

# DISCOVER THE INSIDE WORLD OF MINERALS

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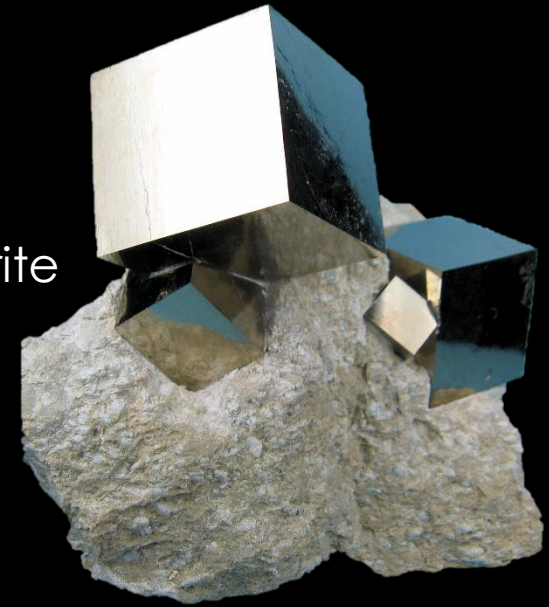


Natrolite

Prehnite



Pyrite



Fluorite



Aquamarine



Rhodochrosite

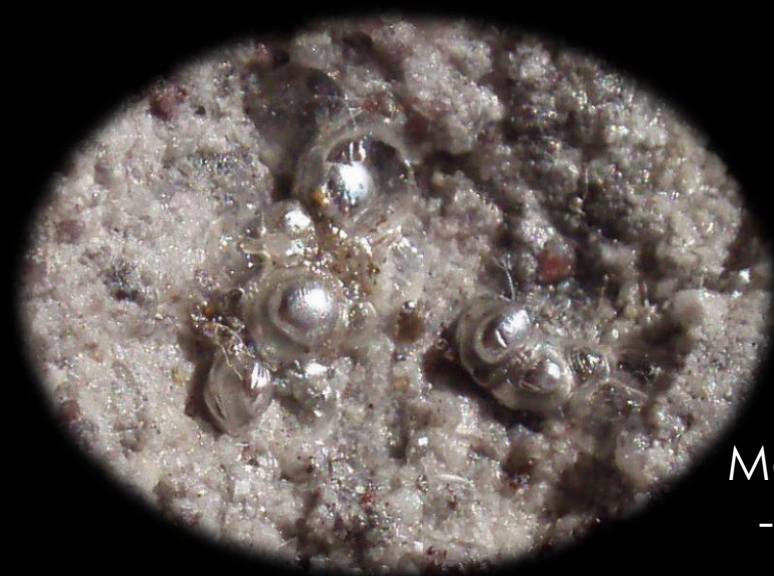
A collection of various colorful mineral specimens is displayed against a black background. The specimens include a yellow mineral, a gold-colored mineral, a red mineral, a white mineral, a blue mineral, a purple mineral, and a green mineral. The text "What makes a mineral a mineral?" is overlaid on a semi-transparent blue rectangle in the center of the image.

What makes a  
mineral a  
mineral?

