NASA News

National Aeronautics and
Space Administration

Washington D C 20546
AC 202 755-8370

P77-10695

JMW (Last)

For Release

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IMMEDIATE

RELEASE NO: 77-105

EARLY ASTEROID BOMBARDMENTS MAY HAVE AIDED EVOLUTION OF LIFE

Does man owe his evolutionary existence to a barrage of huge asteroids that struck the Earth, the Moon and the other inner planets in the solar system some four billion years ago?

Are the modern ocean basins the product of giant impact craters that formed early in the history of this planet?

If so, what are the consequences for life elsewhere in the universe?

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Mailed:
May 24, 1977

(NASA-News-Release-77-105) EARLY ASTEROID BOMBARDMENTS MAY HAVE AIDED EVOLUTION OF LIFE (National Aeronautics and Space Administration) 7 p

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These are some of the questions raised by a paper to be presented June 2 at the Washington meeting of the American Geophysical Union by Dr. Herbert Frey, a NASA-University of Maryland scientist working at NASA's Goddard Space Flight Center, Greenbelt, Md.

Information returned from Apollo lunar landings and photographic evidence from spacecraft studies of the Moon, Mercury and Mars seem to show that all of these planets experienced an intense bombardment by asteroids 50 kilometers (30 miles) or more in diameter four billion years ago. This catastrophic cratering must also have affected the early Earth.

Building on the work of other scientists -- including that of Goddard's Dr. Paul Lowman's studies of crustal evolution -- Frey suggests this early destructive bombardment may be responsible for the first ocean basins formed on the Earth.

Giant impacts would trigger subsurface melting, leading to vast outpourings of lava that would flood the huge craters caused by the impacts.

Frey further suggests that these conditions make possible a very early beginning of plate tectonics, in which large rigid crustal blocks can shift position on the surface of the Earth. Such movements are the cause of earthquakes and volcanic eruptions today.

Formation of these basins flooded by basaltic lavas is necessary for plate motion to occur. According to Frey, "Crustal uplift and rifting were probably initiated in the thinned crust of the Earth's mare basins. Loading of these basin margins by sediments encouraged subduction, which initially was probably confined to the continent-ocean (highland-mare) interface. With subduction (sinking of crustal plates) established, sea-floor spreading at mid-mare ridges could begin the long process of oceanic crustal reworking, which, after several cycles, would eventually generate the young oceanic crust of the modern plate-tectonics period."

Four billion years ago the Earth would have looked much like the Moon does today. The Moon never had plate tectonic motions, because it cooled too rapidly.

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Had there been no asteroidal bombardment four billion years ago, evolution of life on the Earth would have been very different from what it has been over the history of Earth in Frey's opinion.

For example, the Earth might well have been covered with a global ocean, with no continents and no islands. Nothing but water. Or it might have been mostly dry land, with only a few patches of water here and there.

In either case evolution of life would have been far different because the environment would have been radically different from that which we know has existed over eons. It is likely that many of the higher life forms, including man would not have evolved Frey believes.

Origin of continents and ocean basins has long been a problem in geologic research. The most likely explanation is asteroidal bombardment, according to Frey: "It is obvious that the Moon, Mercury and Mars were struck by hundreds of huge objects approximately four billion years ago. There is no way the Earth could have escaped such a pounding as well. My calculations show that more than 50 per cent of the Earth's original crust would have been converted into ocean basin topography based on the number, diameter and depth of the observed lunar basins."

If asteroidal bombardment is responsible for the original ocean basins of the Earth, then intelligent life elsewhere in the universe may also depend on such a catastrophic event. Frey says, "There is no reason to believe that similar events would have occurred in the same time frame on other Earth-like worlds in other star systems." Timing of the bombardment is critical. If too early, they would impact molten crust and no traces would remain. If much later, after life had formed, evolution would be seriously affected. Intelligent life forms might not have time to evolve.

Planets which suffered no asteroidal bombardment of this type would probably not have moving plates, as does the Earth. The dense crust of the ocean floors is necessary for subduction (a crustal plate being pushed back into the deeper parts of the Earth). Without such sinking of the plates, only limited plate movement is possible. Atlantic-type oceans such as occur on the Earth would not exist.

Here's how Frey pictures the asteroid bombardment and its effect:

After the formation of the planets four and one-half billion years ago, there was still a large amount of mass left over in the form of asteroids located throughout the solar system.

These objects had their paths changed by the gravitational force of the large planets, especially Jupiter. For reasons that are still not clear, a large number of these asteroids were deflected into the inner solar system about four billion years ago.

As a result, all of the inner plants (Mercury, Venus, Earth and Moon, and Mars) were pounded by the 50-km (30-mi.) diameter rocks. On the Earth, such impacts produced gigantic craters (basins) more than 1,000 km (620 mi.) across, and 10 to 20 km (8 to 12 mi.) deep.

Over one-half of the Earth's original crust became low basins; the rest remained as high-standing continents.

Lava from below the fractured crater floors poured up into the basin and flooded the low-lying areas with basaltic material. These deep basins provided natural drains into which the water of the Earth would collect.

Below the new ocean basins the molten Earth was moving, causing uplift of the basin floor. The floor rifted apart, and new lava welled up along the rift. The crack widened, and seafloor spreading pushed apart the newly formed plates on either side.

Near the edge of the basins the greater weight of the basaltic lava crust sank below the continental edge as subduction responded to the pressure from the spreading ridge.

Modern ocean crust is formed in this way, by the welling up of lava from huge mid-ocean ridges. Frey suggests that this process began early on the Earth. "It seems likely that a kind of plate tectonic activity -- but with very small plates and very rapid motions -- was occurring on the Earth perhaps as long ago as three and one-half billion years."

Are there more of the giant asteroids still around in the solar system? And what are the chances that they will hit the Earth?

"The best modern example are the Apollo asteroids," says Frey, "which have orbits that cross the orbit of the Earth. None of these are likely to hit the Earth in the forseeable future."

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