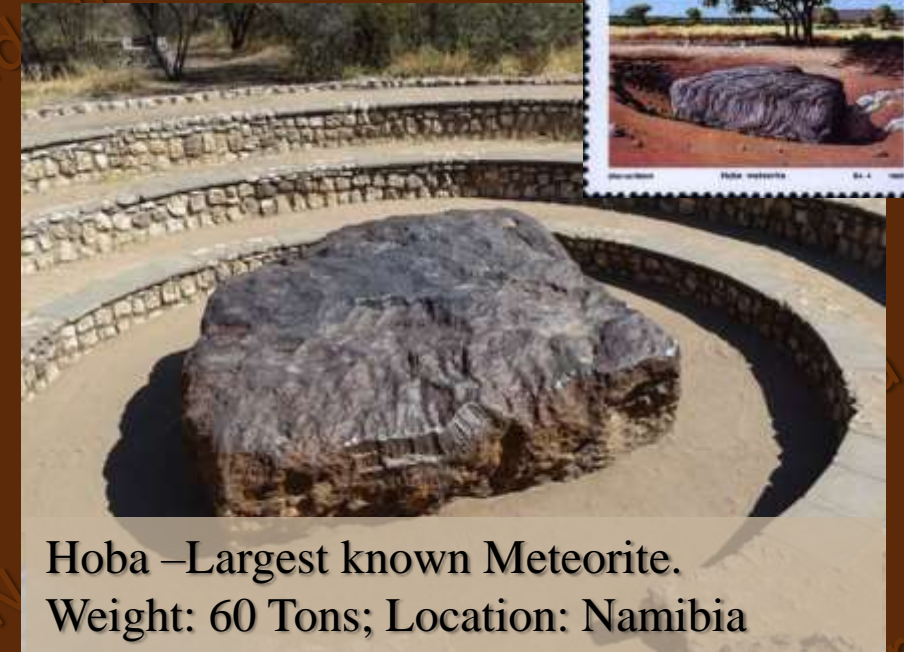


# Summary of the Last Lecture

- ❑ Falling stones from the sky
  - Asteroid fragments (Why?)
  - Space junk (manmade satellites)
  - A comet\* ?
- ❑ Meteorites
  - Specimens of solar system history
  - Free samples from far off planetary bodies
  - What are we surrounded with? What material is likely going to hit us?
- ❑ Asteroids (Rocky)
  - Belt between Mars – Jupiter
  - Trojans – Jupiter orbit
  - Potential mineral resources (Metal Asteroids)
- ❑ Comets (Icy)



- ❑ Asteroid: An extinct comet ?
- ❑ Clues: Altered minerals

\* Want to know how cometary impacts could happen? And what could be the consequences?  
Mention it in your 'feedback' and I can bring it for discussion. Fall 2023/ ESO213 / IIT Kanpur / Deepak Dhingra

# NEOs & Planetary Defense

It happened this year!

- ❑ NEO – Near Earth Objects
  - *Comets & Asteroids* (~meters – 40 km)
  - *Earth-crossing orbits*
- ❑ Potentially hazardous asteroids
  - >140 meters
  - Within 7.5 million km of Earth's orbit



