Quartz

SiO_2

Classification:
tectosilicate

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic
- sedimentary
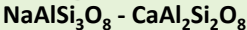
Hardness:	**7**
Specific gravity:	**2.65**
Cleavage:	**poor/none**
Crustal abundance:	**high**
Economic value:	**moderate**

Plagioclase

$NaAlSi_3O_8$ - $CaAl_2Si_2O_8$

Classification:
tectosilicate

Crystal system:
triclinic

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	6 – 6.5
Specific gravity:	2.6 – 2.8
Cleavage:	1 perfect, 1 good
Crustal abundance:	very high
Economic value:	moderate

Orthoclase

KAlSi$_3$O$_8$

Classification:
tectosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	6 – 6.5
Specific gravity:	2.5 – 2.6
Cleavage:	1 perfect, 1 good
Crustal abundance:	high
Economic value:	moderate

Biotite

K(Fe,Mg)$_3$AlSi$_3$O$_{10}$(OH)$_2$

Classification:
phyllosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic
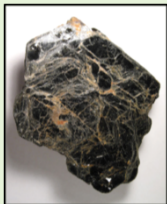
Hardness:	**2.5 – 3**
Specific gravity:	**2.7 – 3.3**
Cleavage:	**1 perfect**
Crustal abundance:	**moderate**
Economic value:	**low**

Muscovite
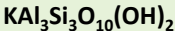
KAl$_3$Si$_3$O$_{10}$(OH)$_2$

Classification:
phyllosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic

Hardness:	2.5 – 3
Specific gravity:	**2.8 – 2.9**
Cleavage:	**1 perfect**
Crustal abundance:	**moderate**
Economic value:	**moderate**

Hornblende
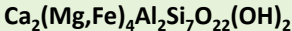
$Ca_2(Mg,Fe)_4Al_2Si_7O_{22}(OH)_2$

Classification:
inosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic
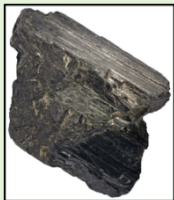
Hardness:	**5 – 6**
Specific gravity:	**3.0 – 3.5**
Cleavage:	**2 good**
Crustal abundance:	**moderate**
Economic value:	**trivial**

Actinolite
Ca$_2$(Mg,Fe)$_5$Si$_8$O$_{22}$(OH)$_2$
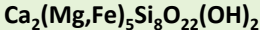
Classification:
inosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic

Hardness:	**5 – 6**
Specific gravity:	**3.0 – 3.5**
Cleavage:	**2 good**
Crustal abundance:	**low**
Economic value:	**low**

Glaucophane
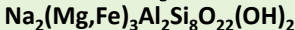
$Na_2(Mg,Fe)_3Al_2Si_8O_{22}(OH)_2$

Classification:
inosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic
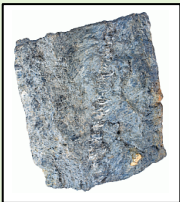
Hardness:	6
Specific gravity:	3.0 – 3.2
Cleavage:	2 good
Crustal abundance:	low
Economic value:	trivial

Olivine
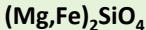
(Mg,Fe)$_2$SiO$_4$

Classification:
nesosilicate

Crystal system:
orthorhombic

Occurrence:
- igneous
- metamorphic
- mantle

Hardness:	**6.5 – 7**
Specific gravity:	**3.2 – 4.4**
Cleavage:	**2 poor**
Crustal abundance:	**high**
Economic value:	**low**

Garnet

$(Fe,Mg,Ca,Mn)_3(Al,Fe)_2Si_3O_{12}$
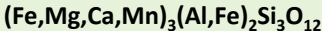
Classification:
nesosilicate

Crystal system:
isometric

Occurrence:
- igneous
- metamorphic
- mantle

Hardness:	**6 – 7.5**
Specific gravity:	**3.5 – 4.3**
Cleavage:	**none**
Crustal abundance:	**moderate**
Economic value:	**moderate**

Titanite

$CaTiSiO_5$

Classification:
nesosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic

Hardness:	5 – 5.5
Specific gravity:	**3.4 – 3.6**
Cleavage:	**3 good**
Crustal abundance:	**low**
Economic value:	**low**

Zircon

$ZrSiO_4$

Classification:
nesosilicate

Crystal system:
tetragonal

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	7.5
Specific gravity:	4.6 – 4.7
Cleavage:	2 poor
Crustal abundance:	trace
Economic value:	moderate

