LUNAR SAMPLE 12063 AND THE EVOLUTION OF SATELLITE CALLISTO

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The lunar sample fragment 12063,39 is a piece chipped from a large breccia which was exposed at the lunar surface for a period long enough to acquire a surface heavily altered by micro-impacts and irradiation. Thus, the upper part of 12063,39 is characteristic of the morphology resulting from weathering by long space exposure, whilst the inner surface reveals the fresh structure of a broken piece.

The optical properties of astrophysical interest for our purpose are described by three parameters which are the albedo A, the minimum of the amount of polarization P_{min} and the phase angle V_o for which the polarization is zero (inversion angle), (cf. DOLLFUS et al 1975 and 1976).

These parameters are directly comparable with similar measurements collected on celestial objects by telescopic observations.

In fig. 1, we combine these three parameters by plotting V_o horizontally, P_{min} vertically and A as a subscript (cf. DOLLFUS et al. 1975-1976). Measurements on large numbers of freshly chipped consolidated lunar rocks or breccias, of exposed surface rocks coated with adhesive dust grains or powders and of lunar regoliths of fines cluster respectively into three distinct domains in fig. 1, which conversely identify specifically these types of surfaces. We reproduce in fig. 1 only the plots for the two faces of lunar breccia 12063,39.

The galilean satellite of Jupiter J IV, Callisto, has radically different optical properties for its hemisphere which is in the direction of the orbital motion and for the opposite hemisphere (cf. DOLLFUS, 1975).

In fig. 1, the symbol (J IV)L refers to the leading hemisphere; it coincides with the exposed surface of sample 12063 in an area heavily coated with cohesive dust grains, which might alternatively be a layer of fines. This behaviour is expected for a solar system object which has a silicaceous surface subjected to regolithization by impacts.

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On the other hand, for the opposite hemisphere, the corresponding symbol (JIV)F in fig. 1 locates in the domain of the freshly fragmented solid rocks. In particular, it is approximatively matched by the bottom part of rock 12068,38 which was not exposed.

For both hemispheres, the surface of Callisto appears to be of a rocky nature.

However, with a diameter of about 5000 km, Callisto has a mean density of $1.65 gr.cm^{-3}$ and this implies that its interior is mostly composed of water ice as the cosmochemically dominant component. A geochemical differentiation is not likely to generate a crust of rocks with a density near $3.4 gr.cm^{-3}$ above an icy mantle of $1.65 gr.cm^{-3}$. It is postulated that the mantle of ice had originally silicate fragments embedded in it, and that recent surface evaporation of the ice left blocks piled up at the surface in a chaotic manner.

The fact that the whole following hemisphere is not regolithized requires that this surface is protected against micrometeroid impacts. This implies that the evaporation of ice responsible for the stony crust must have occurred or at least continued after the objects and debris originally orbiting Jupiter in Callisto-crossing orbits have been eliminated from the vicinity of Jupiter. Those meteorites which now continue to enter Jupiter's gravitational influence, in great part as a result of collisions within the asteroid belt, reach the planet at low velocity and are placed in highly eccentric orbits. They could approach Callisto only from the front and either hit the surface on the leading face in orbital motion and contribute to produce the regolith observed, or be deflected by the gravitational field; in this case, since the orbital velocity is 8.1 km/sec., the relative velocity will be higher than the escape velocity of 2.4 km/sec; and these bodies cannot hit the following hemisphere, which is protected as observed.

References :

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