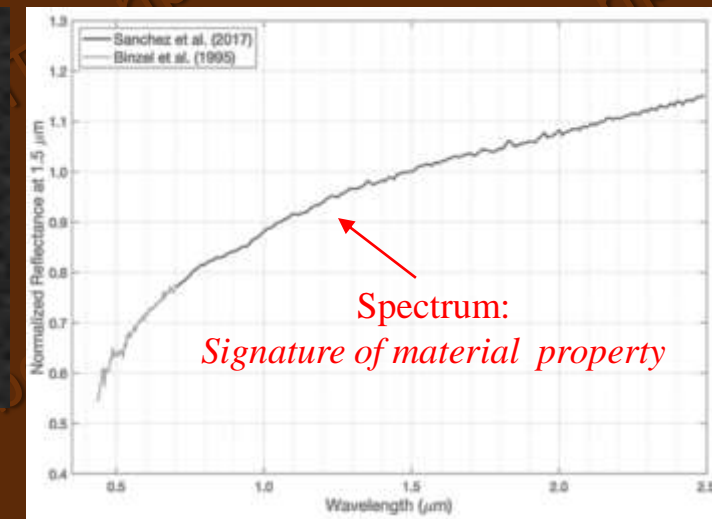
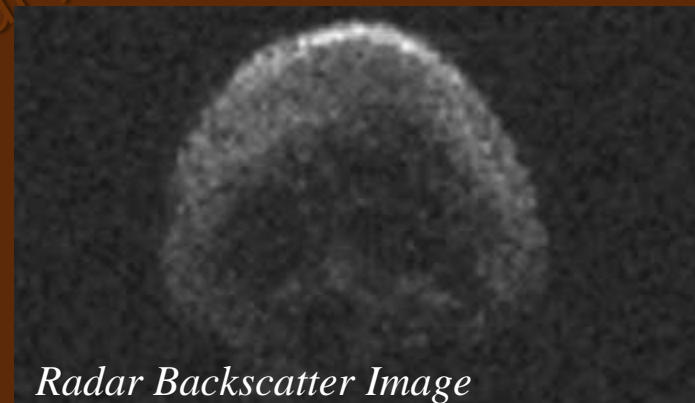
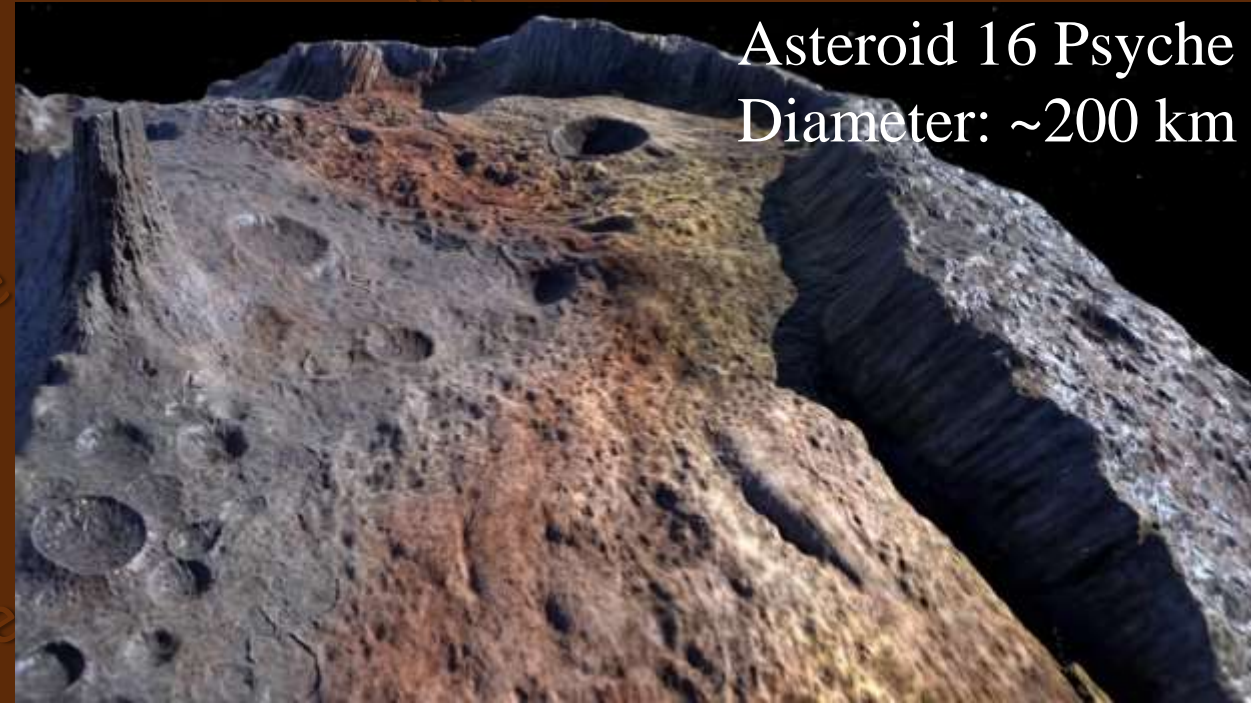
(Credit: NASA)



