http://www.rocksandminerals4u.com/properties_of_minerals.html

Mohs Hardness of Common Minerals

Alphabetical

Mineral	Mohs Hardness
Anhydrite	3 to 3.5
Apatite	5
Arsenopyrite	5.5 to 6
Augite	5.5 to 6
Azurite	3.5 to 4
Barite	2.5 to 3.5
Bauxite	1 to 3
Beryl	7.5 to 8
Biotite	2.5 to 3
Bornite	3 to 3.25
Calcite	3
Cassiterite	6 to 7
Chalcocite	2.5 to 3
Chalcopyrite	3.5 to 4
Chlorite	2 to 2.5
Chromite	5.5 to 6
Chrysoberyl	8.5
Cinnabar	2 to 2.5
Copper	2.5 to 3
Cordierite	7 to 7.5
Corundum	9
Cuprite	3.5 to 4
Diamond	10
Diopside	5.5 to 6.5
Dolomite	3.5 to 4
Enstatite	5 to 6
Epidote	6 to 7

Decreasing Hardness

Mineral	Mohs Hardness
Diamond	10
Corundum	9
Chrysoberyl	8.5
Topaz	8
Beryl	7.5 to 8
Spinel	7.5 to 8
Zircon	7.5
Cordierite	7 to 7.5
Staurolite	7 to 7.5
Tourmaline	7 to 7.5
Quartz	7
Garnet	6.5 to 7.5
Jadeite	6.5 to 7
Sillimanite	6.5 to 7.5
Olivine	6.5 to 7
Spodumene	6.5 to 7
Marcasite	6 to 7.5
Cassiterite	6 to 7
Epidote	6 to 7
Zoisite	6 to 7
Orthoclase	6 to 6.5
Plagioclase	6 to 6.5
Prehnite	6 to 6.5
Pyrite	6 to 6.5
Rutile	6 to 6.5
Diopside	5.5 to 6.5
Rhodonite	5.5 to 6.5

Fluorite	4
Galena	2.5 to 2.75
Garnet	6.5 to 7.5
Glauconite	2
Gold	2.5 to 3
Graphite	1 to 2
Gypsum	1.5 to 2
Halite	2 to 2.5
Hematite	5 to 6.5
Hornblende	5 to 6
Ilmenite	5 to 6
Jadeite	6.5 to 7
Kyanite	4.5 to 5 or 7
Limonite	1 to 5
Magnesite	3.5 to 5
Magnetite	5 to 6.5
Malachite	3.5 to 4
Marcasite	6 to 7.5
Molybdenite	1 to 2
Monazite	5 to 5.5
Muscovite	2 to 3
Nepheline	5.5 to 6
Nephrite	5 to 6
Olivine	6.5 to 7
Orthoclase	6 to 6.5
Plagioclase	6 to 6.5
Prehnite	6 to 6.5
Pyrite	6 to 6.5
Pyrophyllite	1 to 2
Pyrrhotite	3.5 to 4.5
Quartz	7

Arsenopyrite	5.5 to 6
Augite	5.5 to 6
Chromite	5.5 to 6
Hematite	5.5 to 6.5
Nepheline	5.5 to 6
Sodalite	5.5 to 6
Magnetite	5 to 6.5
Enstatite	5 to 6
Hornblende	5 to 6
Ilmenite	5 to 6
Nephrite	5 to 6
Turquoise	5 to 6
Uraninite	5 to 6
Monazite	5 to 5.5
Titanite	5 to 5.5
Apatite	5
Wollastonite	4.5 to 5.5
Kyanite	4.5 to 5 or 7
Fluorite	4
Magnesite	3.5 to 5
Pyrrhotite	3.5 to 4.5
Siderite	3.5 to 4.5
Azurite	3.5 to 4
Chalcopyrite	3.5 to 4
Cuprite	3.5 to 4
Dolomite	3.5 to 4
Malachite	3.5 to 4
Rhodochrosite	3.5 to 4
Sphalerite	3.5 to 4
Serpentine	3 to 5
Anhydrite	3 to 3.5