# #1

## 5 CRITERIA

The substance must exist as a solid under normal conditions (25°C) on Earth



Mercury  
-39°C



Ice  
0°C

# #2

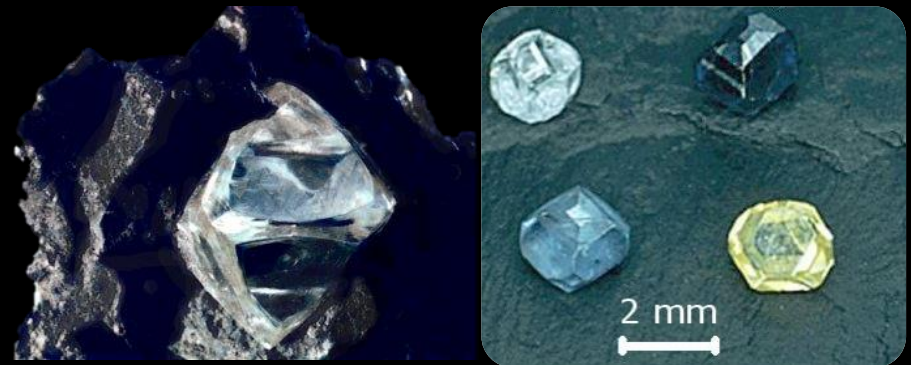
## 5 CRITERIA

The substance must be naturally occurring on Earth and not man-made

Natural and synthetic amethyst and quartz



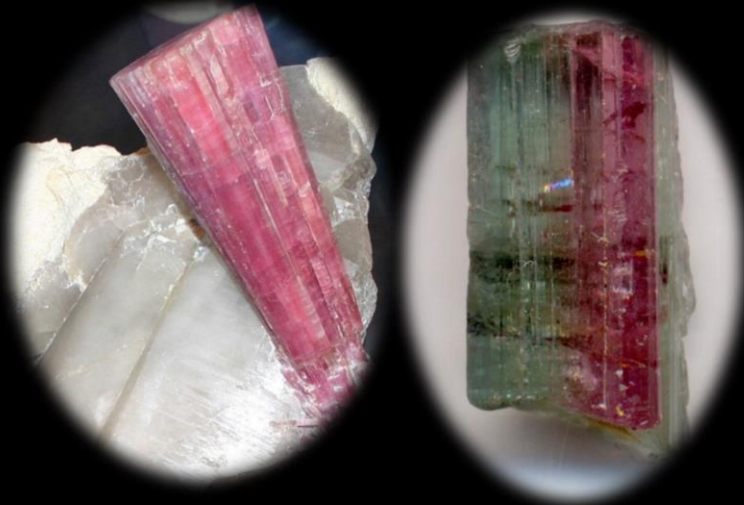
Natural and synthetic diamonds



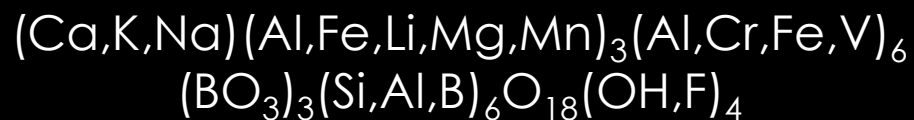
# #3

## 5 CRITERIA

The substance must have a fixed chemical formula, made of specific elements



Tourmaline



Quartz  
 $\text{SiO}_2$

# #4

## 5 CRITERIA

The substance must, not be living or made from living things

~~Pearls~~



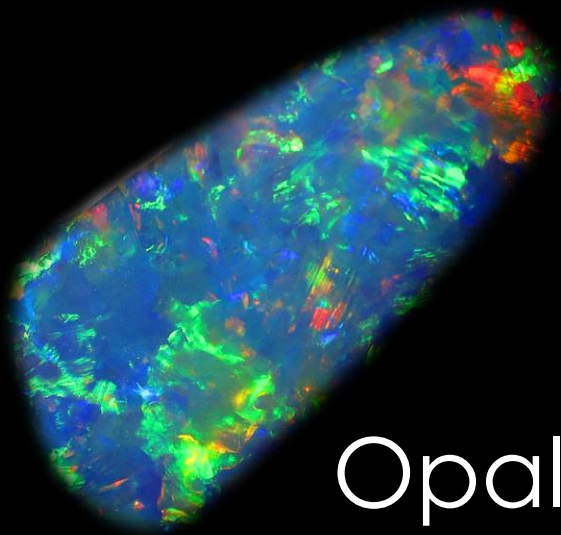
~~Shells~~



# #5

## 5 CRITERIA

The atoms that make up the substance must be arranged in an orderly structure → *crystal structure*



Opal ?



# NEW DEFINITION

A mineral is an element or chemical compound that is normally crystalline and that has been formed as a result of geological processes.

# WHAT IS A CRYSTAL STRUCTURE?

- A crystal structure consists of atoms, molecules, or ions that are arranged in an ordered repeating pattern that extends in three dimensions.



# ALL THE PHYSICAL PROPERTIES OF A MINERAL...

Hardness



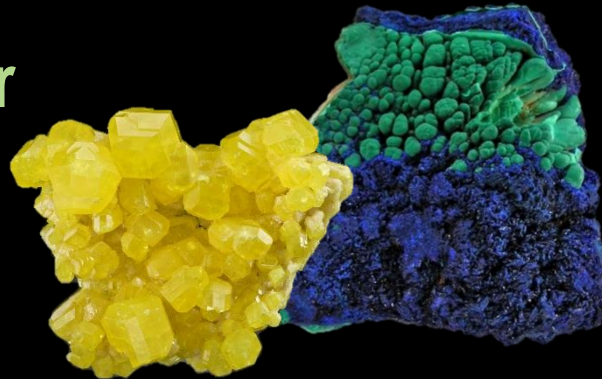
Breaking pattern



Crystal shape



Colour



...RESULTS FROM ITS INTERNAL ARRANGEMENT OF ATOMS → ITS CRYSTAL STRUCTURE.