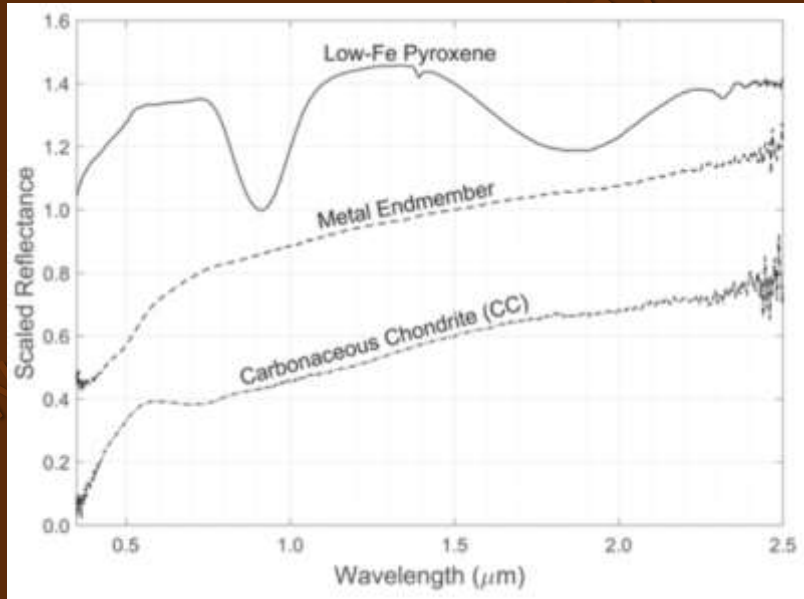


# Metal Asteroids: How do we know?

- ❑ How do we know the material properties of far-off bodies without going there?
- ❑ Remote Sensing – Collecting information from a distance
- ❑ Observations in the electromagnetic spectrum provide key information
- ❑ Radar observations
- ❑ Visible - Near IR observations