Rhodochrosite	3.5 to 4
Rhodonite	5.5 to 6.5
Rutile	6 to 6.5
Serpentine	3 to 5
Siderite	3.5 to 4.5
Sillimanite	6.5 to 7.5
Silver	2.5 to 3
Sodalite	5.5 to 6
Sphalerite	3.5 to 4
Spinel	7.5 to 8
Spodumene	6.5 to 7
Staurolite	7 to 7.5
Sulfur	1.5 to 2.5
Sylvite	2
Talc	1
Titanite	5 to 5.5
Topaz	8
Tourmaline	7 to 7.5
Turquoise	5 to 6
Uraninite	5 to 6
Witherite	3 to 3.5
Wollastonite	4.5 to 5.5
Zircon	7.5
Zoisite	6 to 7

Witherite	3 to 3.5
Bornite	3 to 3.25
Calcite	3
Barite	2.5 to 3.5
Biotite	2.5 to 3
Chalcocite	2.5 to 3
Copper	2.5 to 3
Gold	2.5 to 3
Silver	2.5 to 3
Galena	2.5 to 2.75
Muscovite	2 to 3
Chlorite	2 to 2.5
Cinnabar	2 to 2.5
Halite	2 to 2.5
Glauconite	2
Sylvite	2
Sulfur	1.5 to 2.5
Gypsum	1.5 to 2
Limonite	1 to 5
Bauxite	1 to 3
Graphite	1 to 2
Molybdenite	1 to 2
Pyrophyllite	1 to 2
Talc	1

Mohs Hardness Scale

A rapid hardness test for field and classroom use

What is Mohs Hardness Scale?

Table 1 Mohs Hardness Scale	
Mineral	**Hardness**
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Orthoclase	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

One of the most important tests for identifying mineral specimens is the Mohs Hardness Test. This test compares the resistance of a mineral to being scratched by ten reference minerals known as the Mohs Hardness Scale (see Table 1). The test is useful because most specimens of a given mineral are very close to the same hardness. This makes hardness a reliable diagnostic property for most minerals.

Friedrich Mohs, a German mineralogist, developed the scale in 1812. He selected ten minerals of distinctly different hardness that ranged from a very soft mineral (talc) to a very hard mineral (diamond). With the exception of diamond, the minerals are all relatively common and easy or inexpensive to obtain.

Making Hardness Comparisons

"Hardness" is the resistance of a material to being scratched. The test is conducted by placing a sharp point of one specimen on an unmarked surface of another specimen and attempting to produce a scratch. Here are the four situations that you might observe when comparing the hardness of two specimens:

1. If Specimen A can scratch Specimen B, then Specimen A is harder than Specimen B.

2. If Specimen A does not scratch Specimen B, then Specimen B is harder than Specimen A.

3. If the two specimens are equal in hardness then they will be relatively ineffective at scratching one another. Small scratches might be produced, or it might be difficult to determine if a scratch was produced.

4. If Specimen A can be scratched by Specimen B but it can not be scratched by Specimen C, then the hardness of Specimen A is between the hardness of Specimen B and Specimen C.

Mohs Hardness Testing Procedure

- Begin by locating a smooth, unscratched surface for testing.
- With one hand, hold the specimen of unknown hardness firmly against a table top so that the surface to be tested is exposed and accessible. The table top supports the specimen and helps you hold it motionless for the test.
- Hold one of the standard hardness specimens in the other hand and place a point of that specimen against the selected flat surface of the unknown specimen.
- Firmly press the point of the standard specimen against the unknown specimen, and firmly drag the point of the standard specimen across the surface of the unknown specimen.
- Examine the surface of the unknown specimen. With a finger, brush away any mineral fragments or powder that was produced. Did the test produce a scratch? Be careful not to confuse mineral powder or residue with a scratch. A scratch will be a distinct groove cut in the mineral surface, not a mark on the surface that wipes away.
- Conduct the test a second time to confirm your results.

