

## Properties Used to Identify Minerals

### Colour

Generally, colour alone is not diagnostic in mineral identification because colour can be highly variable. Some minerals, such as quartz, calcite, or fluorite, can occur in almost every possible colour due to impurities in the chemical makeup of the mineral. However, some minerals can be easily identified by their diagnostic colours, such as pyrite (fool's gold – brassy coloured) or azurite (deep blue). Colour can be used to narrow down possible mineral identification but should not be relied upon as the sole property for identification. An example image below shows the major different varieties of the mineral quartz, and you can see, they are all very different colours, showing how colour is not a diagnostic property for the mineral quartz.



Image from <https://www.geologyin.com/2016/04/major-varieties-of-quartz.html>

## Hardness

The Mohs scale of mineral hardness is a qualitative scale from 1 to 10 characterizing scratch resistance of common minerals through the ability of harder material to scratch softer material. Hardness is tested using a variety of objects with known Mohs hardness:

- Fingernail → 2.5
- Copper nail → 3
- Glass plate → 5.5
- Steel nail → 6.5
- Porcelain plate → 7

The hardness of possible unknown minerals is listed in the guidebook below. There are lots of free videos on YouTube demonstrating how to test hardness. Three examples are

<https://www.youtube.com/watch?v=MorDV1LGTqQ>,  
<https://www.youtube.com/watch?v=1Eizqc2NRz4>, and  
<https://www.youtube.com/watch?v=tJOqcdbWFw0>.

## Streak

Streak is the colour of powder a softer mineral leaves behind when dragged across a porcelain plate. Many minerals have a different colour when powdered than they do in crystalline or massive form. Non-silicate minerals typically leave a coloured streak, whereas silicate minerals typically have a white streak.

There are lots of free videos on YouTube demonstrating how to test the streak of a mineral. One example is <https://www.youtube.com/watch?v=ngM-xww9Aps>.

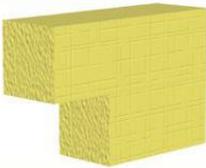
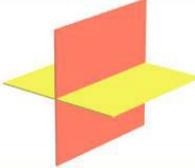
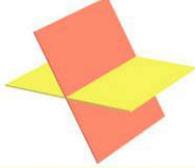
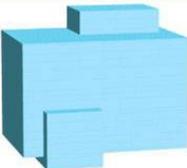
## Cleavage/Fracture

Cleavage describes how a crystal breaks when subjected to stress on a particular plane. If part of the crystal breaks due to stress and the broken piece still has a smooth plane and reflects light, the mineral has cleavage. Minerals may also fracture, usually meaning there are no distinct cleavage planes. A common example of fracture is the mineral quartz, which exhibits conchoidal fracture. Examples of cleavage types can be seen below:

- Basal, or one direction of cleavage (like pages in a book) → Biotite
- 2 directions of cleavage at 90° → Feldspar
- 3 directions of cleavage at 90° (cubic) → Halite
- 3 directions of cleavage at 60° and 120° (rhombohedral – not at 90°) → Calcite
- 2 directions of cleavage at 56° and 124° (prismatic- not at 90°) → Hornblende
- 4 directions of cleavage (octahedral) → Fluorite
- 6 directions of cleavage (dodecahedral) → Sphalerite

Note: minerals with 4 or 6 directions of cleavage are not common.

There are lots of free videos on YouTube demonstrating how to identify the cleavage planes in a mineral. Two examples are <https://www.youtube.com/watch?v=1SGC3VBQZY0> and <https://www.youtube.com/watch?v=wAg5JjKdKgg>.

