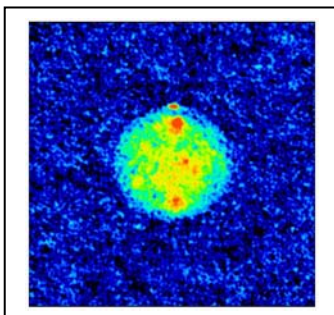# Is there Ice on Mercury ?

The NASA MESSENGER spacecraft performed its first flyby of Mercury on January 14, 2008. In addition to mapping the entire surface of this planet, one of its goals is to shed new light on the existence of ice under the polar regions of this hot planet. Ice on Mercury? It's not as strange as it seems!

In 1991, Duane Muhleman and her colleagues from Caltech and the Jet Propulsion Laboratory, created the first radar map of Mercury. The image, shown here, contained a stunning surprise. The bright red dot at the top of the image indicates strong radar reflection at Mercury's North Pole, resembling the strong radar echo seen from the ice-rich polar caps of Mars.

Delay-Doppler image of Mercury by John Harmon, National Astronomy and Ionosphere Center, Arecibo Observatory, Puerto Rico.

In 1999, astronomer John Harmon at the Arecibo Observatory in Puerto Rico, repeated the 1991 study, this time using the powerful microwave beam of the Arecibo Radio Telescope. The microwave energy reflected from mercury and was detected by the VLA radio telescope array in New Mexico, where a new image was made.

The radio-wavelength image to the left shows Mercury's North Polar Region at very high resolution. The image is 370 kilometers wide by 400 kilometers tall.

All the bright features are believed to be deposits of frozen water ice, at least several meters thick in the permanently shaded floors of the craters.

Reference: Harmon, Perillat and Slade, 2001, Icarus, vol 149, p.1-15

Problem 1 - From the information provided in the essay, what is the scale of the image in kilometers per millimeter?

Problem 2 - Measure the diameters of the craters, in kilometers, and estimate the total surface area covered by the large white patches in A) square kilometers and B) square meters.

Problem 3 - Suppose the icy deposit is mixed into the Mercurian surface to a depth of 10 meters. What is the total volume of the ice within the craters you measured in cubic meters?

Problem 4 - Suppose half of the volume is taken up by rock. What is the total remaining volume of ice?

Problem 5 - The density of ice is 917 kilograms/cubic meter. How many kilograms of ice are present?

Problem 6 - If this ice were 100% water ice, and 3.8 kilograms of water equals 1.0 gallons, how many gallons of water might be locked up in the shadowed craters of Mercury?

Answer Key:

Problem 1 - From the information provided in the essay, what is the scale of the image in kilometers per millimeter?

Answer; The image is 370 kilometers wide by 400 kilometers tall. The image is 95 millimeters wide by 104 millimeters tall. The scale is therefore about **4.0 kilometers / millimeter.**

Problem 2 - Measure the diameters of the craters, in kilometers, and estimate the total surface area covered by the large white patches in A) square kilometers and B) square meters.

Answer: Students should measure the diameters of at least the 5 large craters that form the row slanted upwards from right to left through the center of the image. Their diameters are about 90 km, 40 km, 30 km, 20 km and 25 km. The area of a circle is πR^2, so the crater areas are 6,400 km^2, 700 km^2, 314 km^2 and 490 km^2. The total area A) in square kilometers is about **7,900 km^2** or B) 7,900 x (1000 m/km) x (1000 m/km) = **7.9 x 10^9 meters^2**. Students may reasonably ask how to estimate the area of partially-filled craters such as the largest one in the image .They may use appropriate percentage estimates. For example, the largest crater is about 1/2 filled (white color in image) so its area can be represented as 6,400 x 0.5 = 3,200 km^2.

Problem 3 - Suppose the icy deposit is mixed into the Mercurian surface to a depth of 10 meters. What is the total volume of the ice within the craters you measured?

Answer: Volume = surface area x height = 7.9 x 10^9 meters^2 x 10 meters = 7.9 x 10^{10} meters^2.

Problem 4 - Suppose half of the volume is taken up by rock. What is the total remaining volume of ice?

Answer; 7.9 x 10^{10} meters^2 x 0.5 = **8.0 x 10^{10} meters^2**

Problem 5 - The density of ice is 917 kilograms/cubic meter how many kilograms of ice are present?

Answer: 8.0 x 10^{10} meters^2 x 917 kg/meters^3 = **7.3 x 10^{13} kilograms**

Problem 6 - If this ice were 100% water ice, and 3.8 kilogram of water equals 1.0 gallons, how many gallons of water might be locked up in the shadowed craters of Mercury?

Answer: 7.3 x 10^{13} kilograms / 3.8 kg/gallon = **1.9 x 10^{13} gallons or 19 trillion gallons!**