When conducting the test, place the unknown specimen on a table top and firmly hold it in place with one hand. Then place a point of the reference specimen against a flat, unmarked surface of the unknown specimen. Press the reference specimen firmly against the unknown, and deliberately drag it across the flat surface while pressing firmly. To avoid injury drag the known specimen away from your body and parallel to the fingers that are holding the unknown specimen.

Mohs Hardness Testing Tips

- A list of minerals in order of hardness can be a handy reference. If you determine that a specimen has a hardness of Mohs 4 you can quickly get a list of potential minerals.

- Practice and experience will improve your abilities when doing this test. You will become faster and more confident.

- If the hardness of the unknown specimen is about 5 or less, you should be able to produce a scratch without much exertion. However, if the unknown specimen has a hardness of about 6 or greater, then producing a scratch will require some force. For those specimens, hold the unknown firmly against the table, place the standard specimen against it, press firmly with determination, then holding pressure slowly drag the standard specimen across the surface of the unknown.

- Don't be fooled by a soft standard specimen producing a mark on a hard unknown. That mark is like what a piece of chalk produces on a blackboard. It will wipe off without leaving a scratch. Wipe your finger across the tested surface. If a scratch was produced there will be a visible groove. If marks wipe away then a scratch was not produced.

- Some hard materials are also very brittle. If one of your specimens is breaking or crumbling rather than scratching, you will have to be very careful while conducting the test. Testing tiny or granular specimens can be difficult.

- Some specimens contain impurities. If the results of your test are not visibly conclusive, or if the information from your test does not conform with other properties, do not hesitate to do the test again. It is possible that a small piece of quartz (or another impurity) was embedded in one of your specimens.

- Don't be wimpy! This is a very common problem. Some people casually rub one specimen back and forth against another and then look for a mark. That is not how the test is done. It is done with a single, determined motion with the goal of cutting a scratch.

- Be careful. When you hold the unknown specimen against the table, position it so that the known specimen will not be pulled across one of your fingers.

- This test should be done on a lab table or work bench with a durable surface or a protective covering. Don't do this type of testing on fine furniture.

- Test tiny particles or grains by placing them between two pieces of an index mineral and scraping them together. If the grains are harder than the index mineral scratches will be produced. If the grains are softer they will smear.

Hardness of Common Objects

Mohs Hardness of Common Objects	
fingernail	2 to 2.5
copper	3
nail	4
glass	5.5
knife blade	5 to 6.5
steel file	6.5
streak plate	6.5 to 7
quartz	7

Some people use a few common objects for quick hardness tests. For example, a geologist in the field might always carry a pocket knife. The knife can be used for a quick hardness test to determine if a specimen is harder or softer than Mohs 5 to 6.5.

Before using these objects as quick testing tools it is a good idea to confirm their hardness. Some knives have harder steel than others. Test yours and then you know its hardness.

These common objects can also be useful if you don't have a set of reference minerals. We included quartz in this list because it is a ubiquitous mineral. In the field you are often no more than a few steps away from a piece of quartz.

Hardness Picks

An alternative to using the reference minerals for testing is a set of "hardness picks." These picks have sharp metal points that you can use for very accurate testing. The picks allow much more control, and their sharp points can be used to test small mineral grains in a rock.

The sharp picks can be used easily and either produce a scratch if they are harder than the specimen being tested or leave behind a tiny streak of metal if they are softer. Examine the test site with a hand lens to see the results of your test.

We have used hardness picks and think that they do a great job. They are easier to use and more accurate than testing with specimens. They can be resharpened when they dull. The only downside is their price (about $80 per set).

Harder than Diamond, Softer than Talc?