A person wearing a red jacket, black pants, and a yellow helmet is climbing a large, complex ice formation. The ice is composed of many sharp, angular, and translucent crystals, creating a highly textured and reflective surface. The person is positioned in the lower right quadrant of the frame, leaning forward and reaching out with their hands to grip the ice. The background is filled with more of these ice crystals, some of which are illuminated by a light source, creating bright highlights and deep shadows. In the upper left corner, there is a graphic element consisting of several red squares of varying sizes and positions, with the word 'Wel' written in white text above them.

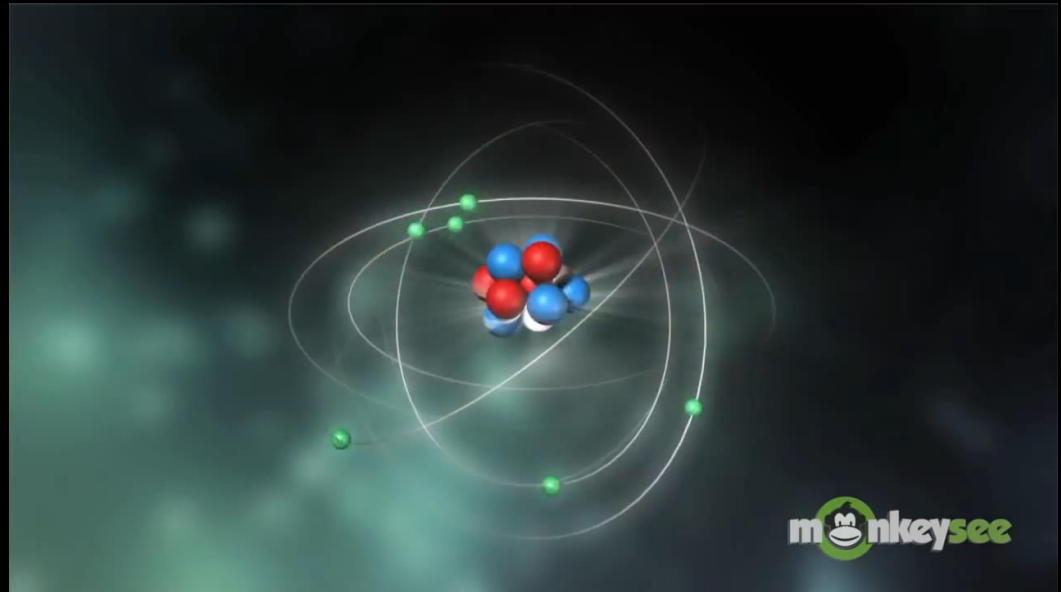
Wel

Crystallography is the science looks at crystal structures and examines the arrangement of atoms in solids

# WHAT ARE ATOMS?

*Atoms* are the basic building blocks of matter that make up everyday objects. They usually consist of

- nucleus
  - containing electrically neutral **neutrons**
  - and positively charged **protons**
- cloud of negatively charged **electrons**.



