Methane on Mars

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Abstract

From 1999 methane on Mars was detected through ground-based observations, then from 2004 by the instrument PFS (Planetary Fourier Spectrometer) on board of Mars Express (from 2004), from 2012 NASA MSL mission's Curiosity rover had also detected methane plume emissions in Gale crater during specific times of the Martian day (SOL) and by the ACS (Atmospheric Chemistry Suite) and NOMAD (Nadir and Occultation for MArs Discovery) on board of ESA-Roscosmos ExoMars Tracer Gas Orbiter from 2018. After the Global dust storm in 2018 the upper limit concentration of methane decreased drastically (10 to 100 time lower) and TGO stopped detecting it, as opposed to the Curiosity rover, which continues to this day to detect plumes of CH4. The topic, as can be seen, stirs much debate in the scientific community, not only for its astrobiological implications but also regarding possible theories that reconcile current and past observations from the orbiters and the Curiosity rover. To try to bring some clarity, many questions have been raised that have not yet been answered such as, was methane produced in the past and then stored in reservoirs, or is there some mechanism that allows its formation in the subsurface of present-day Mars? If methane was produced in the past, through what mechanisms was it generated and what are the morphological and geo-mechanical characteristics of the reservoirs containing it? Is Gale Crater the only hot spot where methane is being released gradually at present? If there have been other spots similar to Gale crater in the past that featured surveys from 1999 to before the 2018 global storm, how can they be recognized? Are there particular mineralogical or morphological features (such as those in Vernal crater)? At what depth can methane be found in the subsurface of Mars to enable both past and current detections? The purpose of this research is to: (1) define possible current local emission zones, (2) evaluate the emission pattern associated with mud volcanoes). At global scale there will be a detection of the following features expected to be methane sources: (1) hectometric to kilometric conical mounds of volcanic origin (2) hectometric to kilometric sedimentary mounds (Pockmack) that could contain clathrates (such as Mt Sharp in Gale Crater) (3) chaotic terrains (4) fracture fields in sedimentary piles. After obtaining a comprehensive map of all these morphologies with attached mineralogical analyses, a similar work will be done on terrestrial analogues environments where methane is detected. At local scale I will work in the Gale crater, in the areas where Methane was detected. I will build a virtual reality environment for these places using the images provided by Curiosity rover and by the HiRISE instrument to have a map of the sedimentary layers and fractures. This map will contain also data about porosity and permeability that can be estimated from very high-resolution images (10-3 m resolution) acquired locally by Curiosity. Finally, I will estimate the possible methane discharges that

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could occurred in such environment integrating the geo-mechanical parameters I measured in the Martian field in a percolation model adapted to the Martian environment. All this should lead to clearer learning of the mechanism that generated methane on Mars in the past and that which allows its release in the present day with an updated Global map of the morphological features mentioned above.