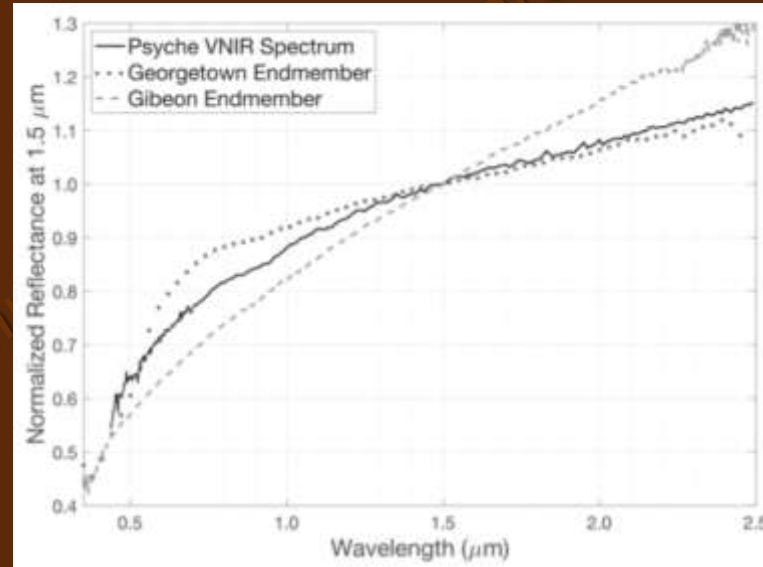


# Metal Asteroids: How do we know?



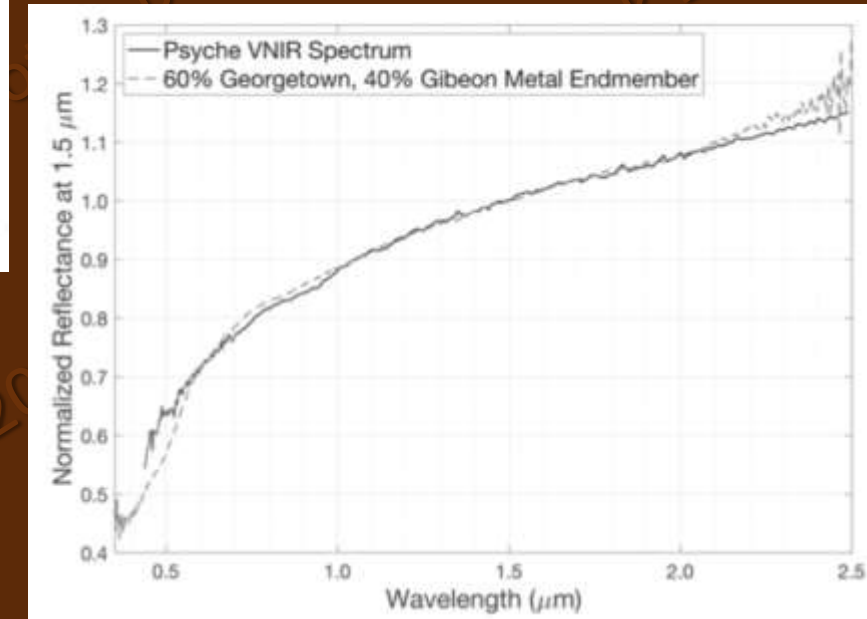
## Vis-NIR Spectroscopy

What are the possibilities?



