MINERALS SCRIPT

Why study minerals? All rocks on planet Earth are composed of varying amounts, sizes, and mixtures of minerals, organic debris such as shells or bones, and other components such as volcanic glass. Each rock tells a story about its formation and hence the geologic processes at work when it formed. To read this story, we first have to identify the minerals within the rock.

By the end of this learning module, you should be able to list the most common rock-forming minerals, recognize their key distinguishing characteristics, and consider their importance to understanding the geologic formation settings of the rocks in which they are found.

Each mineral can form only if the temperature, pressure, and chemical conditions are just right. So finding a particular mineral in a rock can tell us a lot about the temperature, pressure, and chemical environment of its formation. In addition, mineral size and form and the exact mix and proportion of minerals in a rock provide further clues and details. There are over 300 different known minerals in the world – most of which are unique to one location or a rare set of conditions. A few dozen minerals represent the core of the most common rock-forming minerals, and those are the ones we'll review in this video.

What you see here are about 20 different rock-forming minerals, representing a variety of sizes, shapes, and colors. The atoms that make up the mineral (as indicated in exact proportions in their chemical formulas) and the way in which those atoms bond together give rise to the physical and chemical behaviors of each mineral. An easy way to identify a mineral then would be to put it in a mass spectrometer and measure the exact proportions of the elements and then go a step further and look through an electron microscope to see the underlying bonding (since the same chemical constituents can bond in multiple ways and thus produce different minerals). However, such costly technology is unnecessary for identifying the basic rock-forming minerals which can be readily identified in hand sample using more cost-effective and readily available analytical tools such as our eyes, our touch, our smell, our taste, and more. So let's get started!

When studying a particular mineral, the first thing one usually notices is color. However, many common minerals, such as quartz, calcite, feldspar, and garnet, come in a multitude of colors and thus color is not a distinguishing characteristic. For correct mineral identification, we are best served by identifying multiple distinguishing characteristics. For the purposes of this video and identifying the minerals in this pile, I'll begin with the characteristic of LUSTER – or the quality (not the color) of light reflection. The minerals on this table can be split into two basic luster groups – metallic (in which light reflects off the surface in the same way it does off metals – often referred to by beginning geology students as "shiny") and nonmetallic. These five minerals display a multitude of colors – black, grey, red, silver, and gold – but they all display metallic luster. The rest of these minerals are nonmetallic. They may have lusters that look greasy, glassy, dull, pearly, waxy, or resinous, to name a few lusters, but none of them display metallic luster.

Let's drill down further into the metallic minerals. Notice that one of them has a metallic luster in some places but an earthy or dull red one in other places? If I scratch this mineral across the surface of a streak plate, we see a red STREAK left behind. Metallic minerals often have distinctive streaks, and this mineral, HEMATITE, is distinguished primarily by its combined metallic + red-earthy luster and its red streak. Let's look at the streak of these other four metallic minerals.

Notice that none of them have a red streak. In fact, despite their color differences, the remaining minerals all have a grey streak.

Notice that this mineral's streak is quite wide and rich. In fact, I can leave a streak of this mineral on a piece of paper. It feels soft and greasy, and I can scratch it with my fingernail. That means the HARDNESS of this mineral is softer than a fingernail or less than 2.5. None of the rest of these metallic minerals is so soft. This combination of distinctive traits tells us that this mineral is GRAPHITE, which, because of its softness and streak, is what we use inside our pencils (referred to incorrectly as “lead”).

CRYSTAL FORM can help us distinguish among the remaining three minerals. Crystal form is the way a crystal grows. A mineral’s outer crystal form is a reflection of the internal crystalline structure. It is often hard to see crystal form, because crystals are a perfectly edged version of a mineral. They only form when minerals grow slowly with lots of space around them. It’s way more common for minerals to simply fill the space they’re given and thus look more massive. And of course even if they do grow as a perfect crystal, natural weathering and erosional processes often break or wear down the crystal faces before we find them. So we can’t always rely on this method of identification. However, notice that two of these minerals have a cubic crystal form – this mineral grows as gold-colored cubes, and this mineral grows as silver-colored cubes. In this case, it also breaks as silver cubes (we can see the breakage of the mineral along its edges here). It’s not always true that a mineral grows and breaks along the same planes, but in this mineral’s case, it IS true. When minerals break along planes, we call that CLEAVAGE. If they break NOT along a plane, such as splintering of wood or rough irregular edges, we call that FRACTURE. Notice that this gold-colored cube mineral displays no cleavage, but does have some fractured edges. The silver-colored cubic mineral that breaks as cubes is said to display 3 planes of cleavage that come together at 90 degrees. Not only is it typically found as a composite of silver-colored metal cubes, but it is almost 4 times denser than graphite or hematite, and you can “feel” this trait when you lift it. DENSITY, also referred to as SPECIFIC GRAVITY, can be a useful distinguishing characteristic of some minerals. This mineral is known as GALENA and it is high density because it is made of lead (real lead – the chemical formula is PbS – lead sulfide – equal parts lead and sulfide).

