# *GARATÉA II* MISSION: THE EARTH'S STRATOSPHERE AS A MARS ANALOGUE ENVIRONMENT FOR POTENTIAL MOLECULAR BIOSIGNATURES STUDIES AND SPACE MISSIONS APPLICATION.

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**Introduction:** Earth's stratosphere (12 to 50 km above sea level) can mimic the harsh conditions on the surface of Mars – low atmospheric pressure and temperature paired with high radiation and dryness (Table 1). [1, 2] Unlike Mars, however, Earth's stratosphere is easily accessible and affordable to reach via scientific balloons, what makes it an interesting testbed for astrobiology experiments on biosignatures' investigation.

*High-altitude balloons.* They are sub-orbital platforms typically made of thin polyethylene filled with helium, capable of carrying payloads of up to 3 tons at altitudes of up to 45 km. Simple and of low-cost, they do not require motor and fuel, they fly with the wind and payloads can be recovered after flights of up to hours or days, making them environmentally responsible scientific tools for atmospheric and astronomical research, as well as technological development.

*Garatéa II.* Formed by undergraduate engineering and physics students of the University of São Paulo (USP), the *Zenith* group designed and built a stratospheric balloon gondola, named *Garatéa* (which means "searching for life", in native Brazilian language, Tupi-Guarani). Launched in December 19th 2016, the balloon travelled through the stratosphere for ~1h, reaching a maximum altitude of 25.5 km above sea level.

**Table 1.** Typical physical conditions at Earth's stratosphere and on Mars' surface. [1,2]

| Parameter | Mars (surface) | Earth (12-25 km) |
|---|---|---|
| Pressure | 6.3 mbar | 193 to 11 mbar |
| Temperature | 213 K | 253 to 279 K |
| RH | ~0 % | 1 to 2.6 % |
| Density | 1.6 x $10^{-2}$ kg/m$^3$ | 2.0 x $10^{-2}$ kg/m$^3$ |
| Solar constant | 589.0 W/m$^2$ | 1367 W/m$^2$ |

**The experiment:** Three set of 14 samples in duplicate were prepared: the 1st flew with the balloon and was "Exposed to UV radiation" (E), the 2nd also flew but was "Not exposed" (N) and the 3rd remained on the ground to be a "Control" (C). Diamond powder (robust and inert internal standard for quantification under Raman spectroscopy) and 3 μL of water (to facilitate any reaction) were added to all samples. The samples included a lyophilized radiation resistant bacterium (*Deinococcus radiodurans*) and 8 biomolecules (of different classes) – which can be used as biosignatures. Also, one of them (DL-cysteine) was mixed with 5 inorganic substrates, analogs to the Martian surface.

**Results:** The analysis was made using a Renishaw inVia micro Raman spectrometer with a 785 nm excitation laser. Figure 1 shows the spectra of (a) β-carotene and (b) DL-cysteine + Montmorillonite after being submitted to the experimental conditions (C, N and E).

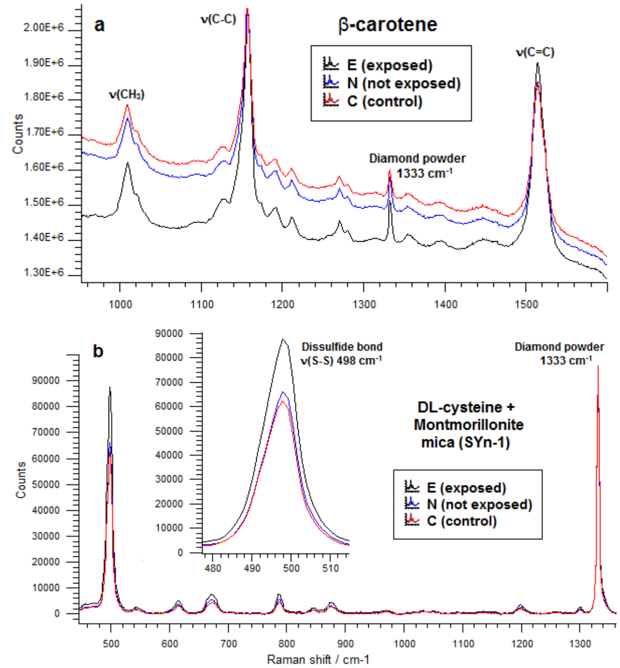

**Figure 1.** Raman spectra of (a) β-carotene and (b) DL-cysteine + Montmorillonite mica (SYn-1).

It is possible to observe variations in the spectra. For β-carotene there is a decrease of the baseline from C to N to E – a sign of decrease in fluorescence. For cysteine, there is an increase of peaks intensities, which can be a sign of bond formation (e.g. disulfide bond). The quantitative analysis with respect to the diamond powder peak gives more detailed and reliable results.

**Conclusions:** High-altitude balloons have proven to be reliable research platforms to use the stratospheric environment as a very complete Martian analogue. It is being used by our group to prepare more complex space missions, including one of a CubeSat to the Lunar Orbit, *Garatéa-L*, to be launched in 2020.

**References:** [1] Wieser M. et al. (2009) *Advances in Space Research*, *44*, 308–312 [2] Schlatter, T. W. (2009) NOAA, Earth System Research Laboratory Boulder, CO, USA.