Diamond is not the hardest substance known, but the materials that are harder are much more rare. Researchers have reported that wurtzite boron nitride and lonsdaleite can be harder than diamond. [1]

It is unlikely that you will find a mineral that is softer than talc. However, a few metals are softer. These include: caesium, rubidium, lithium, sodium and potassium. You will probably never need to test their hardness. [2]

Is the Mohs Scale Linear?

Mohs Hardness Scale is not linear. The steps in the scale have gaps of variable size between them. "For instance, the progression from calcite to fluorite (from 3 to 4 on the Mohs scale) reflects an increase in hardness of approximately 25 percent; the progression from corundum to diamond, on the other hand (9 to 10 on the Mohs scale), reflects a hardness increase of more than 300 percent." [3]

Hardness Variations in a Single Mineral

Most minerals have a fairly consistant hardness. For example, the hardness of calcite is always about 3. However, some minerals have a range of hardness.

Minerals that are part of a solid solution series can change in hardness as the composition varies. Atomic bonds between some elements are stronger than others. An example is garnet which has a composition of $X_3Y_2(SiO_4)_3$ where X can be Ca, Mg or Fe and Y can be Al, Fe or Cr. Garnets with different compositions have different hardness. Garnets range in hardness from 6.5 to 8.

Minerals such as kyanite have different hardness in different directions. Kyanite is a mineral that frequently occurs in blade-shaped crystals. These crystals have a hardness of about 5 if they are tested parallel to the long axis of the crystal and a hardness of about 7 if they are tested parallel to the short axis of a crystal.

Weathering can also influence the hardness of a mineral. Weathering usually changes a mineral's composition with the weathering product usually softer than the original material. When testing the hardness or streak or other property of a mineral, the best way to test is on a freshly broken surface that has not been exposed to weathering.

About Hardness Tests

The hardness test developed by Friedrich Mohs was the first known test to assess resistance of a material to scratching. It is a very simple but inexact comparative test. Perhaps its simplicity has enabled it to become the most widely used hardness test.

Since the Mohs Scale was developed in 1812, many different hardness tests have been invented. These include tests by Brinell, Knoop, Rockwell, Shore and Vickers. Each of these tests uses a tiny "indenter" that is applied to the material being tested with a carefully measured amount of force. Then the size or the depth of the indentation and the amount of force are used to calculate a hardness value.

Because each of these tests uses a different apparatus and different calculations they can not be directly compared to one another. So if the Knoop hardness test was done the number is usually reported as a "Knoop hardness". For this reason, Mohs hardness test results should also be reported as a "Mohs hardness."

Why are there so many different hardness tests? The type of test used is determined by the size, shape and other characteristics of the specimens being tested. Although these tests are quite different from the Mohs test there is some correlation between them. [2]

Hardness, Toughness and Strength

When testing for hardness, remember that you are testing "the resistance to scratching." During the test, some materials might fail in other ways. They could break, deform, or crumble instead of scratching. Hard materials often break when subjected to stress. This is a lack of toughness. Other materials might deform or crumble when subjected to stress. These materials lackstrength. Always keep in mind that you are testing for the resistance to being scratched. Don't be fooled by other types of failure in the specimen being tested.

Uses for Hardness Tests

The Mohs Hardness Test is almost exclusively used to determine the relative hardness of mineral specimens. This is done as part of a mineral identification procedure in the field, in a classroom, or in a laboratory when easily identified specimens are being examined or where more sophisticated tests are not available.

In industry, other hardness tests are done to determine the suitability of a material for a specific industrial process or a specific end-use application. Hardness testing is also done in manufacturing processes to confirm that hardening treatments such as annealing, tempering, work hardening or case hardening have been done to specification.

Some Notes on Spelling

Mohs Hardness Scale is named after its inventor, Friedrich Mohs. This means that an apostrophe is not needed when typing the name of the test. "Moh's" and "Mohs' " are incorrect.

Google is really smart about these names. You can even type "Moe's Hardness Scale" as a query and Google knows to return results for "Mohs Hardness Scale". :-)

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- Conduct the test a second time to confirm your results

Deluxe Hardness Picks by Mineralab

Only $89.95

Picks Available in Plastic Field Case Below

What are Minerals?

