SHOCK PRESSURE AND ORBITAL EVOLUTION OF LUNAR AND MARTIAN METEORITES.

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Impact ejection and the subsequent transfer of rocks from Mars and Moon to Earth is documented by ~35 Martian and ~40 lunar meteorites, which are all unpaired. This process involves 1) impact ejection from the parent body; 2) transport through interplanetary space, and 3) landing on Earth. These stages can be investigated by considering petrology and geochemistry of the delivered meteorites and compare these results with theoretical predictions derived from numerical models of impact events, and orbital evolution of the escaping fragments [1-7].

A comparison of shock pressures with ejection and terrestrial ages of Martian meteorites supports theoretical predictions that, on average, the highest shocked fragments escape at highest velocities from Mars and, thus, acquire Earth-crossing orbits in the shortest time [7]. In contrast to Martian meteorites which are weakly to strongly shocked [7], it appears that almost all lunar meteorites are weakly shocked, as plagioclase was not transformed to maskelynite in the ejection event(s). These differences in shock pressures can be explained by considering the orbital evolution of fragments which escaped from Mars and Moon.

The probability that fragments that escape Mars eventually impact on Earth was calculated to range from ~2 to 8% and only slightly varies with their departure velocity [2]. However, the probability that fragments that escape Moon will hit Earth is about 25 to 50% and strongly depends on their departure velocity (relative to the motion of Moon) [1]. Three different scenarios can be discriminated: 1) direct collision with Earth for fragments departing from the Moon at various velocities; 2) fragments with departure velocities of 2.4-3.0 km/s travel in geocentric orbits towards Earth; and 3) fragments with departure velocities >3.0 km/s escape into heliocentric orbits [1]. The highest probability for Earth impacts have fragments that travel in geocentric orbits [1-2]. Thus, the lack of recovered highly shocked lunar meteorites can be explained by the following conclusion: Generally, the most highly shocked fragments escape with highest velocities, are preferably transferred into heliocentric orbit, and thus have a lower probability to impact Earth compared to weakly shocked fragments which travel on geocentric orbits. Thus, it appears plausible that no shock melted lunar impact ejecta have been recovered so far, although there could be a small amount.

Additionally, the equal number of lunar and Martian meteorites document that no moderate to large lunar impact occurred in the last few Myr. However, it is tempting to speculate whether the Giordano Bruno crater (22 km Ø), which appears to be the youngest lunar impact of this size [8] ejected the lunar highland breccias Y-82192/Y-82193 and Y-86032 at 8 ± 3 Myr ago [4].

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