

## Today's Class: Venus & Climate Change

- Reading for next class on *Jupiter and Its Waterworld moons* – Chapter 11, Sections 11.1-11.2 in *Cosmic Perspective*.
- Homework #5 due by 5 pm today. Please send via E-mail.



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A new mineral from the Moon could explain what happens in the Earth's mantle  
**Addison Swindell**

- New mineral **donwilhelmsite** discovered by European researchers in lunar meteorite
- First high-pressure mineral found in meteorites, compositionally similar to continental crust
- Continental crust is subducted into the mantle where its minerals transform under high temperature and pressure conditions
- **Donwilhelmsite** mirrors minerals that only exist in the mantle



Based on this discovery, should lunar geology take a "front seat" in the upcoming Artemis missions? Should Artemis astronauts receive more extensive geological training before their missions?

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## Last Class

- **Venus**
  - Interior
  - Cratering
  - Volcanoes
  - Tectonics
- **Spacecraft Observations of Venus**
  - Venera
  - Magellan

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## Today's Class

- The atmosphere of Venus.
- Greenhouse Effect on Venus & Earth.
- How did Earth's atmosphere end up so different from Venus?
  - Effects of water and carbon
  - Dangers of human activity

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## Atmosphere of Venus



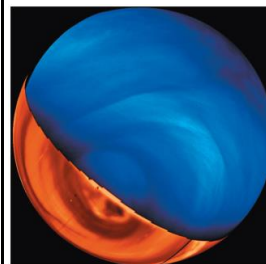
This image is a composite of a visible wavelength image of the day side (color enhanced, red-orange side) and an infrared image of the night side (blue).

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- Venus has a very thick carbon dioxide atmosphere with a surface pressure 90 times that of Earth.
- Slow rotation produces only a small amount of weather.

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## Greenhouse Effect on Venus

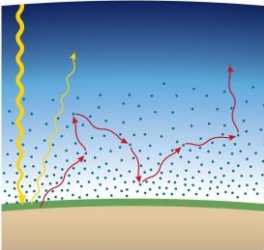


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- Thick carbon dioxide atmosphere produces an extremely strong greenhouse effect.
- Earth escapes this fate because most of its carbon and water is in rocks and oceans.

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## Greenhouse Effect

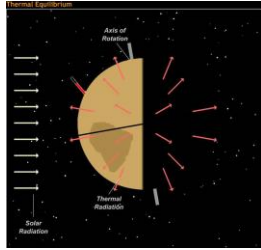


- Visible light passes through the atmosphere and warms a planet's surface.
- The atmosphere absorbs infrared light from the surface, trapping heat.

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## Planetary Temperature

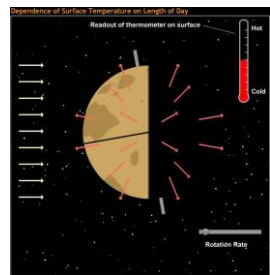


- A planet's surface temperature is determined by the balance between energy from sunlight it absorbs and energy of outgoing thermal radiation.

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## Temperature and Rotation



- A planet's rotation rate affects the temperature differences between day and night.

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## Temperature and Reflectivity

- A planet's reflectivity (or *albedo*) is the fraction of incoming sunlight it reflects.
- Planets with low albedo absorb more sunlight, leading to hotter temperatures.

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## "No Greenhouse" Temperatures

TABLE 10.2 The Greenhouse Effect on the Terrestrial Worlds

World	Average Distance from Sun (AU)	Reflectivity	"No Greenhouse" Average Surface Temperature	Actual Average Surface Temperature	Greenhouse Warming (actual temperature minus "no greenhouse" temperature)
Mercury	0.387	12%	163°C	day: 425°C night: -175°C	—
Venus	0.723	75%	-40°C	470°C	510°C
Earth	1.00	29%	-16°C	15°C	31°C
Moon	1.00	12%	-2°C	day: 125°C night: -175°C	—
Mars	1.524	16%	-56°C	-30°C	6°C

\*The "no greenhouse" temperature is calculated by assuming no change to the atmosphere other than lack of greenhouse warming. For example, Venus has a lower "no greenhouse" temperature than Earth even though it is closer to the Sun, because the high reflectivity of its bright clouds means that it absorbs less sunlight than Earth.


- Venus would be 510°C colder without greenhouse effect.
- Earth would be 31°C colder (below freezing on average).

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## Class Exercise

Venus is nearly the twin of Earth in terms of size, gravity, and density. So, why do you think the surface conditions on Venus are so harsh relative to Earth?



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## How did Venus get so hot?



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## Runaway Greenhouse Effect

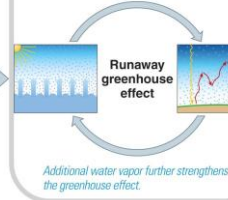
If Earth moved to Venus's orbit

More intense sunlight...

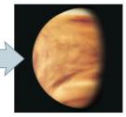


...would raise surface temperature by about 30°C.

Higher temperature increases evaporation, and warmer air holds more water vapor.



Result: Oceans evaporate and carbonate rocks decompose, releasing CO<sub>2</sub>...



...making Earth hotter than Venus.

- A runaway greenhouse effect would account for why Venus has so little water.

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## How did Earth's atmosphere end up so different?

Earth



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## Earth's Water and CO<sub>2</sub>

Earth



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- Earth's temperature remained cool enough for liquid oceans to form.
- Oceans dissolve atmospheric CO<sub>2</sub>, enabling carbon to be trapped in rocks.

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## Dangers of Human Activity

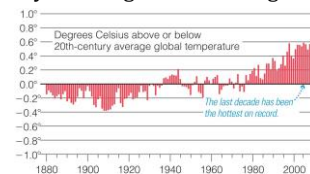
- Human-made **Chlorofluorocarbons** (carbon, flourine, chlorine) in the atmosphere destroy ozone, reducing protection from ultraviolet radiation.
- Human activity is driving many species to extinction.
- Human use of fossil fuels produces greenhouse gases that can cause global warming.

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## Global Warming

- Earth's average temperature has increased by 0.5 C in past 50 years.
- The concentration of CO<sub>2</sub> is rising rapidly.
- An unchecked rise in greenhouse gases will eventually lead to global warming.



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