Number of Cleavage Directions	Sketch	Illustration of cleavage directions	Example
1			
2 at 90°			
2 not at 90°			
3 at 90°			
3 not at 90°			
4			

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Image from: <https://sternberg.fhsu.edu/research-collections/geology/mineral-classification-page.html>

## Lustre

Lustre is the overall sheen of a mineral's surface. Very simply, lustre can be grouped into metallic lustre – looking like polished metal, or non-metallic lustre – which is further broken down into other types such as vitreous (glassy), earthy, dull, silky, resinous, pearly, etc. Some typical lustre names are listed below:

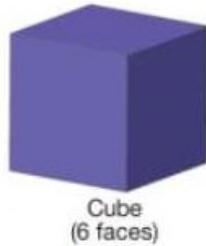
- Metallic → Pyrite
- Vitreous (non-metallic) → Quartz
- Earthy (non-metallic) → Hematite
- Pearly (non-metallic) → Talc

There are lots of free videos on YouTube demonstrating how to identify the lustre of a mineral. Two examples are <https://www.youtube.com/watch?v=rkZOdng2oJk> and <https://www.youtube.com/watch?v=MujN-H52mGM>.

## Crystal System

A crystal system is the shape that a mineral grows in, based on its internal chemical composition and crystal structure. Each crystal system is based on the angles and intersection of a 3-point axis. Some mineral shapes are listed below: Images modified from <https://www.geologyin.com/2019/10/crystal-habits-and-forms.html>

- Cube → Halite



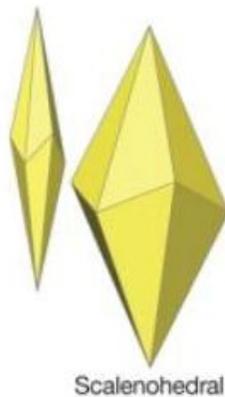
- Rhomb-dodecahedron → Garnet



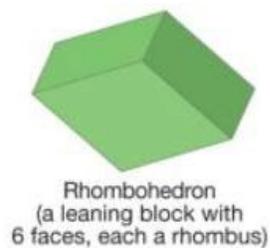
- Pentagon-dodecahedron (Pyritohedron) → Pyrite



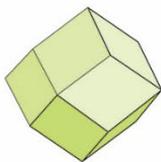
- Scalenohedron → Calcite



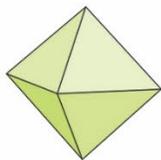
- Rhombohedron → Calcite



## Cubic



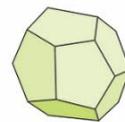
garnet



spinel



halite

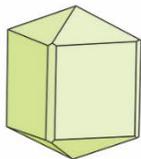


pyrite

## Tetragonal



apophyllite



rutile

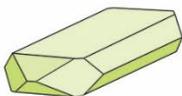


zircon

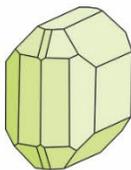


wulfenite

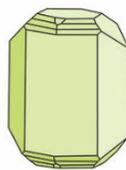
## Orthorhombic



barite



olivine



topaz



sulfur

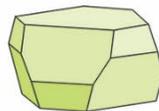
## Hexagonal or Trigonal



corundum



quartz

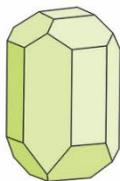


ilmenite

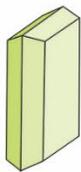


calcite

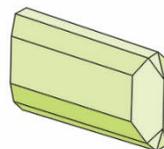
## Monoclinic



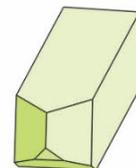
diopside



gypsum

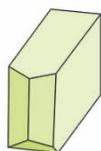


epidote

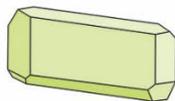


orthoclase

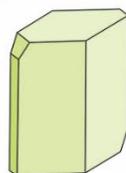
## Triclinic



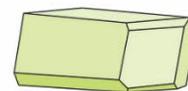
albite



wollastonite



kyanite



rhodonite

## Example Mineral Identification

The section below is a step-by-step example of the process used to identify an unknown mineral specimen, known as “UKN” utilizing the properties discussed above.