Minerals are the foundation of industries ranging from construction to manufacturing to agriculture to technology and even cosmetics.

We Use Minerals Many Times Every Day!

Every person uses products made from minerals every day. The salt that we add to our food is the mineral halite. Antacid tablets are made from the mineral calcite.

It takes many minerals to make something as simple as a wooden pencil. The "lead" is made from graphite and clay minerals; the brass band is made of copper and zinc, and the paint that colors it contains pigments and fillers made from a variety of minerals. A cell phone is made using dozens of different minerals that are sourced from mines throughout the world.

The cars that we drive, the roads that we travel, the buildings that we live in, and the fertilizers used to produce our food are all made using minerals. In the United States, about three trillion tons of mineral commodities are consumed each year to support the standard of living of 300 million citizens. That is about ten tons of mineral materials consumed for every person, every year.

What are Minerals?

To meet the definition of "mineral" used by most geologists a substance must meet five requirements:

- naturally occurring
- inorganic
- solid
- definite chemical composition
- ordered internal structure

"Naturally occurring" means that people did not make it. Steel is not a mineral because it is an alloy produced by people. "Inorganic" means that the substance is not made by an organism. Wood and pearls are made by organisms and thus are not minerals. "Solid" means that it is not a liquid or a gas at standard temperature and pressure.

"Definite chemical composition" means that all occurrences of that mineral have a chemical composition that varies within a specific limited range. For example: the mineral halite (known as "rock salt" when it is mined) has a chemical composition of NaCl. It is made up of an equal number of atoms of sodium and chlorine.

"Ordered internal structure" means that the atoms in a mineral are arranged in a systematic and repeating pattern. The structure of the mineral halite is shown in the illustration at right. Halite is composed of an equal ratio of sodium and chlorine atoms arranged in a cubic pattern.

Did You Know? Although liquid water is not a mineral, it is a mineral when it freezes. Ice is a naturally occurring, inorganic solid with a definite chemical composition and an ordered internal structure.Learn more.

The Word "Mineral"

The word "mineral" is used in many different ways. The definition given above is a formal definition preferred by geologists.

The word also has a nutritional meaning. It is used in reference to the many inorganic chemicals that organisms need to grow, repair tissue, metabolize and carry out other body processes. Mineral nutrients for the human body include: iron, calcium, copper, sulfur, phosphorus, magnesium and many others.

An archaic use of the word "mineral" comes from the Linnaean taxonomy in which all things can be assigned to the animal, vegetable and mineral kingdoms.

The word "mineral" is also used inconsistently in geology. In mining, anything obtained from the ground and used by man is considered to be a "mineral commodity" or a "mineral material". These include: crushed stone, which is a manufactured product made from crushed rocks; lime, which is a manufactured product made from limestone or marble (both composed of the mineral calcite; coal which is organic; oil and gas which are organic fluids; rocks such as granite that are mixtures of minerals; and, rocks such as obsidian which do not have a definite composition and ordered internal structure.

Mineral Commodities in Industry

2010 United States Mineral Commodity Consumption	
Mineral Commodity	**Millions of Metric Tons**
Crushed Stone	1,200.0
Sand and Gravel	786.1
Salt	55.8
Iron Ore	48.0
Phosphate Rock	30.5
Gypsum	22.5
Clays	21.3
Dimension Stone	14.0
Lime	18.5
Sulfur	11.30
Bauxite	8.4
Potash	5.6
Soda Ash	5.2
Barite	2.66
Copper	1.74
Lead	1.40
Values above are estimates of mineral commodity consumption from the United States Geological Survey. Many other commodities could be added to this table.	

The construction industry is the largest consumer of mineral commodities. Crushed stone is used for foundations, road base, concrete, and drainage. Sand and gravel are used in concrete and foundations. Clays are used to make cement, bricks and tile. Iron ore is used to make reinforcing rods, steel beams, nails and wire. Gypsum is used to make drywall. Dimension stone is used for facing, curbing, flooring, stair treads, and other architectural work. These are just a few of the many uses for these commodities in construction.