Augite
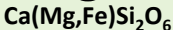
Ca(Mg,Fe)Si$_2$O$_6$

Classification:
inosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic

Hardness:	5.5 – 6.5
Specific gravity:	3.2 – 3.6
Cleavage:	2 good
Crustal abundance:	high
Economic value:	trivial

Orthopyroxene
(Mg,Fe)$_2$Si$_2$O$_6$
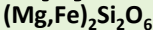
Classification:
inosilicate

Crystal system:
orthorhombic

Occurrence:
- igneous
- metamorphic
- mantle

Hardness:	**5 – 6**
Specific gravity:	**3.2 – 3.9**
Cleavage:	**2 good**
Crustal abundance:	**high**
Economic value:	**trivial**

Chlorite
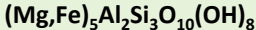
$(Mg,Fe)_5Al_2Si_3O_{10}(OH)_8$

Classification:
phyllosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic

Hardness:	**2 – 3**
Specific gravity:	**2.6 – 3.3**
Cleavage:	**1 perfect**
Crustal abundance:	**moderate**
Economic value:	**low**

Antigorite

$(Mg,Fe)_3Si_2O_5(OH)_4$
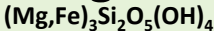
Classification:
phyllosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic
- mantle

Hardness:	**3.5 – 4**
Specific gravity:	**2.6**
Cleavage:	**1 perfect**
Crustal abundance:	**low**
Economic value:	**low**

Talc
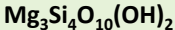
$Mg_3Si_4O_{10}(OH)_2$

Classification:
phyllosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic

Hardness:	**1**
Specific gravity:	**2.6 – 2.8**
Cleavage:	**1 perfect**
Crustal abundance:	**low**
Economic value:	**moderate**

Kaolinite

$Al_2Si_2O_5(OH)_4$
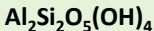
Classification:
phyllosilicate

Crystal system:
triclinic

Occurrence:
- sedimentary

Hardness:	**1.5 – 2.5**
Specific gravity:	**2.6 – 2.7**
Cleavage:	**1 perfect**
Crustal abundance:	**moderate**
Economic value:	**high**

Andalusite

Al_2SiO_5

Classification:
nesosilicate

Crystal system:
orthorhombic

Occurrence:
- metamorphic

Hardness:	6.5 – 7
Specific gravity:	3.15
Cleavage:	2 good
Crustal abundance:	low
Economic value:	moderate

Kyanite

Al_2SiO_5

Classification:
nesosilicate

Crystal system:
triclinic

Occurrence:
- metamorphic

Hardness:	5.5 – 7
Specific gravity:	**3.5 – 3.7**
Cleavage:	**1 perfect, 1 good**
Crustal abundance:	**trace**
Economic value:	**moderate**

Sillimanite

Al$_2$SiO$_5$

Classification:
nesosilicate

Crystal system:
orthorhombic

Occurrence:
- igneous
- metamorphic

Hardness:	6.5 – 7.5
Specific gravity:	3.25
Cleavage:	1 perfect, 1 good
Crustal abundance:	low
Economic value:	low

Staurolite
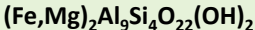
$(Fe,Mg)_2Al_9Si_4O_{22}(OH)_2$

Classification:
nesosilicate

Crystal system:
monoclinic

Occurrence:
- metamorphic

Hardness:	7
Specific gravity:	3.7 – 3.8
Cleavage:	1 good
Crustal abundance:	trace
Economic value:	low

Epidote

$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$
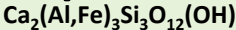
Classification:
sorosilicate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic

Hardness:	**6 – 6.5**
Specific gravity:	**3.2 – 3.5**
Cleavage:	**1 perfect**
Crustal abundance:	**moderate**
Economic value:	**trivial**

Tourmaline
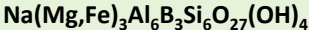
Na(Mg,Fe)$_3$Al$_6$B$_3$Si$_6$O$_{27}$(OH)$_4$

Classification:
cyclosilicate

Crystal system:
hexagonal

Occurrence:
- metamorphic

Hardness:	7 – 7.5
Specific gravity:	3.0 – 3.2
Cleavage:	2 poor
Crustal abundance:	trace
Economic value:	moderate

Topaz
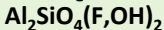
$Al_2SiO_4(F,OH)_2$

Classification:
nesosilicate

Crystal system:
orthorhombic

Occurrence:
- metamorphic
- sedimentary

Hardness:	**8**
Specific gravity:	**3.5 – 3.6**
Cleavage:	**1 perfect**
Crustal abundance:	**ultratrace**
Economic value:	**low**