### LUSTRE:

- *UKN has a non-metallic lustre. This means that UKN is not the mineral graphite, hematite, magnetite, pyrite, chalcopyrite, sphalerite, galena or copper.*

### HARDNESS:

- *UKN is scratched across a glass plate, and UKN does not make a scratch on the glass plate. We now know that UKN is softer than the glass plate, or softer than 5.5 on Moh's scale.*
- *We can then scratch UKN with a copper nail, and the copper nail does not scratch UKN. This means that UKN is harder than the copper nail, or 3 on Moh's scale.*
- *Therefore, UKN has a hardness between 3 and 5.5. We can use this information to compare to the known hardness of minerals in the below guidebook to narrow down the possible identity of UKN. Possible mineral identification for UKN is fluorite, malachite, celestite, azurite, apophyllite. To narrow this down, we must test other properties.*

### COLOUR:

- *UKN is blue in colour. This narrows down our list of possible mineral identification for UKN to fluorite, celestite, azurite, and apophyllite.*

### STREAK:

- *UKN is scratched along the surface of a porcelain streak plate. UKN does not appear to leave a streak. However, knowing that the hardness is less than 5.5, or in other words, UKN is softer than the streak plate, a streak should have been left behind. Upon closer inspection, you see that a white streak was left behind on the porcelain streak plate. This narrows down our list of possible mineral identification for UKN to fluorite, celestite, and apophyllite.*

### CLEAVAGE/CRYSTAL SYSTEM:

- *UKN appears as octahedral crystals, but at first it is unknown if these specimens are exhibiting growth features (i.e. the mineral grew as octahedrons) or cleavage planes (i.e. the mineral was broken, resulting in this shape). From referring to your chart, you recall that the only mineral listed as having octahedral cleavage is fluorite.*

**Based on the above information, you are able to identify that UKN is the mineral fluorite!**

A free video demonstrating mineral identification strategies is available on YouTube, and the link is <https://www.youtube.com/watch?v=YxpnvDAkczM>.

# Mystery Minerals Guidebook

## Minerals

The below table shows the minerals that could be provided in Mystery Minerals, and their properties, with key properties underlined.

<p><b>1. Talc - <math>Mg_3Si_4O_{10}(OH)_2</math></b>            Colour: white, grey, pale green, pale pink  <u>Hardness: 1</u>            Streak: white            Cleavage: basal perfect  <u>Lustre: greasy to dull, pearly, soapy feel</u>            System: monoclinic</p>	 <p>Source: <a href="https://www.britannica.com/science/talc">https://www.britannica.com/science/talc</a></p>
<p><b>2. Gypsum (selenite) - <math>CaSO_4 \cdot 2H_2O</math></b>            Colour: colourless to white; often tinged other hues due to impurities; yellow, tan, blue, pink, dark brown, reddish brown, or gray  <u>Hardness: 2</u>            Streak: white            Cleavage: 3 directions, rhombohedral            Lustre: vitreous to pearly            System: monoclinic</p>	 <p>Source: <a href="https://www.minerals.net/mineral/gypsum.aspx">https://www.minerals.net/mineral/gypsum.aspx</a></p>
<p><b>3. Calcite - <math>CaCO_3</math></b>            Colour: any colour            Hardness: 3            Cleavage: perfect rhombohedral            Lustre: vitreous to pearly on cleavage surfaces            Streak: white  <u>System: rhombohedral</u>  <u>Other: effervesces in HCl</u>  <u>Other: Clear varieties show double refraction of images under the specimen</u></p>	 <p>Source: <a href="https://www.mineralauctions.com/items/large-calcite-iceland-spar-cleavage-81303">https://www.mineralauctions.com/items/large-calcite-iceland-spar-cleavage-81303</a></p>
<p><b>4. Fluorite - <math>CaF_2</math></b>            Colour: green, purple, blue, yellow, etc.            Hardness: 4            Streak: white  <u>Cleavage: four directions – octahedral</u>            Lustre: vitreous            System: isometric</p>	 <p>Source: <a href="https://www.deepearthtreasures.com/products/madagascar-green-fluorite-natural-specimen-32mm-22g">https://www.deepearthtreasures.com/products/madagascar-green-fluorite-natural-specimen-32mm-22g</a></p>

**5. Quartz - SiO<sub>2</sub>**

Colour: any colour

Hardness: 7

Streak: none

Fracture: conchoidal

Lustre: vitreous

System: trigonal

Varieties: amethyst (purple), smoky (black-brown), rose (pink), citrine (yellow)