In agriculture, phosphate rock and potash are used to make fertilizer. Lime is used as an acid-neutralizing soil treatment. Mineral nutrients are added to animal feed.

The chemical industry uses large amounts of salt, lime and soda ash. Large amounts of metals, clay and mineral fillers/extenders are used in manufacturing.

Physical Properties of Minerals

There are approximately 4000 different minerals and each of those minerals has a unique set of physical properties. These include: color, streak, hardness, luster, diaphaneity, specific gravity, cleavage, fracture, magnetism, solubility and many more. These physical properties are useful for identifying minerals. However, they are much more important in determining the potential industrial uses of the mineral. Let's consider a few examples.

The mineral talc, when ground into a powder is perfectly suited for use as a foot powder. It is a soft, slippery powder so it will not cause abrasion. It has the ability to absorb moisture, oils and odor. It adheres to the skin and produces an astringent effect - yet it washes off easily. No other mineral has a set of physical properties that are as suitable for this purpose.

The mineral halite, when crushed into small grains is perfectly suited for flavoring food. It has a salty taste that most people find pleasing. It dissolves quickly and easily, allowing its flavor to spread through the food. It is soft, so if some does not dissolve it will not damage your teeth. No other mineral has physical properties that are better suited for this use.

The mineral gold is perfectly suited for use in jewelry. It can be easily shaped into a custom item of jewelry by a craftsperson. It has a pleasing yellow color that most people enjoy. It has a bright luster that does not tarnish. Its high specific gravity gives it a nice "heft" that is preferred by most people over lighter metals. Other metals can be used to make jewelry but these properties make gold an overwhelming favorite. (Some people might add that gold's rarity and value are two additional properties that make it desirable for jewelry. However, rarity is not a property and its value is determined by supply and demand.)

Physical Properties: Determining Factors

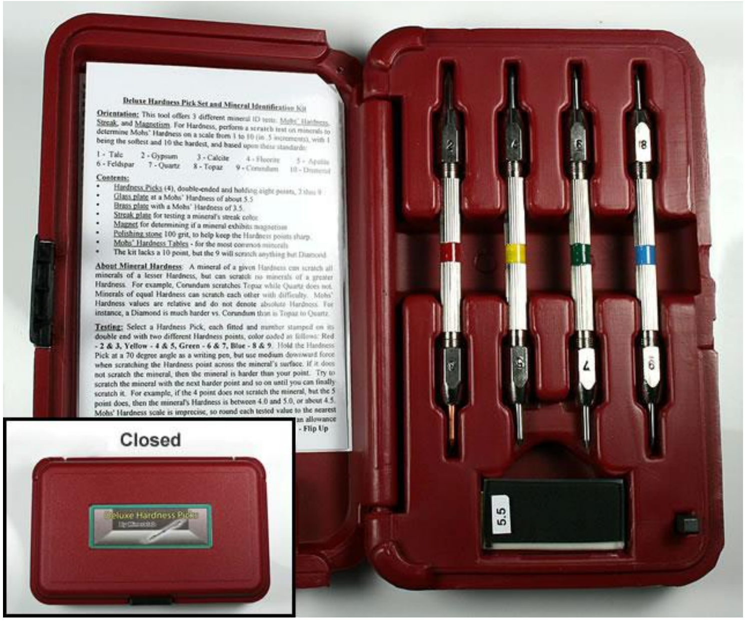
The primary characteristics of a mineral that determine its physical properties are its composition and the strength of the bonds in its ordered internal structure. Here are some examples:

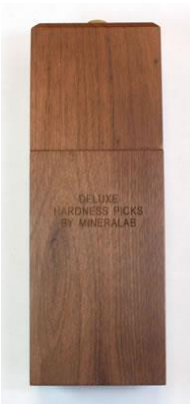
Galena, a lead sulfide, has a much higher specific gravity thanbauxite, an aluminum hydroxide. This difference is because of their composition. Lead is much heavier than aluminum.