Beryl

$Be_3Al_2Si_6O_{18}$

Classification:
cyclosilicate

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic

Hardness:	**7.5 – 8**
Specific gravity:	**2.6 – 2.9**
Cleavage:	**1 poor**
Crustal abundance:	**trace**
Economic value:	**moderate**

Pyrite

FeS_2

Classification:
sulfide

Crystal system:
isometric

Occurrence:
- igneous
- metamorphic
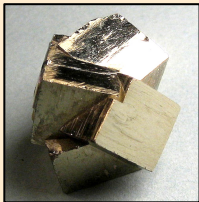
Hardness:	6 – 6.5
Specific gravity:	5.0
Cleavage:	2 poor
Crustal abundance:	low
Economic value:	moderate

Pyrrhotite

$Fe_{1-x}S$

Classification:
sulfide

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic

Hardness:	**3.5 – 4.5**
Specific gravity:	**4.6**
Cleavage:	**none**
Crustal abundance:	**low**
Economic value:	**moderate**

Chalcopyrite

CuFeS$_2$

Classification:
sulfide

Crystal system:
tetragonal

Occurrence:
- igneous
- metamorphic
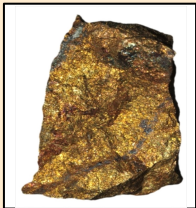
Hardness:	**3.5 – 4**
Specific gravity:	**4.1 – 4.3**
Cleavage:	**2 poor**
Crustal abundance:	**low**
Economic value:	**very high**

Galena

PbS

Classification:
sulfide

Crystal system:
isometric

Occurrence:
- metamorphic

Hardness:	2.5
Specific gravity:	7.5 – 7.6
Cleavage:	3 perfect
Crustal abundance:	trace
Economic value:	high

Sphalerite

(Zn,Fe)S

Classification:
sulfide

Crystal system:
isometric

Occurrence:
- metamorphic
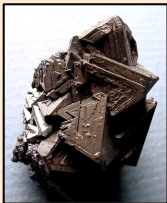
Hardness:	3.5 – 4
Specific gravity:	3.9 – 4.1
Cleavage:	6 perfect
Crustal abundance:	trace
Economic value:	high

Molybdenite

MoS_2

Classification:
sulfide

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic

Hardness:	1 – 1.5
Specific gravity:	4.7
Cleavage:	1 perfect
Crustal abundance:	trace
Economic value:	high

Gold

Au

Classification:
native element

Crystal system:
isometric

Occurrence:
- metamorphic
- sedimentary

Hardness:	**2.5 – 3**
Specific gravity:	**19.3**
Cleavage:	**none**
Crustal abundance:	**ultratrace**
Economic value:	**I'm rich!**

Diamond

C

Classification:
native element

Crystal system:
isometric

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	10
Specific gravity:	3.5
Cleavage:	4 perfect
Crustal abundance:	ultratrace
Economic value:	I'm rich!

Graphite

C

Classification:
native element

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	1 – 2
Specific gravity:	2.2
Cleavage:	1 perfect
Crustal abundance:	trace
Economic value:	moderate

Halite

NaCl

Classification:
halide

Crystal system:
isometric

Occurrence:
- sedimentary

Hardness:	**2.5**
Specific gravity:	**2.2**
Cleavage:	**3 perfect**
Crustal abundance:	**trace**
Economic value:	**moderate**

Fluorite

CaF_2

Classification:
halide

Crystal system:
isometric

Occurrence:
- metamorphic

Hardness:	4
Specific gravity:	3.2
Cleavage:	4 perfect
Crustal abundance:	trace
Economic value:	moderate

Gypsum
$CaSO_4(H_2O)_2$
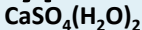
Classification:
sulfate

Crystal system:
monoclinic

Occurrence:
- metamorphic
- sedimentary

Hardness:	2
Specific gravity:	2.3
Cleavage:	1 perfect, 2 good
Crustal abundance:	trace
Economic value:	high

Barite

$BaSO_4$

Classification:
sulfate

Crystal system:
orthorhombic

Occurrence:
- metamorphic
- sedimentary

Hardness:	3 – 3.5
Specific gravity:	4.5
Cleavage:	2 perfect, 1 good
Crustal abundance:	trace
Economic value:	moderate