Source: <https://www.minerals.net/mineral/quartz.aspx>



Source: <https://canada.michaels.com/en/rough-rose-quartz-by-ashland/10558676.html>

**6. Microcline - KAlSi<sub>3</sub>O<sub>8</sub>**

Colour: usually white or pink, can be blue or green (amazonite)

Hardness: 6

Streak: white

Cleavage: 2 directions of cleavage at 90°

Lustre: vitreous

System: triclinic

Other: will show exsolution



Source: <https://www.sandatlas.org/microcline/>

**7. Albite - NaAlSi<sub>3</sub>O<sub>8</sub>**

Colour: white or grey or brown (iridescent albite is called peristerite or moonstone)

Hardness: 6-6.5

Streak: white

Cleavage: 2 directions at ~90°

Lustre: vitreous, typically pearly on cleavages

System: triclinic



Source: <https://www.boreal.com/store/product/8865926/albite>

**8. Hornblende - (Ca,Na)<sub>2-3</sub>(Mg,Fe,Al)<sub>5</sub>Si<sub>6</sub>(Si,Al)<sub>2</sub>O<sub>22</sub>(OH)<sub>2</sub>**

Colour: generally black or dark green

Hardness: 5-6

Streak: pale grey, grey-white, white

Cleavage: 56° / 124°

Lustre: vitreous to dull

System: monoclinic



Source: <https://www.eiscolabs.com/products/esng0019>

<p><b>9. Augite - <math>(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6</math></b>  Colour: dark green to black  Hardness: 5.5-6  Streak: greenish white  <u>Cleavage: 2 directions at 90°</u>  Lustre: vitreous, resinous to dull  System: monoclinic</p>	 Source: <a href="https://geology.com/minerals/augite.shtml">https://geology.com/minerals/augite.shtml</a>
<p><b>10. Muscovite - <math>KAl_2Si_3AlO_{10}(OH)_2</math></b>  <u>Colour: colourless/transparent to pale greenish</u>  Hardness: 2-2.5  Streak: white  <u>Cleavage: basal</u>  Lustre: vitreous, silky, or pearly  System: monoclinic</p>	 Source: <a href="http://nevada-outback-gems.com/mineral_information/Mica_muscovite_mineral_info.htm">http://nevada-outback-gems.com/mineral_information/Mica_muscovite_mineral_info.htm</a>
<p><b>11. Biotite - <math>K(Mg,Fe)_3Si_3AlO_{10}(OH)_2</math></b>  <u>Colour: black</u>  Hardness: 2-3  Streak: white  <u>Cleavage: basal</u>  Lustre: vitreous  System: monoclinic</p>	 Source: <a href="https://geologyscience.com/minerals/biotite/">https://geologyscience.com/minerals/biotite/</a>
<p><b>12. Olivine - <math>(Mg,Fe)_2SiO_4</math></b>  <u>Colour: green</u>  Hardness: 6.5-7  Streak: colourless or white  <u>Cleavage: conchoidal</u>  <u>Lustre: glassy</u>  System: orthorhombic</p>	 Source: <a href="https://www.geologyin.com/2016/12/study-of-olivine-provides-new-data-for.html">https://www.geologyin.com/2016/12/study-of-olivine-provides-new-data-for.html</a>
<p><b>13. Graphite - C</b>  Colour: steel grey to black  <u>Hardness: 1-2</u>  <u>Streak: grey (like a pencil)</u>  Cleavage: basal  Lustre: greasy, metallic to dull  System: hexagonal  <u>Other: is what pencil lead is made of</u></p>	 Source: <a href="https://geologyscience.com/minerals/graphite/">https://geologyscience.com/minerals/graphite/</a>

**14. Halite - NaCl**

Colour: colourless, white, greyish, blueish, yellowish, red, etc.