Closest match

*Radiation interaction with matter*



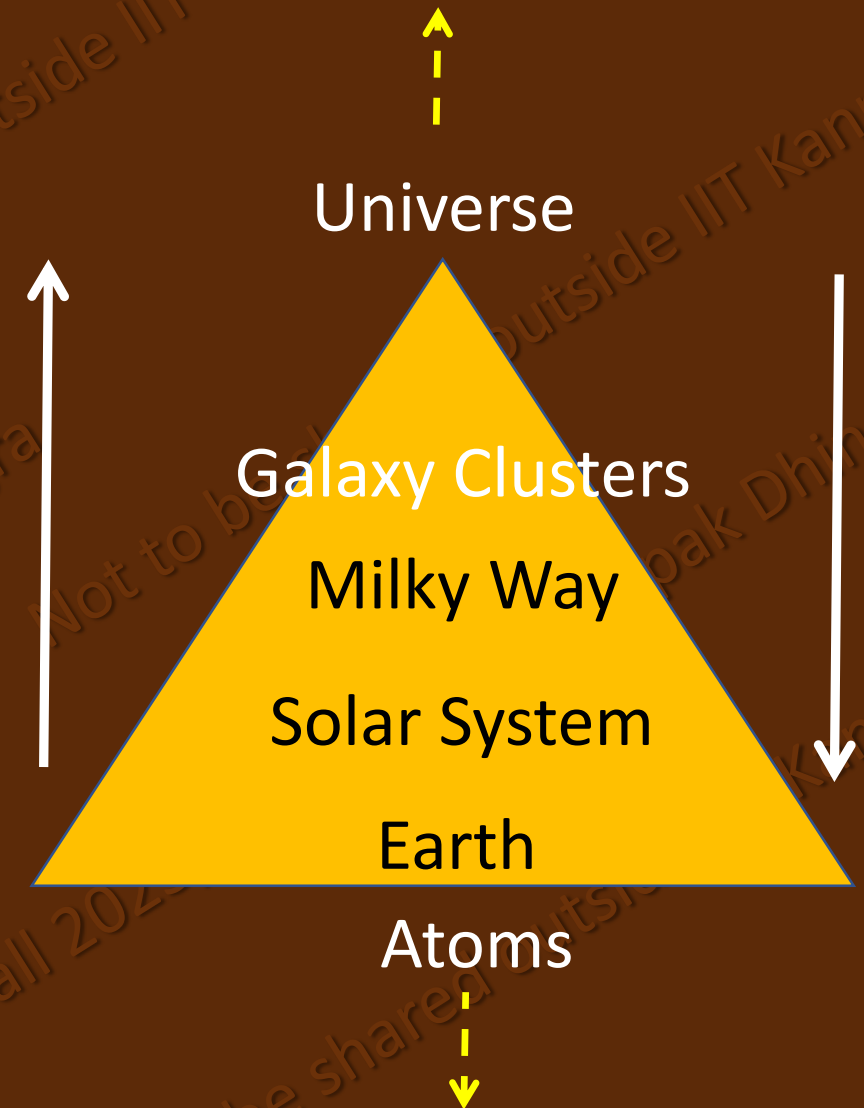
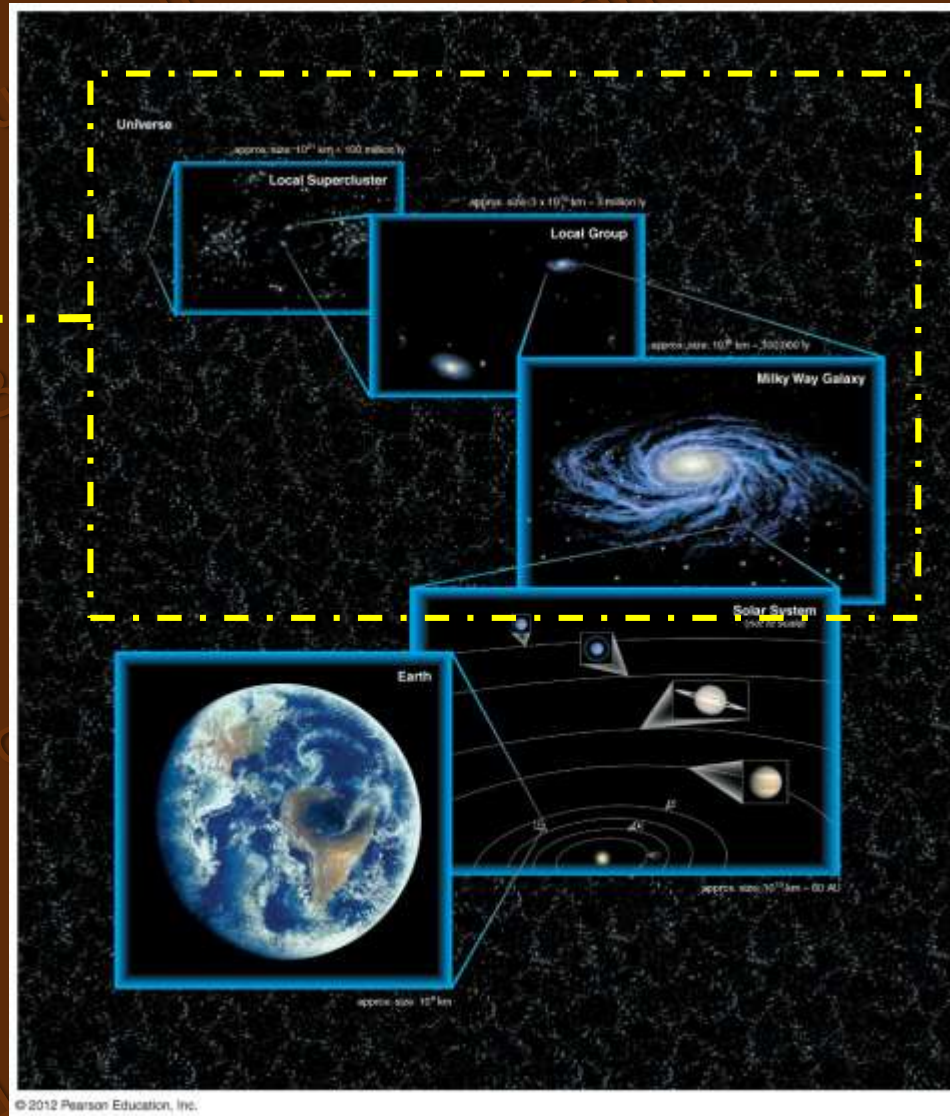
Modeled match

# End of the Tour of Solar System

- ❑ Some other time...
  - *Rings of planetary bodies*
  - *Kuiper belt objects (KBOs)*



# The Bigger Picture: Components of Our Universe



Want this part (or any specific topics) to be covered in the lectures?