# WHAT ARE CHEMICAL BONDS?

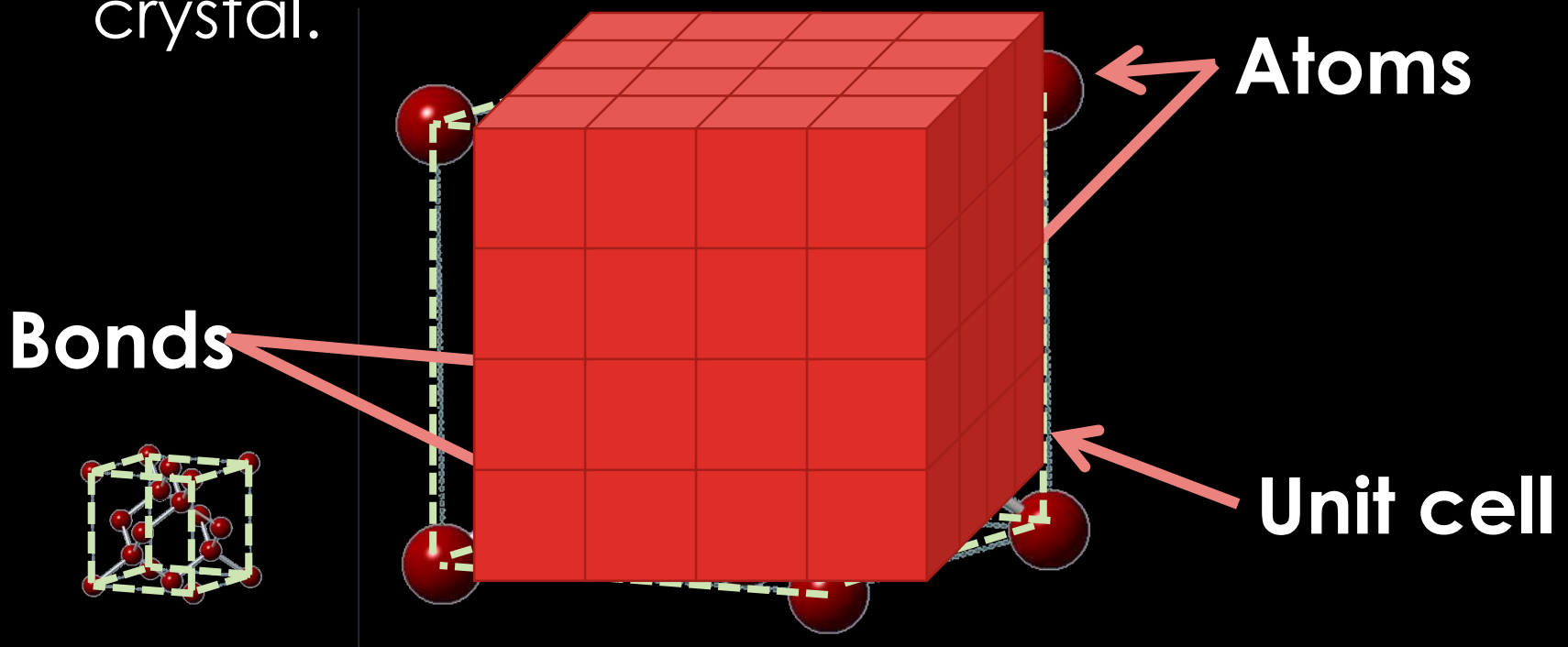
A **chemical bond** is an **attraction between atoms** that allows the formation of chemical substances that contain two or more atoms.



# WHAT ARE CHEMICAL BONDS?

# WHAT IS A CRYSTAL STRUCTURE?

- A **crystal structure** is composed of a **unit cell** that contains a set of atoms arranged in a particular way. The unit cell is periodically repeated in three dimensions to form the crystal.





# HOW BIG ARE ATOMS?

How many atoms or ions  
can we fit into 1 grain of  
salt?

**1.2 quintillion**

**1200**

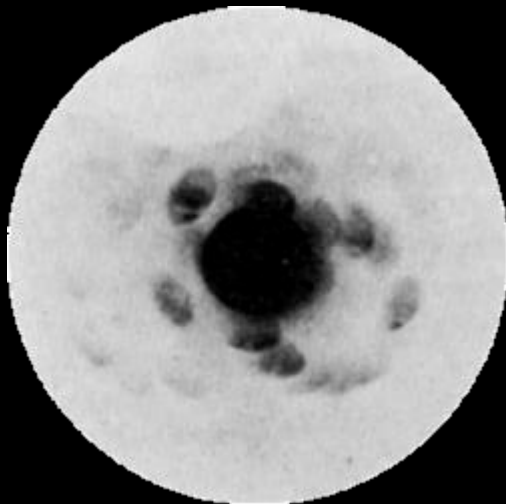
**quadrillion**

1 2000000000000000000



# HOW CAN WE SEE A CRYSTAL STRUCTURE

- No Microscope for that
- Scientists beam X-rays onto molecules (idea from Max von Laue)
  - Molecules, atoms or ions scatter the rays, just as light is reflected when it hits any object
  - Shattered rays (diffraction) are collected either on film or by a computer
- Sample needs to be large enough to give any results



Very first X-ray image of a Copper sulfate crystal

# A SHORT HISTORY OF CRYSTALLOGRAPHY

**Celebrating  
Crystallography**

*Bragg Centenary 1913 - 2013*





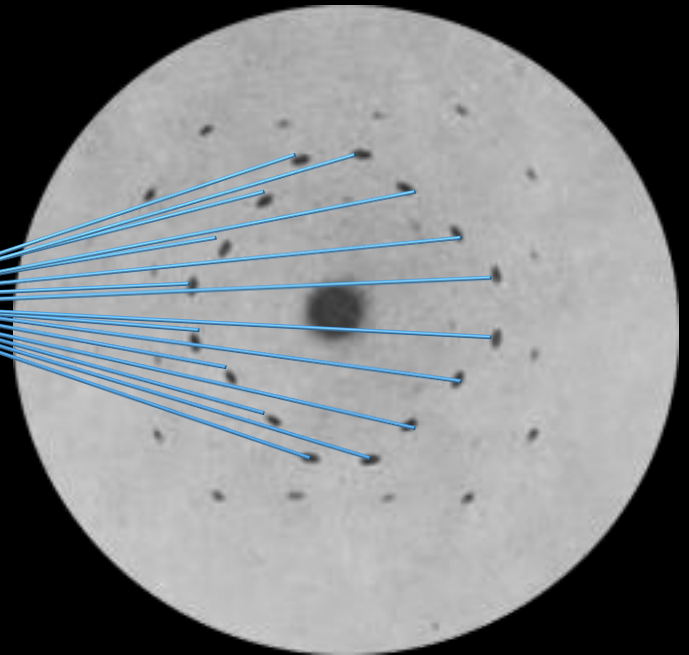
PROBLEM: WE FOUND  
CRYSTALS AND WANT TO FIND  
OUT WHAT IT IS!

