PANSPERMIA: A PROMISING FIELD OF RESEARCH. P. H. Rampelotto, Exobiology and Biosphere Laboratory - Southern Regional Space Research Center (CRS/INPE), P.O.Box 5021, 97105-900, Santa Maria, RS, Brazil & Department of Biology, Federal University of Santa Maria, P.O.Box 5096, 97105-900, Santa Maria, RS, Brazil, e-mail: pabulo@lacesm.ufsm.br.

The Panspermia hypothesis states that the seeds of life exist all over the Universe and can be propagated through space from one location to another. For millennia, this idea has been a topic of philosophical debate [1]. Its earliest recorded advocate was the Greek philosopher Anaxagoras (500-428 B.C.) who asserted that the seeds of life are present everywhere in the Universe.

However, just in the 19th, the physician H.E. Richter (1865) firstly proposes a mechanism with meteors as the transfer vehicles for life through space and may be considered the founder of the modern theory of Panspermia (Lithopanspermia). In the 20th, after Arrhenius, this idea lost momentum due the lack of any validation and remained merely speculative. Nevertheless, with recent advances in space science research, the Panspermia hypothesis could be tested experimentally and a variety of studies from different fields of research has been performed [2].

This interest was revived in the late 70s by the recognition of Martian meteorites here on Earth [3] which proves beyond doubt that intact rocks can be transferred between the surfaces of planetary bodies in the Solar System. Petrographic analysis of the Martian meteorites and mathematical simulations of impact-induced ejection demonstrated that these rocks experienced shocks from 5- 10 GPa to 55 GPa [4], heating in the range from 40ºC to 350ºC [5] and acceleration on the order of 3.8 x 10^6 m/sec2 [6].

Based in these data, mechanisms for the transfer of planetary material have been proposed. The most well accepted mechanism, developed by Melosh [7], indicate that materials can be expelled into interplanetary space under lightly shocks and modest temperature increases. In fact, recent measurements in the Martian meteorite ALH84001 have shown that it was probably not heated over 40ºC since before it was ejected from Mars [8].

These results leaded to the question whether living organisms has been transported between the planets of our solar system by the same mechanism. The viable transfer from one planet to another requires microorganisms to survive the escape process from one planet, the journey through space as well as the reentry/ impact process on another planet [9]. In this context, a variety of studies has been performed in order to simulate different aspects of Lithopanspermia [10].

Because of their high resistance to different extreme conditions [11], spores of *Bacillus subtilis* are the most widely used model microorganism for these studies [12, 13]. However, various other microbes have been used including vegetative cells of the soil bacteria *Deinococcus radiodurans* and *Rhodococcus erythropolis*, some halophilic archaea (*Halorubrum* and Halobacterium spp.), the cyanobacterium *Chroococcidiopsis* and the lichens *Xanthoria elegans* [14, 15].

Evidences for the possible interplanetary transfer of biological materials began with experiments testing the resistance of microbes to space environment [16]. In the space environment, microbes would be subjected to different stresses, including extreme vacuum, desiccation, solar and cosmic radiation, microgravity and both extreme hot and cold temperatures [17]. Of these factors, solar UV is the most immediately lethal [17].

However, spaceflight experiments demonstrate that with minimal UV shielding several types of microbes can survive for years at exposures to the harsh environment of space [18, 19]. It is important take into account that the minimum Mars-Earth transfer time is only of 7 months [20]. Furthermore, it is estimated that, if shielded by 2 meters of meteorite, a substantial number of spores would survive after 25 million years in space [21].

Further support to the theory of Lithopanspermia has been given by simulation experiments in which model microbes are subjected to ultracentrifugation, hypervelocity, shock pressure and heating in the range defined for the Martian meteorites. These experiments simulate the physical forces that hypothetical endolithic microbes would be subjected during ejection from one planet and landing on another. Previous simulation experiments have measured each of these stresses isolated and the results indicate that spores can survive each stress applied singly [22, 23, 24]. The analyses of the combined stresses can be most closely simulated in the laboratory via hypervelocity ballistics experiments.

The results demonstrated that microbes could survive rapid acceleration to Mars escape velocities and subsequent impact into surfaces of different compositions [25, 26]. Thus, there is a body of evidence that microbes can survive the conditions of interplanetary transfer from Mars to Earth or from any Mars-like planet to other habitable planets in the same solar system.

Interplanetary transfer from Earth to Mars is limited due to the very high ejection velocities that are required to materials escape the Earth's gravity field and pass its dense atmosphere [27]. This condition may be only achieved by very large impact events. Recent studies indicate that such impact events happened frequently during the Early Heavy Bombardment phase, i.e., before 3.75 billion years ago [28], which overlaps with the postulated time of the origin of life on Earth [21].

The Earth–Mars system is not the only place where natural transfer may occur. The discovery of potentially habitable environments such as the satellites of Jupiter and Saturn (e.g. Europa, Ganymede, Callisto, Titan and Enceladus), expands the possibility of interplanetary transfer of life in the Solar System [29]. Consequently, hypothesis of natural transfer of material occurring between satellites has been developed [30].

Regardless of the current debates about the possibility of extraterrestrial life in Martian meteorites, the physical mechanisms of the interplanetary transfer of life have been clearly elucidated [2]. Therefore, in recent years, most of the major barriers against the acceptance of this theory have been demolished and Panspermia reemerges as a promising field of research.

References:

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