Apatite
$Ca_5(PO_4)_3(OH,F,Cl)$
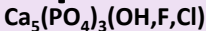
Classification:
phosphate

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	5
Specific gravity:	3.1 – 3.2
Cleavage:	2 poor
Crustal abundance:	low
Economic value:	high

Monazite
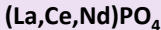
(La,Ce,Nd)PO$_4$

Classification:
phosphate

Crystal system:
monoclinic

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	5
Specific gravity:	5.0 – 5.3
Cleavage:	1 good, 1 poor
Crustal abundance:	trace
Economic value:	moderate

Calcite

CaCO$_3$

Classification:
carbonate

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	3
Specific gravity:	2.7
Cleavage:	3 perfect
Crustal abundance:	moderate
Economic value:	high

Dolomite
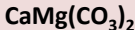
CaMg(CO$_3$)$_2$

Classification:
carbonate

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	**3.5 – 4**
Specific gravity:	**2.9**
Cleavage:	**3 perfect**
Crustal abundance:	**low**
Economic value:	**low**

Magnesite

MgCO$_3$

Classification:
carbonate

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary
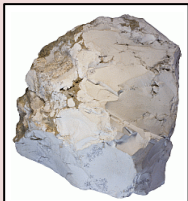
Hardness:	**4**
Specific gravity:	**3.0**
Cleavage:	**3 perfect**
Crustal abundance:	**low**
Economic value:	**moderate**

Siderite

FeCO$_3$

Classification:
carbonate

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	**4 – 4.5**
Specific gravity:	**4.0**
Cleavage:	**3 perfect**
Crustal abundance:	**trace**
Economic value:	**moderate**

Magnetite

Fe_3O_4

Classification:
oxide (spinel)

Crystal system:
isometric

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	5.5 – 6
Specific gravity:	5.2
Cleavage:	none
Crustal abundance:	moderate
Economic value:	very high

Hematite

Fe_2O_3

Classification:
oxide

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	5 – 6
Specific gravity:	5.3
Cleavage:	none
Crustal abundance:	trace
Economic value:	high

Chromite

(Fe,Mg)Cr$_2$O$_4$
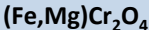
Classification:
oxide (spinel)

Crystal system:
isometric

Occurrence:
- igneous
- sedimentary

Hardness:	5.5
Specific gravity:	4.5 – 5.1
Cleavage:	none
Crustal abundance:	low
Economic value:	high

Ilmenite

TiFeO$_3$

Classification:
oxide

Crystal system:
hexagonal

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	**5 – 6**
Specific gravity:	**4.7 – 4.8**
Cleavage:	**none**
Crustal abundance:	**low**
Economic value:	**moderate**

Rutile

TiO_2

Classification:
oxide

Crystal system:
tetragonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	6 – 6.5
Specific gravity:	4.3
Cleavage:	2 good
Crustal abundance:	low
Economic value:	high

Corundum

Al_2O_3

Classification:
oxide

Crystal system:
hexagonal

Occurrence:
- metamorphic
- sedimentary

Hardness:	**9**
Specific gravity:	**4.0**
Cleavage:	**none**
Crustal abundance:	**trace**
Economic value:	**moderate**

Cassiterite

SnO_2

Classification:
oxide

Crystal system:
tetragonal

Occurrence:
- igneous
- metamorphic
- sedimentary

Hardness:	6 – 7
Specific gravity:	6.9 – 7.1
Cleavage:	1 good, 1 poor
Crustal abundance:	trace
Economic value:	high

Gibbsite

$Al(OH)_3$

Classification:
hydroxide

Crystal system:
monoclinic

Occurrence:
- metamorphic
- sedimentary

Hardness:	**2.5 – 3.5**
Specific gravity:	**2.4**
Cleavage:	**1 perfect**
Crustal abundance:	**low**
Economic value:	**high**

Goethite

FeO(OH)

Classification:
hydroxide

Crystal system:
orthorhombic

Occurrence:
- sedimentary

Hardness:	5 – 5.5
Specific gravity:	4.3
Cleavage:	1 perfect, 1 good
Crustal abundance:	moderate
Economic value:	moderate

Change trumps category to
"Economic value"

supertrump supertrump
supertrump supertrump
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The Petrologist

**Change trumps category to
"Crustal abundance"**

The Gemmologist

Change trumps category to
"Hardness"

Change trumps category to
"Cleavage"

The Geophysicist

Change trumps category to
"Specific gravity", or
throw "Magnetite"