*Mention it in the feedback*

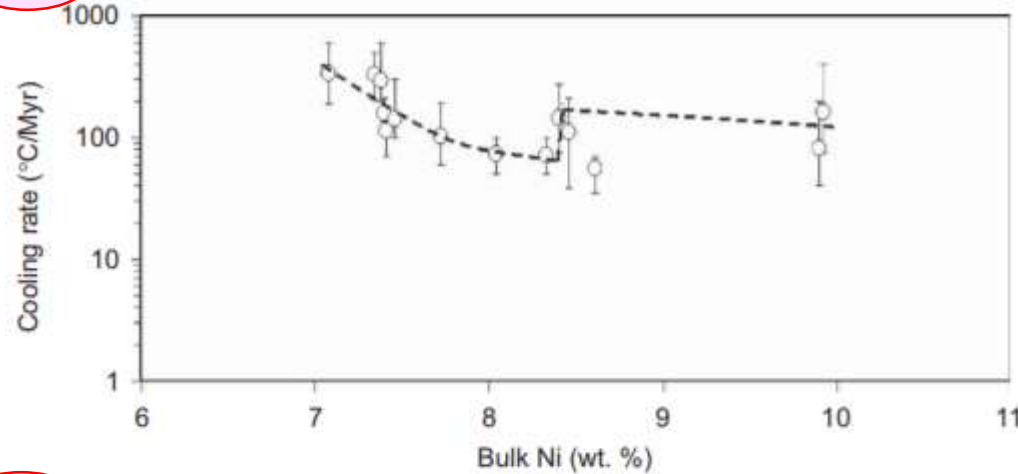
# Rocks & Minerals

## *The Foundation of Earth Science*

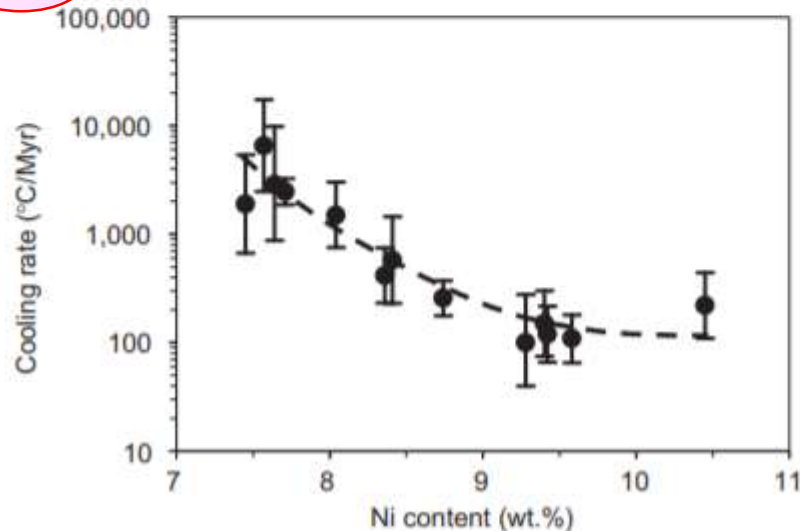
# Reconstructing Geological Conditions

Iron Meteorite Varieties

IIIAB



IVA



- ❑ Planetary cores?
- ❑ Cooling rates derived from studies of Widmanstätten patterns and profiling
- ❑ 100 — 10,000 °C / Myr
- ❑ Extreme diversity in cooling rates
- ❑ Extremely slow cooling rates will be achievable only with thick insulation.
- ❑ Rapid cooling rates indicate little or no insulation.

(Goldstein et al., 2009)



# Minerals in Iron Meteorites



Widmanstätten pattern

**Kamacite**  
(*High Ni Fe-Ni Alloy*)

**Taenite**  
(*High Fe Fe-Ni Alloy*)

# The science of minerals, rocks...



- ❑ What mineral properties do you see here?
- ❑ Try defining the properties.

