
Relatively high resolution images (better than 5 km/lp) were obtained for ~ 53% of the surface of Callisto by Voyager 1 and 2 spacecraft. This permits investigation of the regional variation in crater density down to about 25 km crater diameter. At least three factors may be expected to have caused regional variation in crater density on Callisto; a) variation of cratering rate from apex to antapex of orbital motion (1), b) formation of large palimpsests, which locally reduces the crater density (2), and c) regional variation in cooling history of the lithosphere, which governs the time at which the lithosphere locally became thick and stiff enough to retain craters of a given size (2).

Distribution of Crater Densities: More than 2200 craters $\geq$ 25 km in diameter were measured and latitudes and longitudes of each crater were determined, using the network of control points established by Davies and Katayama (3). This survey is believed to be complete down to 30 km crater diameter for the 53% of the surface of the satellite studied. The observed local crater density at a spatial resolution of 10° latitude and 10° longitude is shown in Figure 1. Large areas of relatively low crater density are observed in the neighborhood of the Valhalla and Asgard multiring structures (centered at 16° N 55° W, and at 36° N and 125° W). Most of the areas of highest crater density are located in the leading hemisphere and tend to be concentrated near the north pole. The observed latitude dependence probably is influenced, in part, by the location of Valhalla; high resolution coverage near the south pole was not obtained. With the exception of regions near the large multiring structures, the overall crater density of the leading hemisphere is higher than in the trailing hemisphere. The occurrence of all the large multiring structures in the leading hemisphere (4) and the high density of craters in the leading hemisphere (in areas outside the multiring structures) probably reflects a consistently high rate of crater production on this part of Callisto's crust. Some of the local variation in crater density is due to the low frequency of craters in the 10° x 10° bins used in the construction of Figure 1. The average frequency is approximately 6 craters per bin; at low latitudes, the frequency averages about 10 craters per bin.

Distribution of Model Ages: Because of the relatively high orbital velocity of Callisto (8.2 km sec$^{-1}$), the cratering rate at the apex of motion must be higher than at the antapex. According to the model of Shoemaker and Wolfe (1) the present production of craters by comet impact is 6.5 times higher at the apex than at the antapex. If it is assumed that Callisto has been tidally locked throughout the preserved cratering history, then the gradient in cratering rate across the surface should be reflected in the cratering record. For a surface of uniform age, on which all craters formed have been preserved, the crater density should vary in proportion to the average local cratering rate.

In order to test for variation in age, we have transformed crater densities to model ages by applying the Shoemaker and Wolfe cratering model and timescale (1). The distribution of determined model ages, based on 10° x 10° bins, is shown in Figure 2.

For the coverage shown in Figure 2, about 2% of the surface has model ages less than 3.8 GY; 26% has model ages between 3.8 and 4.0 GY, 60% between 4.0 and 4.2 GY, and approximately 13% between 4.2 and 4.4 GY. The oldest surface areas, based on the cratering model, are found in the trailing hemisphere near the antapex of orbital motion (0° N 270° W). It should be stressed that these model ages refer to retention times for craters $\geq$ 30 km in diameter. Areas near Valhalla and Asgard have relatively low model ages; the best estimate for the model age of Valhalla (based on craters $\geq$ 25 km in diameter) is $3.96 \pm 0.02$. © Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System
AGE OF CALLISTO'S SURFACE

Passey, Q.R. and Shoemaker, E.M.

GY; for Asgard, the best estimate is 4.04 ± 0.04 GY.

Our interpretation of the distribution of model crater retention ages on Callisto is that Callisto's lithosphere generally became thick and rigid enough to support craters > 30 km in diameter near the antapex earlier than it did near the apex; in part, this may have been a consequence of a higher impact flux, and thus higher impact heating, in the leading hemisphere very early in the history of the satellite. In addition, the higher production rate of large multiring structures on the leading hemisphere probably resulted in regional resurfacing at times later than in the trailing hemisphere.

Crater Retentivity of Callisto's Lithosphere: It has been proposed by Passey and Shoemaker (2) that the mechanical crust or lithosphere was at one time, early in its history, too thin to retain moderate sized craters (diameter > 10 km). With a reduction of radiogenic and impact heating, the lithosphere cooled and thickened, and in so doing became less susceptible to mechanical disruption by the impacts of large projectiles; also, with a decreasing thermal gradient in the lithosphere, at any given location, progressively larger craters could be sustained against viscous collapse as time passed. A 10 km crater could be retained from a period earlier than the period from which a 100 km crater would be retained. Thus crater size must be specified when discussing crater retention ages. The diameter of the largest retained crater is roughly proportional to the thickness and stiffness of the lithosphere at the time at which the crater formed.

For the lithosphere near the antapex, the model crater retention age based on craters with diameters > 10 km is 4.4 GY; the model crater retention age determined from craters > 30 km diameter is 4.3 GY, 4.2 GY for craters > 70 km diameter and 4.1 GY for craters > 100 km diameter. Near the apex, however, the crater retention ages based on craters with diameters > 30 km is 4.0 GY; 3.9 GY for craters > 70 km diameter and 3.9 GY for craters > 100 km diameter. The model ages suggest that the lithosphere of Callisto could support craters > 30 km diameter approximately 0.3 GY earlier near the antapex than near the apex. For 100 km diameter craters, the difference in time of crater retention between the apex and antapex is approximately 0.2 GY. This implies that although the cooling of the lithosphere was delayed at the apex, it finally cooled and thickened there at a more rapid rate than at the antapex. Probably by ~ 3.7 GY the temperature gradient in the lithosphere was very nearly globally uniform; the thickness of the lithosphere, at this stage, was relatively uniform, at any given location, and increased systematically toward the poles (because of the dependence of mean surface temperature on latitude). From this time forward, craters in excess of about 150 km in diameter have been retained.

AGE OF CALLISTO'S SURFACE

Passey, Q.R. and Shoemaker, E.M.

Fig. 1 - Cylindrical equal area map of Callisto showing the density of craters ≥ 30 km diameter per 10^6 km^2. The unshaded areas were not included in the study because of relatively low resolution coverage.

Fig. 2 - Cylindrical equal area map of Callisto showing the calculated model crater retention ages of regions of the surface from craters ≥ 30 km diameter. The ages shown assumed the cratering timescale model proposed by Shoemaker and Wolfe (1). The apex of orbital motion is a 0° N and 90° W.