12.002 Physics and Chemistry of the Earth and Terrestrial Planets
Fall 2008

**Mercury**

Orbital period of 80 days

1800s first detailed telescope observations
    close to the Sun: makes telescope observations tremendously difficult

1881 - 1889 - G. Schiaparelli -- tried to map surface of Mercury, came up with this idea that the spin period of mercury is equal to the orbital period of 88 days

1962 - microwave studies of Mercury's dark hemisphere showed that it was quite hot

1964 - Gordon Pettengill (MIT) showed using radar observations that the spin period = 2/3 orbital period

Spins three times for every two orbital periods
-Mercury has two hot longitudes 180 degrees apart

Surface temperature on sunwards side is 740 K, slightly < Venus
    Dark side, 90 K
    88 days of darkness

Obliquity = 90.0 degrees due to tidal effects. Permanently shadowed regions inside a crater at the pole, temperatures 60-100 K

Hydrogen - radar bright anomaly, trapped water ice in shadowed areas

Mariner 10 only spacecraft to visit Mercury, imaged 45% of the surface
    Found lots of craters (heavily craters)
    No weathering or plate tectonics
Most of the rest of the surface recently imaged by MESSENGER spacecraft.

Two Terranes (geological term!)
    1 Highlands (4.0 - 4.2 Ga)
    2 Lowlands Plains (3.8 Ga)

Caloris Basin 1340 km wide. Second largest impact crater on terrestrial planets

Composition
    Almost no information about the composition of the crust
    -hard to do spectroscopy when near bright object (near the Sun)
    -high air mass to observe right after sunset, poor spatial resolution

Nearly featureless absorption spectra
    Possible absorption of 0.9 microns, low iron pyroxene
    Weak absorption features from 8-12 microns
        bronzite $Mg_{0.9}Fe_{0.1}SiO_3$
        albite (feldspar) $NaAlSi_3O_8$
        sodalite $Na_4Al_3Si_3O_{12}Cl$

Leading idea is that Mercury's crust is predominately plagioclase feldspar – anorthosite

Mercury also has an atmosphere….a very small one, originates from micrometeorite impacts

(Na, K), solar wind (H, He) and planetary degassing

Geophysics of Mercury

High uncompressed density predicts high Fe/FeO ratio

Assuming chondritic bulk composition predicts a core that is 75% of the radius of the planet! Matches spectroscopy data suggesting Fe-poor crust

We have showed that the gravitational energy of formation of a spherical body

$$E_g = \frac{-16}{15}\pi^2 G\rho^2 R^5$$

This represents the minimum energy of assemblage, if we neglect energy of materials assembling body.

So what is this for Mercury?

$E_g = 3 \times 10^{30}$ J

For the Earth

$E_g = 8 \times 10^{30}$ J

This energy has to be lost somehow, turned into heat:

$\Delta Q = mC_p\Delta T$

$\Delta T = \Delta Q/mC_p$

$\Delta Q = E_g = 3 \times 10^{30}$ J

Mass (mercury) = $3.3 \times 10^{23}$ kg

$Cp$ = 750 J / (k kg) (70% metal, 30% silicate )

So $\Delta T$ = 12,000 degrees C

Heat of fusion (required to go from solid to liquid state) is about equal to heat required to heat rock up to melting temperature.

This means that Mercury was initially mostly molten. Do to radiative cooling, molten zone probably was only outer few hundred km: magma ocean. Would predict a crust of anorthosite on Mercury. Predicts metallic core formation should occur nearly instantaneously, crust and mantle as well.