HEAT TOLERANCE OF METHANOGENS: IMPLICATIONS FOR THE POSSIBILITY OF LITHOPANSPERMIA.

T. A. Kral[1,2] and R. K. Tryon[2], [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, 332 N. Arkansas Avenue, Fayetteville, Arkansas 72701, tkral@uark.edu, [2]Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701.

Introduction: The hypothesis of panspermia, the idea that life could be transported from one planet to another through space, was first developed by Arrhenius in 1908 (1). Since then, the idea of lithopanspermia, the transfer of organisms in rocks such as meteors and asteroids, has become amenable to testing. These organisms would have to survive ejection from the home planet, transit through space, and entry through the atmosphere of the destination planet. Conditions encountered would include increases in shock pressure, temperature, and radiation. Of the microorganisms tested, *Bacillus subtilis* endospores were able to withstand the high shock pressure as well as the elevated temperatures and radiation if protected within the rock (2,3). Of course, endospores are well-known for their tolerance to many extreme factors including high temperature and radiation. We have been studying methanogens, microorganisms in the domain Archaea for over 20 years as a model for life on Mars. These organisms do not form endospores and therefore do not have the well-known tolerance levels of endospore-forming organisms such as *B. subtilis*. Nonetheless, if methanogens exist on Mars, it is conceivable that they were seeded there from a piece of Earth that was ejected by a meteor impact sometime in the past, or that material from Mars seeded our home planet by the same mechanism. With either possibility, these methanogens would have had to endure shock pressure, temperature and radiation problems mentioned earlier. In the research reported here, we concentrated on one of those factors, temperature.

Methods: Methanogens used in this series of experiments were *Methanothermobacter wolfeii* and *Methanosarcina barkeri*. Organisms were first grown in their ideal media, centrifuged, dried, and exposed to 100^{o}C for various lengths of time, from one minute up to one hour. One set of organisms was subjected to the high temperature in sealed tubes without oxygen present. A second set was subjected in open tubes which were exposed to the ambient atmosphere. Following this heat treatment, the cell pellets were suspended in their ideal growth media under anaerobic conditions, and incubated at their optimal temperatures. Survival was determined by increasing methane concentrations in headspace gas samples measured at regular time intervals by gas chromatography.

Results: Both *M. barkeri* and *M. wolfeii* demonstrated survival following various times of 100^{o}C exposure under aerobic and anaerobic conditions. Both organisms survived longer exposure under anaerobic conditions with *M. barkeri* surviving a maximum of one hour and *M. wolfeii* surviving a maximum of 30 minutes.

Discussion: One of the factors any organism would have to survive to be successfully transported from one planet to another is elevated temperature. This factor would be especially significant during ejection from the home planet and entry through the atmosphere of the destination planet. Using bacterial endospores as a model, Mileikowsky et at. (4) showed that transfer of microbes from Earth to Mars or vice versa in rocks greater than 1 m in size is highly probable. Here we have demonstrated that a non-spore-forming microbe, a methanogen, can withstand temperatures up to 100^{o}C for up to one hour. If methanogens are trapped within a meteoroid that is at least 1 m in size, and the interior temperature does not exceed that temperature for that amount of time, then there is no reason to believe that these methanogens could not be transported from one planet to another.

References: (1) Arrhenius, S. 1908. Worlds in the Making: The Evolution of the Universe. New York, Harper and Row. (2) Horneck et al., 2008. *Astrobiology* 8: 17-44. (3) Horneck et al., 2001, *Origins Life Evol. Biosphere* 31: 527-547. (4) Mileikowsky et al., 2000. *Icarus* 145: 391-427.