Europa

And the Moons of Jupiter
Venus

- Near the inner edge of the Solar habitable zone
- Runaway greenhouse effect makes planet too hot to be inhabitable
Earth

• Outside the unmodified Solar habitable zone

• Habitable because of a mild greenhouse effect

• Only planet with liquid surface water
Mars

- Outside the unmodified Solar habitable zone
- Uninhabitable: too small to retain sufficient atmosphere for a greenhouse effect to operate
- May have subsurface water ice
Other Types of Habitable Zones

Water requires heat and pressure to remain stable as a liquid.
The Moons of Jupiter

Ganymede  Callisto  Io  Europa

The 4 Galilean moons; there are 59 others
Discovery of the Galilean Satellites
The size of Luna

Sulfur surface produces the orange, yellow, and black colors.
Io

• The most volcanically-active body in the solar system
• Strong tidal stresses and internal heating.
• Density close to that of Earth's moon.
• Molten silicate interior; iron core
• No large craters → surface less than 1 million years old.
Tides

• A tide is a differential gravitational force
• Gravity scales as $1/r^2$
• Tides scale as $1/r^3$
• Tidal forces generate friction, which dissipates as heat
Tidal Heating on Io

Prometheus

Loki
Ganymede

- 3rd of the Galilean satellites
- Bigger than Mercury
- Differentiated, iron core
- Complex surface
  - dark cratered regions
  - light grooved regions
- The grooved terrain:
  - 60% of the surface
  - Faulted
  - Few craters → young
Callisto

- Most distant of the Galilean satellites
- Density $\rightarrow$ rock and ice
- Moment of inertia $\rightarrow$ undifferentiated
- Tidal forces have not heated its interior.
- Heavily cratered, very old surface
Europa

• 2nd of the Galilean satellites

• Smoothest surface in SS

• Surface appears to be water ice

• Surface looks like Arctic Ocean
  • Iceberg-like structures
  • Dark lines appear to be cracks in the ice

• No craters → < 30 million year old surface
Europa

Smooth surface
- few craters
- compression ridges
- stretch fractures
Europa

Conamara Chaos - 70 x 30 km region
blue: young water ice (ejecta from crater Pwyll)
brown: mineral contaminants
Europa close-up

The surface at 1.6km resolution
Europa close-up

The surface at 26 m resolution
Europa Models

- Metallic Core
- Cold Brittle Surface Ice
- Rocky Interior
- Warm Convecting Ice
- H₂O Layer
- Liquid Ocean Under Ice
- Metallic Core
- Ice Covering
Internal Structures
All these worlds are yours ... Except Europa. Attempt no landings there.

Arthur C. Clarke, 2010: Odyssey Two