Hardness: 2.5

Streak: white

Cleavage: cubic, perfect, 3 at 90°, conchoidal fracture

Lustre: vitreous

System: isometric

Other: tastes salty, water soluble, slippery



Source: <https://www.le-comptoir-geologique.com/halite-en-halite-ref-z01-09.html>

**15. Hematite - Fe<sub>2</sub>O<sub>3</sub>**

Colour: red or steel grey (specular hematite)

Hardness: 5-6

Streak: red-brown

Cleavage: none, may show partings

Lustre: earthy-metallic

System: hexagonal



Source: <https://geology.com/minerals/hematite.shtml>

**16. Magnetite - Fe<sub>3</sub>O<sub>4</sub>**

Colour: iron black

Hardness: 5.5-6

Streak: iron black

Cleavage: none, may show partings

Lustre: metallic

System: isometric

Other: very magnetic



© geology.com

Source: <https://geology.com/minerals/magnetite.shtml>

**17. Pyrite - FeS<sub>2</sub>**

Colour: pale brass yellow; lack of tarnish vs. chalcopyrite

Hardness: 6-6.5

Streak: greenish-black to brownish-black

Cleavage: conchoidal to uneven

Lustre: metallic

System: isometric



Source: <https://stock.adobe.com/ca/search?k=pyrite>

**18. Chalcopyrite - CuFeS<sub>2</sub>**

Colour: brass yellow, often with slightly iridescent tarnish

Hardness: 3.5-4

Streak: greenish black

Cleavage: poor – not well defined

Lustre: metallic

System: tetragonal



© geology.com

Source: <https://geology.com/minerals/chalcopyrite.shtml>

**19. Sphalerite - ZnS**

Colour: brown to yellowish, reddish, black

Hardness: 3.5-4

Streak: brownish white, pale yellow

Cleavage: dodecahedral

Lustre: non-metallic to resinous, to sub-metallic in opaque specimens

System: isometric



Source: <https://www.virtualmicroscope.org/content/sphalerite>

**20. Galena - PbS**

Colour: lead-grey; opaque

Hardness: 2.5

Streak: lead-grey

Cleavage: cubic

Lustre: bright metallic

System: isometric, perfect

Other: very heavy (Specific Gravity = 7.6)



Source: <https://www.britannica.com/science/galena-mineral>

**21. Malachite -  $\text{Cu}_2\text{CO}_3(\text{OH})_2$** 

Colour: bright green to blackish green

Hardness: 3.5-4

Streak: light green

Cleavage: Perfect in one direction, conchoidal fracture

Lustre: adamantine, vitreous, silky, dull, earthy

System: monoclinic



Source: <https://en.wikipedia.org/wiki/Malachite>

**22. Copper - Cu**

Colour: copper-red to brown, tarnishes green

Hardness: 3

Streak: copper-red

Fracture: Hackly

Lustre: metallic

System: isometric



Source: <https://en.wikipedia.org/wiki/Copper>

**23. Sodalite -  $\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}\text{Cl}_2$** 

Colour: royal blue, white veining common

Hardness: 5.5-6

Streak: white

Fracture: Conchoidal

Lustre: dull, vitreous, greasy

System: cubic



Source: <https://www.mindat.org/min-3701.html>

**24. Celestite – SrSO<sub>4</sub>**

Colour: white, gray, pale blue

Hardness: 3-3.5

Streak: white

Cleavage: Three directions – splits into thin, flat fragments

Lustre: vitreous, pearly

System: orthorhombic

Other: Tends to crystallize as geodes



Source: <https://www.madagascandirect.com/article/1/Celestite/>

**25. Lepidolite –**

**K(Li,Al)<sub>3</sub>(Al,Si,Rb)<sub>4</sub>O<sub>10</sub>(F,OH)<sub>2</sub>**

Colour: pink, light purple, purple, rose-red, violet-gray, yellowish, white, colourless

Hardness: 2.5-3

Streak: white

Cleavage: basal

Lustre: vitreous, pearly

System: monoclinic



Source: <https://geology.com/minerals/lepidolite.shtml>

**26. Azurite – Cu<sub>3</sub>(CO<sub>3</sub>)<sub>2</sub>**

Colour: azure-blue, dark to pale blue

Hardness: 3.5-4

Streak: light blue

Cleavage: perfect in one direction, conchoidal fracture

Lustre: vitreous

System: monoclinic



Source: <https://en.wikipedia.org/wiki/Azurite>

**27. Garnet - A<sub>3</sub>B<sub>2</sub>(SiO<sub>4</sub>)<sub>3</sub>**

where A is a divalent cation (Fe<sup>2+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Mn<sup>2+</sup>) and B is a trivalent cation (Fe<sup>3+</sup>, Al<sup>3+</sup>, Cr<sup>3+</sup>).