# HOW CAN WE SEE THE CRYSTAL STRUCTURE? STEP 1

- We mount our crystal and shoot X-rays on it.



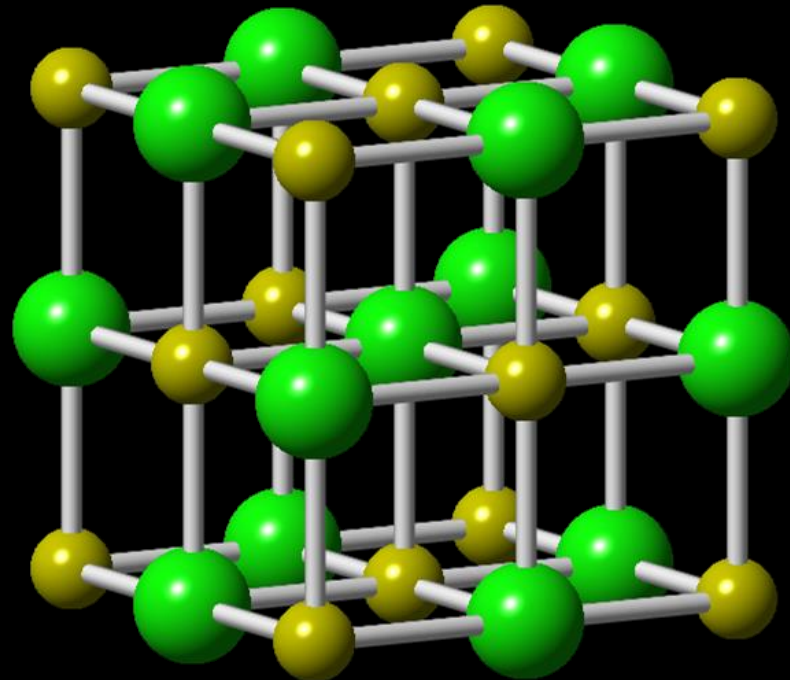
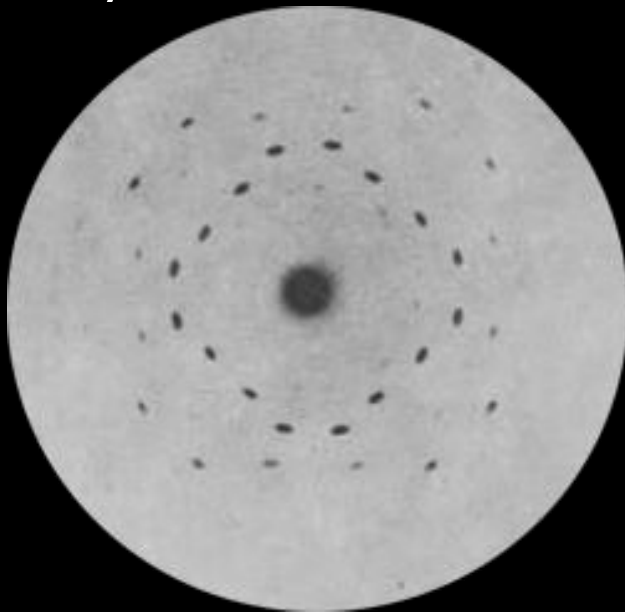
X-Rays



- This is how the X-ray pattern of that crystal looks like in one direction.

# HOW CAN WE SEE THE CRYSTAL STRUCTURE? STEP 2

- From the positions and intensities of the spots in the diffraction pattern, we can determine the 3D structure of our unknown crystal



# HOW CAN WE SEE THE CRYSTAL STRUCTURE? STEP 3

We have done the X-ray analysis and we found out positions the atoms in the crystal structure have. Now

- Rebuild the structure
- Compare the structure of your crystal to the crystal structure of other crystals/minerals on the table.
- Can you identify your crystal?

