N85-26559

IDENTIFICATION OF THE YOUNGEST METEORITES AND A DISCUSSION OF THE POSSIBILITY THAT THEY CAME FROM MARS. John H. Jones, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

The shergottites are a group of basaltic meteorites which are very similar in appearance to terrestrial basalts. On the Earth basalts are formed by volcanic activity; for example, basalt is the primary constituent of volcanic islands such as Hawaii. Thus, the shergottites appear to be the products of igneous (i.e., volcanic) activity from a planet or asteroid in another part of our solar system.

Because the shergottites so resemble terrestrial basalts and because they are apparently very young ($\leq$1.3 billion years), it has been inferred that they come from a large planet. Small planets and asteroids lose heat from their interiors quickly and stop producing hot basaltic liquids early in their history. The Earth's Moon, for example, began to stop producing basalts about three billion years ago - at least two billion years before the shergottites were formed. The inference, therefore, is that the shergottites had to come from a large planet such as Venus or Mars. Further, it appears that gases trapped in one shergottite found in Antarctica (EETA 79001) are chemically similar to the martian atmosphere (as measured by the Viking mission). These observations have led to the exciting and controversial speculation that the shergottites are samples of Mars.

In this context, the time that the shergottites crystallized from basaltic liquids is particularly important. The younger the crystallization age, the more probable it is that the shergottites came from Mars. The conventional interpretation is that the shergottites crystallized 1.3 billion years ago and that a meteor impact ejected them from their parent body (Mars?) 180 million years ago - 1.1 billion years later. If this interpretation is incorrect the martian-origin hypothesis is either strengthened or weakened, depending on whether the 1.3 b.y. crystallization age is too old or too young, respectively.

The time of ejection from the Shergottite Parent Body (SPB) alluded to earlier (180 m.y.) is based on the age of a radioactive "clock" in the shergottites (in this case the rubidium-strontium chronometer) and the assumption that this clock was reset by the shock event that ejected these meteorites from the SPB and into space. The only way that such a radioactive clock can be reset is if the different minerals within a rock chemically communicate with each other. The most probable means of achieving this communication through a shock process is if the shock heats the rock. At high temperature the chemical elements in the minerals of the rock can diffuse and migrate through the rock; communication is achieved; and the clock is reset.

The chemical and physical characteristics of the shergottites themselves belie the conventional chronology. It is difficult to imagine that there can be excellent communication between minerals if there is poor communication within a mineral. Yet the shergottite minerals are not chemically uniform but retain chemical variations which shock heating has not homogenized. If shock has not erased chemical zoning, then the rubidium-strontium clock has not been reset and the 180 m.y. age must be an igneous crystallization age. The shergottites are apparently very young - the youngest meteorites yet discovered by far.

The implications of such a young crystallization age are rather far-reaching. (1) As was discussed earlier, the SPB must have been a rather large body for basalt production to have continued for so long - supporting the martian-origin hypothesis. The term continued is chosen with some care. The shergottites are closely related to other meteorites, the nakhlites and Chassigny (together with the shergottites comprising the SNC suite) which clearly crystallized 1.3 b.y. ago. Further, both the shergottites and the nakhlites show evidence of there having been igneous activity very early in the history of the SPB. Thus, the SPB appears to have been producing basalts throughout its history, and, therefore, the shergottites are not likely to have been produced by a random event such as a meteor impact.

(2) If Mars is the SPB, the extremely young age of the shergottites places severe restrictions on their point of origin. The only area of Mars which could be young enough (based on the density of impact craters) to have produced the shergottites is the Tharsis region, the location of the enormous, young martian volcanoes such as Olympus Mons. The youngest portions of Tharsis, those near Olympus Mons and Arsia Mons are about the same age as that inferred for the shergottites - 100-300 m.y.

(3) The most viable means of ejecting samples from Mars is by meteor impact. It appears that an approximately 30 kilometer crater is necessary to eject 1 meter fragments rapidly enough so that these fragments escape the planet. Since no young, fresh craters in the Tharsis region are greater than 30km in diameter, then, if the shergottites are martian, they must have been ejected as small (<1m) fragments.

(4) When objects float in space they are often struck by high energy particles called cosmic rays. These cosmic rays induce nuclear reactions so that by the time meteorites fall to Earth they are very slightly radioactive. This radioactivity can be used to measure how long an object has been exposed to cosmic rays. In the case of the shergottites, because they were ejected as small fragments, the cosmic ray exposure age probably represents the time that the shergottites floated in space. Thus, the cosmic ray exposure age may well represent the time of ejection from the SPB.

(5) The cosmic ray exposure ages of the shergottites appear to fall into two groups (~0.5m.y. and ~2m.y.). Unless it is possible to eject large (>10m)

objects from 30km craters (so that the interiors are shielded and protected from cosmic rays), it appears that two large, fresh craters are required in the Tharsis region for the shergottites to come from Mars. Preliminary inspection of the Viking orbiter images does show two such craters (25km and 27km diameter) in the region northwest of Olympus Mons, but this observation should be interpreted with care since high resolution images of these craters are not available and their freshness is thus disputable. An added concern is that, two large, proximal cratering events in <5m.y. imply extremely high cratering rates. Thus, the presence of two large craters within 1200km of the summit of Olympus Mons is consistent with the age relations discussed above but is not conclusive support.

(6) Interestingly, if the ages of the shergottites inferred above are correct, the much-discussed "oblique impact" crater near Ceraunius Tholus is probably not the source of the shergottites. Even though it is a large crater in (or near) young terrain, the oblique impact crater is cut by a channel and does not appear fresh.

Summarizing, it appears, based on the presently available data, that the shergottites are extremely young, 180 million years old - the youngest meteorites yet discovered. This observation strengthens arguments that these interesting objects come from Mars. If the shergottites did come from Mars, they must have come from the youngest Tharsis terrain.