

29:52 Exploration of the Solar System
Class Notes for April 30, 2008
Europa: World of Ice

Take a look at the pictures of Europa from space, taken with the Voyager spacecraft. They show a world encased in water ice.

The mean density of Europa is 2.87 grams/cc; that is slightly less than rock, indicating that the moon is a mixture of ice and rock.

As is obvious from pictures of the moon, the crater density is low. This means that the surface has been “active” over the history of the moon.

Even from the Voyager pictures, one could see long cracks in surface, sometimes called “grooves” or “ridges”. The question is, what are these telling us about the present day nature of this moon?

Discoveries with the Galileo spacecraft

The Galileo spacecraft flew within a few hundred kilometers of the surface, and took pictures with high-resolution cameras. It gave high-resolution pictures of the grooves, and showed that new ones covered up, or cut through old ones. It also showed scenes which looked like water had flowed up through the cracks and flowed out onto the surrounding landscape. Many grooves show a colored stain, which might be complex organic chemicals which come from subsurface areas of liquid water.

One of the more important discoveries was that of “ice rafts”, or blocks of ice trapped in the overall ice crust. Look at Figure 14.16 of the book. Similar features are seen in the arctic and antarctic ocean. The hint seems to be that there is liquid water not far below the surface.

Age of Formation of Europa Surface Features

Since there are very few impact craters on the surface of Europa, the surface has obviously formed far more recently than 4.5 Gyr ago. The best estimate is that the surface as we see it now formed about 10 million years ago, although there appear to be places where it is younger.

The Interior Structure of Europa

From measurements of the gravitational forces on the Galileo spacecraft, as well as other measurements such as the mean density, scientists have come up with a model of the interior structure of Europa. Look at Figure 14.14 of the book, or the figure

in the powerpoint notes. The structure is believed to consist of a metal core, a rocky mantle, and an outer case of water and ice which is about 100 - 150 km thick. The best model is that the outer crust changes from ice to water at a depth of 10 - 50 km. Thus Europa probably has a moon-wide ocean with a rocky ocean floor, just like on Earth. The obvious question is whether life exists in that ocean. At the moment, we don't know.

Ancient Europa

Astrophysical models for the evolution of the planet Jupiter show that in the first several hundred million years of the solar system, it would have emitted substantial radiation to space. It would have shown like a small star. It is possible that this radiation would have heated the surface of Europa to the point where the ice crust would have melted, and the surface of Europa would have been covered with an ocean. In that case, Europa would have been a "waterworld".

Io: the innermost moon

The closest of the Galilean satellites to Jupiter is Io. Io is about the same size and mass as the Earth's moon. Being the closest to Jupiter, the tides here are the strongest, and the tides have caused strong heating of the interior of Io. This causes volcanism which is occurring at many places on the moon, all the time. The level of volcanism is sufficient intense that the appearance of Io had changed noticeably in the time between the Voyager visits to Io (late 70s) and the visit of Galileo, approximately 20 years later. The first spacecraft image of Io from Voyager showed a volcano erupting. The volcanism on Io is of hot silicate magma, just like volcanism on Earth.