for learning in detail how rocks and minerals formed. They are also very useful in paleontology, metallurgy, ceramics, forensics, and many other fields. They are also beautiful works of art that can be looked at and enjoyed in their own right.