## WATER IN ASTEROIDS

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Introduction

- 1. Introduction to asteroids
- 2. What are hydrated minerals and how they differ from water
- 3. Water in asteroids
- 4. Detection methods
- 5. Earth's water reservoirs
- 6. Conclusions
- Sources



- Water acts as an solvent for a carbon based life.
- Earth has water reservoirs on top of the crust but also in the mantle and core.
- Asteroids contain water and/or hydrated minerals.
- Asteroid collisions could be the source of Earth's water.



### 1. INTRODUCTION TO ASTEROIDS (1/4)

- Fairly new branch of science.
- Leftovers from the same matter planets grew from.
- First asteroid was found in 1801.
- Did not fit in with any of the previously found celestial objects stars, planets and comets.
- Rocky, icy, metallic bodies without an atmosphere.



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### 1. INTRODUCTION TO ASTEROIDS (2/4) CLASSIFICATION

- Classified in to groups by observed spectra and meteorite analogs
- Bus-DeMeo taxonomy is based on the spectral properties of the mineralogy of the asteroid
- Meteorites are broken pieces of parent asteroids and can be connected to the parent body

Bus-DeMeo Taxonomy Key S-Complex  $s_1 = s_2 = s_3 = s_4 = s_7 = s_7$ C-Complex  $B \_ C \_ Cb \_ Cg \_ Cgh$ X-Complex End Members  $D \swarrow K \swarrow L \swarrow T \checkmark$   $A \swarrow Q \swarrow R \swarrow V \checkmark V$ 

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### 1. INTRODUCTION TO ASTEROIDS (3/4) PROPERTIES

- Sizes of asteroids can vary from an object with the diameter of only 10 km to an object with a diameter of 350 km.
- Densities depend on the composition of the asteroid.
- Shapes can vary from irregular to a sphere.
- Have experienced strong differentiation during their lifetime.



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### 1. INTRODUCTION TO ASTEROIDS (4/5) LOCATION AND ORBITS IN THE SOLAR SYSTEM



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### 1. INTRODUCTION TO ASTEROIDS (5/5) LOCATION AND ORBITS IN THE SOLAR SYSTEM



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### 2. WHAT ARE HYDRATED MINERALS AND HOW THEY DIFFER FROM WATER (1/2)

- Water is composed of two hydrogen and one oxygen atoms.
- Hydrated minerals are minerals that contain either water or both hydrogen and oxygen atoms as HO form.
- These minerals are called hydroxyl bearing minerals or hydrated minerals.



# 2. WHAT HYDRATED MINERALS AND HOW THEY DIFFER FROM WATER (2/2)

- Minerals that do not contain water are anhydrous
- Anhydrous minerals can become hydrated if they come in contact with water.
- Important to note especially in sample return missions.

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### 3. WATER IN ASTEROIDS (1/2)

- Due to aqueous alteration, water has changed the original mineralogical composition of the asteroid.
- Asteroids have gotten their water reservoirs from the solar nebula while accretion processes.
- Observing water in asteroids can explain the heating processes in the young solar system bodies.

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### 3. WATER IN ASTEROIDS (1/2)

- Water has strong absorption features in visible and IRbands.
- The degree of aqueous alteration in asteroids and other small bodies depend on their location in the solar system.
- Asteroids close to the snowline have sustained more aqueous alteration than asteroids beyond it.
- First hydrated asteroids could have become anhydrated during alteration processes → thus aqueous alteration can be seen on the insides of the object.



### **4.DETECTING METHODS** WHY ASTEROIDS ARE OBSERVED

- Asteroids are observed due to various reasons
  - 1. Hazardous NEOs / NEAs
  - 2. Knowledge on the evolution processes in the solar system
  - 3. Possibility of mining minerals





- Spectral observations mostly in visible and mid-IR regions.
- Only observes the surface of the asteroid.
- Space weathering effects.
- Atmosphere and distance from the observed object.

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### **4. SPACE MISSIONS**

- Flyby or sample return missions.
- Flyby missions pose the same problems as telescope observations.
- Sample return missions expensive and difficult but if succeed give the best data.



- Broken parts of parent asteroid.
- Sustain differentiation during the trip to Earth.
- Can be connected to a group of asteroids.
- Already on Earth.



- Water covers 71 percent of Earth's surface and is the precondition for the formation of life.
- Water is also found in Earth's mantle and core.
- Earth's core holds up 60 percent of Earth's hydrogen which oxidized easily to form water or hydrated minerals.
- The origin of Earth's water is still unknown.



- Asteroid collisions could explain the large amount of surface water on Earth.
- Earth grew about 60 percent of its mass before colliding with another planet Theia.
- This collision grew Earth's mass to around its current mass.
- This collision could have brought water on Earth.



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- All of Earth's water is probably not from asteroid collisions but most likely the surface water is.
- Earth got large amounts of water from the accretion of the icy planetesimals which melted and aqueously altered Earth.
- Studying asteroids is still a great way to gain knowledge on the alteration processes that happened during the formation of the planets and other objects.



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The Palermo Circle telescope which Giuseppe Piazzi used to discover the first found asteroid Ceres. https://w.wiki/BWWg

Distance between small-body objects locations in the solar system(not on scale). ESA (acknowledgement: work performed by ATG under contract to ESA

The changes in the giant planetary orbits and planetesimals. The dark blue orbit is Neptune, light blue Uranus, orange Saturn and green Jupiter. en:User:AstroMark, CC BY-SA 3.0 <a href="https://creativecommons.org/licenses/by-sa/3.0">https://creativecommons.org/licenses/by-sa/3.0</a>, via Wikimedia Commons

Spectral classes in the Bus-DeMeo taxonomy DeMeo et al. (2009)

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### Thank you for listening.

### Any questions?

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