The golden metal cubes indicate the mineral PYRITE, also known as fool’s gold. Unlike real gold, which is very soft, pyrite is quite hard, has a gray streak, forms cubes, and has no cleavage. Its density is a little more than twice that of hematite or graphite.

The last mineral left in this metallic pile is often made of an aggregation of small grains. Its most distinctive feature is that it is magnetic, which we can see when we put another magnet near it. This mineral is called MAGNETITE and it has a similar density to pyrite.

These Mineral Identification Tables list all these same traits for each mineral and more. Notice that this table includes only the metallic minerals and is ordered from hardest at the top to softest at the bottom. Each column of the table reviews the basic properties of each mineral, but the last column sums up the best distinguishing characteristics for each mineral. As you can see, the identification of these minerals was verified using a number of different traits.

Now let’s move on to nonmetallic minerals. Like the metallic mineral table, the nonmetallic mineral table lists minerals in order of decreasing hardness. So if we start at the bottom of the table, we see that there are two minerals that should be soft enough to scratch with a fingernail – talc and gypsum. If we quickly run our fingernail over all these minerals, we find that these two here fit that characteristic. You’ll notice from the identification table, that gypsum is usually translucent to transparent, while talc is usually opaque. So we can use the way that light moves through them (or doesn’t) to make our distinction. This sample is translucent – it must be GYPSUM – which means this opaque one must be TALC.

Next we can take an iron wire or nail and see what minerals it can scratch – that leaves us the following pile of minerals that are harder than a fingernail, but softer than an iron nail. Notice that these two minerals have a similar flaky appearance. These minerals have a single cleavage plane that produces layers of thin flexible sheets. One of the minerals has a silver color and the other a dark black color. Furthermore, we see that the dark one has a brown streak, the other a white streak. The family of minerals that cleaves in visible flexible thin sheets is called the MICA family. The darker variety is called BIOTITE. The silver variety is called MUSCOVITE.

How about these two minerals? How do we distinguish between them? Notice that each has a similar color and translucency, though this one looks a bit more waxy in its luster, and this one a bit more glassy. Also notice that each has three cleavage planes, but in this case, the cleavage is at 90-degree angles, producing cubes (both in form and cleavage), while this one is more of a “skewed cube” or rhombohedron, with three cleavage planes NOT at right angles (also found both in crystal form and cleavage). The cubic form mineral is known as Halite. It can be clear, white, or pinkish. It also has a salty taste. A simple taste test will confirm that this sample is HALITE. (I recommend you narrow down your mineral specimens by form and color and hardness before using taste as a final confirmation!). The mineral with a skewed cube form and cleavage is CALCITE. Calcite is also distinctive by its reaction to a weak acid, during which carbon dioxide gas bubbles up. Again, before adding acid to EVERY mineral, narrow down your choices first, and then use it as a final confirmation test. Note: you should be able to identify calcite in hand sample WITHOUT acid in this lab class.

We still have two minerals that can be scratched by an iron nail – one of which is mottled green, opaque, and found in smooth, rounded masses. This mineral is known as SERPENTINE, and it is the major ingredient in a rock called SERPENTINITE, which is the California State Rock. You’ll find a lot of serpentine throughout the state of California.

The other comes in a multitude of colors including clear, white, green, purple, or yellow. It is usually transparent to translucent and often displays a rainbow luster on some surfaces (so too does calcite). Its most distinctive property is its cleavage which happens along 4 different planes, all meeting at angles less than 90 degrees. Perfect cleavage can leave it in an octahedral shape. But usually the four cleavage planes are visible by seeing planar cracks inside the mineral that lead to triangular shapes and triangular faces. This mineral is called FLUORITE. It also fluoresces under a black light. (But so too do many Calcite specimens, so the cleavage planes are the best means for identifying fluorite.)

The rest of the minerals left here are all harder than an iron nail. So now what? Notice the crystal form of this mineral, which is a 12-sided polygon or a dodecahedron. It has a glassy, gemstone-like luster, and when it breaks, there’s no cleavage, just fracture. Often that fracture is irregular. Sometimes the fracture looks like chipped glass, with shell-like rounded surfaces called conchoidal fracture. This mineral is GARNET.

