eur PLANET

Ganymede

Overview

Age Range:

10-14

Lesson Time:

45 Minutes (including 1 video)

Equipment Needed:

Computer

Projector

Topics Covered:

Chemistry

Physics

Geological processes

Biology (Life in extremes)

Astronomy

Activity Outline

Understand magnetism and how aurorae form on both Earth and Ganymede.

Learning Outcomes

After completing this activity, pupils will understand

- Why some moons and planets have magnetic fields
- How craters can be used to date geological surfaces
- What causes aurorae

Europlanet 2024 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

Background Material:

Slide 1 – Lesson Introduction	In this lesson, we will be focusing on Jupiter's moon Ganymede, the largest moon in the Solar System and the only known moon with a magnetic field.
Slide 2 - Objectives	Can be seen above in Learning Outcomes.
Slide 3 – Introduction to Ganymede	Jupiter's moon, Ganymede, is the largest known moon in our Solar System. With a diameter of 5268 kilometres, it's almost 10% bigger than Mercury. Like its sister Galilean moon, Europa, Ganymede has an icy crust covering a very deep subsurface ocean. Earth's oceans are on average about 4 kilometres deep and the deepest point, the Mariana Trench, reaches 11 kilometres below the surface. Ganymede's ocean is thought to be ten times deeper (around 100 kilometres) and is buried under a 150-kilometre crust of ice. Ganymede is also unique in that it is the only known moon with a magnetic field.
Slide 4 – Ganymede's structure	Unlike super-smooth Europa, Ganymede's surface shows evidence of mountains, valleys and craters. Around 40% of the surface is covered by geologically old, dark regions, with multiple impact craters – some of which date back 4 billion years to the very early Solar System! The remaining 60% of the surface is covered by brighter, more reflective terrain that has experienced more recent geological activity (e.g. cracking, deformation or resurfacing). This younger terrain has a lower number of craters, since it has had less time to experience impacts. The Hubble Space Telescope detected ozone at Ganymede, suggesting that there is a thin atmosphere of oxygen caused by the interaction of charged particles from Jupiter's radiation belts with water molecules in the moon's icy surface. There are still many questions about Ganymede's surface and interior geology. Observations by missions and telescopes to date suggest that Ganymede has a metallic iron core, surrounded by a shell of silicate rock, beneath the global ocean and icy crust. The European Space Agency (ESA) JUICE mission, which will perform flybys and eventually orbit Ganymede, has a suite of instruments to study the moon's structure. However, Ganymede will not be a major target for future astrobiology missions. At the bottom of the ocean there is thought to be a layer of ice that would prevent chemical nutrients from entering the moon's ocean from the rocky shell below. This means that, unlike at Europa or Enceladus, very limited chemical reactions would be able take place to form the complex molecules needed for life. There is also no indication of an energy source to warm the oceans to habitable temperatures, unlike Europa and Enceladus which have hydrothermal vents.

Europlanet 2024 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

Slide 5 – Introduction to planetary magnetism	Some rocky planetary bodies, including Earth, Mercury and Ganymede, generate magnetic fields. Magnetism is a physical phenomenon, produced by the motion of an electric charge, which results in attractive and repulsive forces between objects made of magnetic materials (such as iron). In planetary bodies, magnetic fields are generated by the interaction of an internal moving (convecting) magnetic material, such as molten rock or metal, and the rotation of the planetary body. This results in a constantly moving electrical current, which produces a magnetosphere.
Slide 6 – Magnetic fields on Ganymede	The discovery of a magnetic field at Ganymede (by the Galileo spacecraft in 1996) was a surprise – at such a distance from the Sun, its core was expected to have cooled down to a solid mass, prohibiting the flow of electrons needed to produce a magnetic field. The presence of a magnetic field on Ganymede is thought to be due to tidal heating that results from the moon's non-circular orbit around Jupiter. This heating ensures the iron core remains molten. Convection within the core, combined with the rotation of Ganymede, produces a magnetic dynamo. The magnetic field of Ganymede is small in comparison to Jupiter's enormous magnetic field, but it is strong enough to carve out defined boundaries of a distinct magnetosphere.
Slide 7 – Video	Here we have a video which demonstrates magnetic flux lines: https://www.youtube.com/watch?v=9Iehu09czvw *Video background information: In this video, we have placed a large neodymium magnet beneath this blank canvas. The canvas is wrapped in plastic in order to produce the coefficient of friction. Iron powder is sprinkled across the canvas and is being affected by the magnetic field of the neodymium. This allows a visual representation of the magnetic fields around celestial bodies, like Ganymede and even planet Earth.*
Slide 8 – Introduction to aurorae	One clear sign of a magnetic field on Ganymede is the presence of aurorae around its north and south poles. Aurorae are spectacular ribbons of light that decorate the skies, caused by interactions of electrically charged particles. The aurorae seen on Earth, the Northern Lights and Aurora Borealis, are caused by energy released during collisions of energised particles emitted by the Sun with atoms of oxygen and nitrogen in the Earth's atmosphere.
Slide 9 – Aurorae at Jupiter	Jupiter's intense magnetic field, which is 20,000 times stronger than that of Earth, creates the most powerful aurorae in the Solar System. While Earth's aurorae are transient and only occur when solar activity is intense, aurorae at Jupiter are permanent and have a variable intensity. Jupiter's aurorae are caused by electrically charged sulphur and oxygen ions spewed out of Jupiter's volcanic moon Io Jupiter's auroral light shows also include X-ray flares that occur every 27

Europlanet 2024 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

	minutes. These are caused by vibrations in the planet's magnetic field lines, which create waves of plasma (ionised gas) that shoot heavy ion particles along magnetic field lines until they smash into the planet's atmosphere, releasing energy in the form of X-rays.
Slide 10 – Aurorae at Ganymede	Interactions of charged particles, caught in the interplay of the magnetospheres of Ganymede and Jupiter, also produce auroral belts around Ganymede's poles. These aurorae rock back and forwards during Ganymede's orbit due to fluctuations in the magnetic field of Jupiter and the behaviour of Ganymede's subsurface ocean. Thus, the oscillation of Ganymede's aurorae can give clues about the moon's interior and ocean, where the moon's magnetic field is generated.
Slide 11 – Review	From this lesson, students should be able to: ● Understand magnetism and the magnetic field of Ganymede ● Understand how craters can be used to date geological surfaces ● Understand the formation of aurorae.

Sources

For more information, see the following sources:

Ganymede in Depth (NASA): https://solarsystem.nasa.gov/moons/jupiter-moons/ganymede/in-depth/

Juice Mission (ESA): https://www.esa.int/Science_Exploration/Space_Science/Juice

Europlanet 2024 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.