Beagle 2: Seeking the signatures of life on Mars

Conference or Workshop Item

BEAGLE 2: SEEKING THE SIGNATURES OF LIFE ON MARS

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Beagle 2 is a 60 kg probe (with a 30 kg lander) developed in the United Kingdom for inclusion on the European Space Agency's 2003 Mars Express. Beagle 2 will deliver to the Martian surface a payload which consists of a high percentage of science instruments to landed spacecraft mass. Beagle 2 will be launched in June 2003 with Mars Express on a Soyuz-Fregat rocket from the Baikonur Cosmodrome in Kazakhstan. Beagle 2 will land on Mars in December 2003 in Isidis Planitia (~11.5^{o}N and 275^{o}W), a large sedimentary basin that overlies the boundary between ancient highlands and northern plains. Isidis Planitia, the third largest basin on Mars, which is possibly filled with sediment deposited at the bottom of long-standing lakes or seas, offers an ideal environment for preserving traces of life. Beagle 2 is completed and undergoing integration with the Mars Express orbiter prior to launch.

Beagle 2 was developed to search for organic material and other volatiles on and below the surface of Mars in addition to the study of the inorganic chemistry and mineralogy [1]. Beagle 2 will utilize a mechanical mole and grinder to obtain samples from below the surface, under rocks and inside rocks. A pair of stereo cameras will image the landing site along with a microscope for examination of surface and rock samples. Analyses will include both rock and soil samples at various wavelengths, X-ray spectrometer and Mossbauer spectrometer as well as a search for organics and other light element species (e.g. carbonates and water) and measurement of their isotopic compositions. Beagle 2 has as its focus the goal of establishing whether evidence for life existed in the past on Mars or at least establishing if the conditions were ever suitable.

A mechanical arm (PAW) is used for science operations along with sample acquisition. Instruments attached to the PAW include: stereo cameras, Mossbauer and X-ray fluoresence instruments, micro-scope, environmental sensors, rock corer/grinder, a spoon, mirror, brushes, a Mole attachment for acquisition of subsurface to depths of 1 to 2 meters and an illumination device. Each camera has 14 filters which have been optimized for mineralogy composition, dust and water vapor detection. The microscope's camera is designed for viewing the size (down to 4 microns) and shape of dust particles, rock surfaces, microfossils, and characteristics of the samples prior to introduction into the gas analysis package (GAP). The camera features 4 color capability (red, green, blue and UV fluoresence), a depth of focus of 40 micrometers and translation stage of $\pm$3 millimeters.

Beagle 2's heart is the life detection package which is a gas analysis package (GAP) consisting of a mass spectrometer with collectors at fixed masses for precise isotopic ratio measurements and voltage scanning for spectral analysis. Primary aim of the GAP is to search for the presence of bulk constituents, individual species, and isotopic fractionations for both extinct and extent life along with studying the low-temperature geochemistry of the hydrogen, carbon, nitrogen and oxygen components from both the surface and atmosphere. GAP is a magnetic sector mass spectrometer (mass range of 1 to 140 amu) which can be operated in both the static and dynamic modes. A triple Faraday collector array will be used for C, N and O ratios along with a double Faraday array for H/D. Pulse counting electron multiplier will be utilized for noble gases and selected organics. Anticipated detection limits are at the picomole level for operation in the static mode of operation and high precision isotopic measurements will be made in the dynamic mode. Sample processing and preparation system consists of reaction vessels along with references. Sample ovens capable of being heated are attached to the manifold for sample combustion. Surface, subsurface materials and interior rock specimens will be combusted in pure oxygen gas at various temperature intervals to release organic matter and volatiles. Combustion process will permit detection of all forms and all atoms of carbon present in the samples. A chemical processing system is capable of a variety of conversion reactions. Gases are manipulated either by cryogenic or chemical reactions and passed through the gas handling portion of the vacuum system. There are two modes of operation: quantitative analysis and precise isotopic measurements.

Three main types of analysis will be carried out by the GAP: (1) search for organic matter, (2) stepped combustion for total light element content and speciation, and (3) atmospheric analysis. Isotopic measurement of H/D, $^{13}C/^{12}C$, $^{15}N/^{14}N$ and $^{18}O/^{16}O$ and search for possible biogenic methane within the Martian atmosphere will be made. Estimates of the present methane concentration in the atmosphere is believed to be <100 ppb. Lifetime of CH_4 in Mars' atmosphere is believed to be < 300 years and therefore no abiogenic methane is anticipated. The GAP is capable of concentrating gases and the search for biogenic atmospheric methane will be made. The mass spectrometer will operate in the static mode for the CH_4 measurements after chemical reagents have concentrated the atmo-spheric gases. Conversion to a measureable component will be made to ensure no false positive results will be obtained along with lowering the detection limits. Should methane be detected within the Martian atmosphere its putative source would have to be biogenic (i.e. methanogenic bacteria).

An environmental sensor system for surface temperatures, atmospheric pressures, wind speed and direction accompanies atmospheric sampling. Radiation environment's dose and rates will be characterized. UV flux at the lander will be measured in a variety of wavelengths longer than 200nm, information relevant to understanding the survival of organics. High sensitivity isotopic analysis of the carbon species present within the samples makes no assumptions about the bio-chemistry on Mars but provides clues to past life as inferred from the isotopic fractionations mea-sured directly on Mars. Planetary protection protocols have been followed for Beagle 2. The lander has been designated as a Category IVA^{+} mission. A microbial reduction plan is in place and all components have been sterilized. Additional cleaning procedures have been followed to reduce blanks associated with GAP operations.

References: [1] M.R. Sims et al. (1999), *SPIE Conf. on Instruments, Methods and Missions for Astrobiology* II, SPIE Vol. 3755, pp. 10-23. [2] R. Carr et al. (1985) *Nature* 314, 248-250. [3] I.P. Wright et al. (1989) *Nature* 340, 220-222. [4] C.S. Romanek et al. (1994) *Nature* 372, 655-657. [5] D.S. McKay et al. (1996) *Science* 273, 924-930. [6] K. Thomas-Keprta (2000) *Geochimica et Cosmochimica Acta* 64, 4049-4081. [7] E.K.Gibson, Jr. et al. (2001) *Precambrian Research* 106, 15-34.