How about this green glassy mineral? Typically it is found as tiny grains. When looked at through a hand lens or microscope, we can see it is transparent to translucent and displays conchoidal fracture. This mineral is always a shade of green and is thus one of the few minerals in which color is useful for its identification. This mineral is called OLIVINE.

Of the remaining minerals, you will notice that there are two that look very similar – both dark black and massive. One is PYROXENE, and the other HORNBLENDE. How do we tell the difference? If we can see the crystal form well enough, pyroxenes tend to grow as short 8-sided prisms and cleave with two planes that come together at right angles. Hornblende forms longer prisms with two cleavage planes that come together at 60 and 120 degrees. In fact, those distinctions are often hard to see for these two minerals, so we mostly distinguish these two minerals by a splintery fracture that often appears in Hornblende.

Next we’ll look more closely at the transparent or translucent mineral that displays a glassy luster. If we see it in its perfect crystal form, it’s easy to recognize by its six-sided prism that comes to point. However, it’s more likely to find this mineral in a broken or massive form. If we can’t see its crystal form, then we can use its distinctive conchoidal fracture to distinguish it. This mineral is QUARTZ – and it comes in every color of the rainbow.

The remaining two minerals are part of the same family. The traits they share in common are their hardness, opacity, and two cleavage planes at right angles. That makes them part of the FELDSPAR family. One displays a particular type of cleavage apparent on one side of the mineral, known as twinning. It looks like a bunch of thin absolutely straight and parallel grooves made by a sharp knife. When you see twinning on a feldspar face, you know it's a PLAGIOCLASE FELDSPAR. The other feldspar is then a POTASSIUM FELDSPAR. There are many more types of feldspars, but these are the two most common ones. Potassium Feldspar can also be recognized by its typical pink color. However, there's also a white variety, and then it's harder. You have to use the absence of twinning to help you. But when you have the pink Potassium Feldspar variety, you will also see a structure of white mineral growths inside, called exsolution lamellae. These subparallel thick white lines look a lot like marbled fat inside a muscle, and they represent the white variety of the feldspar separating out from the pink variety as the mineral cools after formation.

The goal of mineral identification is to recognize these same minerals later in rocks and based on that recognition to describe something about the formation history and geologic setting of the rock. In our future videos on identifying rocks, you will learn more about what each mineral tells us – what clues they hold. For example, halite forms only when salty waters evaporate. So if we see halite in a rock, we know the rock must have formed at earth's surface in a setting like south San Francisco Bay or Death Valley where there is salty water pooling in shallow ponds and evaporating in a hot dry climate. That's a lot of information to glean from the identification of one mineral. Continue with our rock-identification videos to learn more.

MINERALS ADDENDUM

This addendum video covers these five additional minerals, which the lab class is required to identify. Let's review their distinguishing characteristics. Let's start with the three green minerals. Their color is always going to be green, so that is the first distinguishing characteristic. How do we distinguish further among them? Let's look more closely at their crystal form. This mineral grows in long thin prisms or "needles". This mineral is massive with only one visible crystal face that shows striations – linear indentations along its surface. Those striations won't always be visible on crystal faces for this mineral, but they are common. The rest of the mineral just looks massive. And this green mineral is very small and flaky – with cleavage surfaces very similar to a mica.

The green mineral that appears as long thin prisms or needles is ACTINOLITE. If we look closer we see that it displays a splintery edge, like hornblende. Actinolite and hornblende are both members of the AMPHIBOLE family and share some similar traits.

The green mineral that is massive is called EPIDOTE. It is also quite hard – harder than glass. That helps us distinguish it from serpentine, which is also green and massive. (Remember: serpentine is also smooth and rounded and softer than an iron nail.) Sometimes epidote shows up as long, flat prisms. When that happens it's easier to confuse it with actinolite. But when you see them side by side, you can see the different shape of the prisms.

The green mineral that is flaky is CHLORITE. It is typically found as small crystals, usually too small to see with the naked eye. It is very similar to a mica, but the single-cleavage-plane flakes are not flexible.

Now let's look at the brown mineral. Notice its shape is a six-sided barrel – thicker in the middle than at the top and bottom, which are both flat ends. This crystal form is one of its most distinctive properties. The other is its hardness which on a scale from 1 to 10 is a 9. This mineral is called CORUNDUM, and it can appear in a variety of colors. The transparent blue variety is called SAPPHIRE. The red variety, RUBY. The samples we have in the class are all opaque and brown.

The final mineral is blue to greyish in color and has a crystal shape described as blades – long flat minerals shaped like a sword blade. When thin, the blades are flexible, so you often see the crystals bent. This mineral is called KYANITE.

In all cases, these five additional minerals can be distinguished from each other and the 20 minerals described in the first video by their crystal form. But each also has other distinctive properties that corroborate your identification.