**Enceladus**

Small (~500 km diameter) moon of Saturn - orbits between Mimas and Tethys

Two distinct hemispheres:
- northern is quite heavily cratered (old)
- southern shows almost no craters across wide area

Albedo is almost 100% - icy surface must be very fresh

Enceladus orbits within, and appears to be the source of, Saturn’s faint E ring.

Ejects icy particles into the ring, some of which are later re-accreted by the satellite (note: ring particles are fully exposed to sunlight, so chemistry can happen driven by this exposure).

**Enceladus’ north pole as views by Cassini during last week’s flyby of the satellite.**

Surface of Enceladus that is devoid of craters resembles Europa - appears to have tectonic activity

Definitely a young surface, probably affected by liquid water in the same way as Europa...

**Plumes from Enceladus**

*Cassini* discovered plumes of icy material jetting from the South Pole region

Mass flow is about 100-200 kg/s

Mass of Enceladus is about $10^{20}$ kg - this much mass loss would lead to a significant reduction in the moon’s mass over the lifetime of the Solar System
Plume comes from relatively warm region (145K - still only about -130°C)

Plume contains water (in form of ice), CO₂, nitrogen and methane

Figure 2.1.3-1: False color image of 12.6 micron color temperature on Enceladus. The Cassini Composite Infrared Spectrometer (CIRS) viewing the Hot Anomalies from the warm bright uplands in the south pole region. Hot temperatures are marked white or yellow, and grey for cold areas. The dashed line is the terminator (Spencer et al. 2009).

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

One hypothesis:

- internal heat of the moon is escaping unequally, heating the southern part enough for liquid water to be stable near the surface
- crack allow high pressure water to escape, which instantly freezes

Might also be a deeper ocean, similar to Europa

Possible structure: note no direct evidence for such an ocean

Figure 2.1.3-6: Interior structure of a differentiated Enceladus (Spencer and McKinnon 2007, assuming solid composition rock, Weidenschilling and Greenberg 1989, a hollow core at equal radius, Spencer et al. 2009). An internal liquid layer may exist at the base of the ice shell.

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Mystery...

What is the source of Enceladus’ heat?

- small - would not be heated enough by radioactive decay to sustain liquid water
- tidal heating might be enough - depends upon the moon’s structure and, thus, on whether water is present (might not be in a steady state?)

Further puzzle: plumes contain gases that do not dissolve very easily in water, but there is no evidence for sodium which would be expected to be present in an ocean...

Alternative model: gas is trapped in icy material which is unstable - when pressure is released it degasses violently causing the plumes...

No liquid water is needed if this model is correct

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008

Extraterrestrial Life: Spring 2008
Astrobiology potential

If there is liquid water, conditions may be more favorable for life than Europa because the system is open to space (potentially larger energy source for chemical reactions).

Orbital velocity: \( v = \sqrt{\frac{GM}{R}} \)

…close to surface of Enceladus: \( v = 100 \text{ m/s} \)

Possible to fly gently through the plume in orbit and sample the ices to learn if chemistry or biology is underway in the water!