Colour: any colour

Hardness: 6.5-7.5

Streak: white

Fracture: conchoidal

Lustre: vitreous

System: isometric (rhomb-dodecahedron)

Varieties: almandine, grossular, uvarovite, pyrope



Source: <https://e-rocks.com/item/jwt199949/garnet-var-almandine>



Source: <https://www.abijoux.com/grossular-garnet-19-06-ct.htm>

**28. Apatite –  $\text{Ca}_5(\text{PO}_4)_3$** 

Colour: transparent to translucent, usually green, less often colourless, yellow, blue to violet, pink, brown

Hardness: 5

Streak: white

Fracture: conchoidal

Lustre: vitreous

System: hexagonal



Source: <https://www.britannica.com/science/apatite>

**29. Topaz –  $\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$** 

Colour: colourless, white, blue, brown, orange, gray, yellow, yellowish brown, green, pink, reddish pink, red

Hardness: 8

Streak: none

Cleavage: perfect basal cleavage

Lustre: vitreous

System: orthorhombic



Source: <https://monolisadesigns.com/blogs/gemstones/the-history-behind-a-topaz-gemstone>

**30. Apophyllite -  $\text{Ca}_4\text{KFSi}_8\text{O}_{20} \cdot 8\text{H}_2\text{O}$** 

Colour: white, colourless; also blue, green, brown, yellow, pink, violet

Hardness: 4.5-5

Streak: white

Cleavage: perfect in one direction

Lustre: vitreous, pearly

System: tetragonal



Source: <https://en.wikipedia.org/wiki/Apophyllite>

**31. Epidote -  $\text{Al}_2\text{Ca}_2\text{FeH}_2\text{O}_{13}\text{Si}_3$** 

Colour: pistachio-green, yellow-green, greenish black, brownish-green, green, black

Hardness: 6-7

Streak: greyish white

Cleavage: perfect in one direction

Lustre: vitreous to resinous

System: monoclinic



Source: <https://www.britannica.com/science/epidote>

**32. Corundum -  $\text{Al}_2\text{O}_3$** 

Colour: colourless, gray, golden-brown, brown, purple, pink, red, orange, yellow, green, blue, violet

Hardness: 9

Streak: none

Fracture: conchoidal

Lustre: adamantine to vitreous

System: trigonal (hexagonal prism)

Varieties: ruby (red), sapphire (any colour besides red)



Source: <https://geology.com/minerals/corundum.shtml>



Source: [https://stock.adobe.com/ch\\_fr/search?k=sapphire+raw&asset\\_id=298633930](https://stock.adobe.com/ch_fr/search?k=sapphire+raw&asset_id=298633930)

**33. Labradorite –  $(\text{Ca},\text{Na})(\text{Al},\text{Si})_4\text{O}_8$**

Colour: grey-white, greenish, blue, yellow

Hardness: 6-6.5

Streak: white

Cleavage: 2 at  $90^\circ$

Lustre: vitreous to pearly

System: triclinic

Other: displays iridescent blue/green flashes



Source: <https://www.mindat.org/min-246.html>  
<https://www.mindat.org/photo-411944.html>

**34. Anorthite -  $\text{CaAl}_2\text{Si}_2\text{O}_8$**

Colour: typically gray

Hardness: 6

Streak: white

Cleavage: 2 at  $90^\circ$

Lustre: vitreous

System: triclinic



Source: <https://www.weinrichmineralsinc.com/products/anorthite-4271506.php>