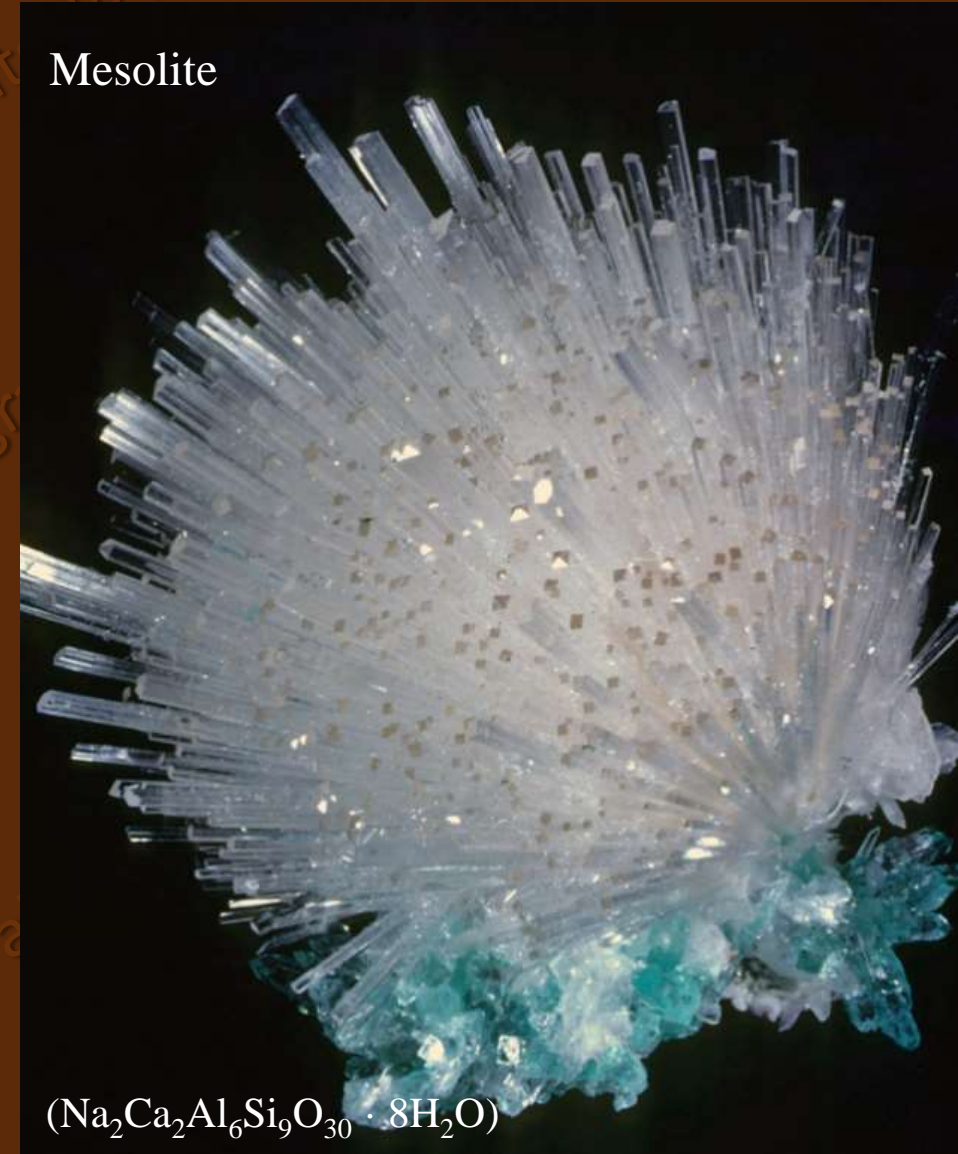




# What is a Mineral ?

- ❑ Naturally-occurring solid
- ❑ Organic/Inorganic Material
- ❑ Fixed range of chemical composition
- ❑ Long range of internal order

Mesolite



(Credit: <https://www.mindat.org/gl/2003>)