**Change to trumps category of
your choice**

About Mineral Supertrumps

Mineral Supertrumps is a game designed to help players learn about the properties and uses of common rock-forming minerals. The pack consists of 54 mineral cards, and 6 "supertrump" cards. Each mineral card includes information about the mineral such as the generic chemical formula, the classification, crystal system, the geological environment where the mineral is commonly found or formed (igneous, metamorphic, sedimentary, or the mantle), as well as information in the five playing categories (or trumps) of *Hardness, Specific Gravity, Cleavage, Crustal Abundance, and Economic Value*. The first three trump categories relate to distinct physical properties of the mineral, while last two categories rate the importance of the mineral in terms of abundance in the Earths crust (continental and oceanic) and value to modern societies.

Number of players: 3 to 5

Objective: To be the first player to lose all of your cards

How to play:

1. A dealer (randomly chosen) shuffles the cards and deals each player 8 cards. Each player can look at their cards, but should not show them to other players. The remaining card pack is placed face down on the table.

2. The player to the left of the dealer goes first by placing a mineral card on the table. The player must state the mineral name, one of the five trump categories (i.e., either *Hardness, Specific Gravity, Cleavage, Crustal Abundance, or Economic Value*), and the top value of that category. For example, a player placing the Glaucophane card may state "Glaucophane, Specific Gravity, 3.2"

3. The player next to the left takes the next turn. This player must play a mineral card that has a **higher value** in the trump category than the card played by the previous player. For the example of the Glaucophane card above, the player must place a card that has a value for specific gravity above 3.2. The player must state the mineral name and value of the category when playing their card. The game continues with the next player to the left, and so on.

4. If a player does not have any mineral cards that are of higher value for the specific trump category being played, then the player must pass and pick up one card from the card pack on the table. The player then cannot play again until all but one player has passed, or until another player throws a supertrump card to change the trump category, as described below. A player is allowed to pass even if they still hold cards that could be played.

5. If the player has a supertrump card (*The Mineralogist, The Geologist, The Geophysicist, The Petrologist, The Miner, The Gemmologist*) they may play this card at any of their turns. By placing a supertrump card, the player changes the trump category according to the instructions on the supertrump card. At this stage, any player who had passed on the previous round is now able to play again. If a player throws the *Geophysicist* card together with the *Magnetite* card, then that player wins the round.

6. The game continues with players taking turns to play cards until all but one player has passed. The last player then gets to lead out the next round and chooses the trump category to be played.

7. The winner of the game is the first player to lose all of their cards. The game continues until all but one player (i.e., the loser) has lost their cards.

Information on trump categories:

Hardness: relates to Moh's hardness scale of minerals from 1 to 10. Where a range of values is presented, the highest value should be used.

Specific Gravity: in grams per cubic cm. Where a range of values is presented, the highest value should be used.

Cleavage: refers to the number of cleavage planes and how well the planes are typically expressed in the crystal. For example, "1 perfect, 2 poor" means the mineral has 1 perfect cleavage plane, and 2 poor cleavage planes. The order of ranking from lowest to highest is:

none ➔ poor/none ➔ 1 poor ➔ 2 poor ➔ 1 good ➔ 1 good, 1 poor ➔ 2 good ➔ 3 good ➔ 1 perfect ➔ 1 perfect, 1 good ➔ 1 perfect, 2 good ➔ 2 perfect, 1 good ➔ 3 perfect ➔ 4 perfect ➔ 6 perfect.

Crustal abundance: is ranked from lowest to highest as: ultratrace ➔ trace ➔ low ➔ moderate ➔ high ➔ very high.

Economic value: is ranked from lowest to highest as: trivial ➔ low ➔ moderate ➔ high ➔ very high ➔ I'm rich!

Strategies:

Like many card games, there are strategies that can increase the chance of winning. Obviously the more you can remember about the mineral cards the better, particularly if you can remember which cards have been played already. The cards with high values in various trump categories and Supertrump cards should be used to try and win a hand, so use these wisely. When leading out a new round try to begin with a card that tends to have low values for many categories; these cards are difficult to get rid of otherwise.

The cards may be used in other way to help learn aspects of mineralogy. They can be used as flash cards for rote learning, or to play a mineralogy version of Celebrity Head.

Sources of information:

The game was devised and designed by Carl Spandler, and is in part based on the *Top Trumps* card game series. Mineral information was collated from the following sources:

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Mineral images were obtained from open-source internet sites including:

http://www.sandatlas.org; http://www.mindat.org; http://www.amazonsupply.com; http://www.minerals.net

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