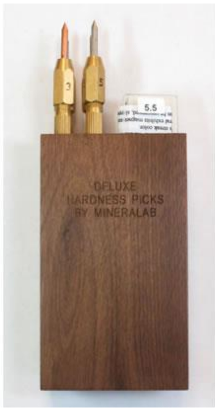
Diamond and graphite both consist of pure carbon. Diamond is the hardest natural mineral and graphite is one of the softest. This difference occurs because of the types of bonds connecting the carbon atoms in their mineral structures. Each carbon atom in diamond is bonded to four other carbon atoms with strong covalent bonds. Graphite has a sheet structure in which atoms within the sheets are bonded to one another with strong covalent bonds but the bonds between the sheets are weak electrical bonds. When graphite is scratched the weak bonds fail easily, making it a soft mineral.

The gemstones ruby and sapphire are color variations of the mineral corundum. These color differences are caused by composition. When corundum contains trace amounts of chromium it exhibits the red color of a ruby. However, when it contains trace amounts of iron or titanium it exhibits the blue color of sapphire. If, at the time of crystallization, enough titanium is present to form tiny crystals of the mineral rutile a star sapphire may form. This occurs when tiny crystals of rutile align systematically within the crystalline structure of the corundum to give it a silky luster that might produce a "star" that aligns with the primary crystallographic axis (see image at right).

Contributor: Hobart King


Deluxe Hardness Pick Set and Mineral Identification Kit
Orientation: This tool offers 3 different mineral ID tests: Mohs' Hardness, Streak, and Magnetism. For Hardness, perform a scratch test on minerals to determine Mohs' Hardness on a scale from 1 to 10 (in .5 increments), with 1 being the softest and 10 the hardest, and based upon these standards:
1 - Talc 2 - Gypsum 3 - Calcite 4 - Fluorite 5 - Apatite
6 - Feldspar 7 - Quartz 8 - Topaz 9 - Corundum 10 - Diamond
Contents:
Hardness Picks (4), double-ended and holding eight points, 2 thru 9
Glass plate at a Mohs' Hardness of about 5.5
Brass plate with a Mohs' Hardness of 3.5
Streak plate for testing a mineral's streak color
Magnet for determining if a mineral exhibits magnetism
Polishing stone 100 grit, to help keep the Hardness points sharp
Mohs' Hardness Tables - for the most common minerals
The kit lacks a 10 point, but the 9 will scratch anything but Diamond
About Mineral Hardness: A mineral of a given Hardness can scratch all minerals of a lesser Hardness, but can scratch no minerals of a greater Hardness. For example, Corundum scratches Topaz while Quartz does not. Minerals of equal Hardness can scratch each other with difficulty. Mohs' Hardness values are relative and do not denote absolute Hardness. For instance, a Diamond is much harder vs. Corundum than is Topaz to Quartz.
Testing: Select a Hardness Pick, each fitted and number stamped on its double end with two different Hardness points, color coded as follows: Red - 2 & 3, Yellow - 4 & 5, Green - 6 & 7, Blue - 8 & 9. Hold the Hardness Pick at a 70 degree angle as a writing pen, but use medium downward force when scratching the Hardness point across the mineral's surface. If it does not scratch the mineral, then the mineral is harder than your point. Try to scratch the mineral with the next harder point and so on until you can finally scratch it. For example, if the 4 point does not scratch the mineral, but the 5 point does, then the mineral's Hardness is between 4.0 and 5.0, or about 4.5. Mohs' Hardness scale is imprecise, so round each tested value to the nearest
an allowance
- Flip Up
Closed
Deluxe Hardness Picks
5.5


DELUXE
HARDNESS PICKS
BY MINERALAB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HARDNESS PICKS
BY MINERALAB


5.5