POTENTIAL BIOLOGICAL COMPONENT OF THE ENCELADUS ENVIRONMENT. KINETIC SIMULATION FOR THE 10 KM THICK OCEAN MODEL. J. P. Kotlarz[1] , K. A. Kubiak[1] and N. E. Zalewska[1], [1]Institute of Aviation, Al. Krakowska 110/114, 02-256, Warsaw, Poland

Introduction: The Enceladus ocean is estimated to be 10 - 50 km thick [1, 2]. Any microorganisms living on the ocean bottom would have to pass that distance before beginning the ascent through the Tiger Stripes linear depressions in the south polar region of this Saturnian moon. Basic plumes parameters like average ice production rate, solid-to-vapor ratio, chemical composition, temperature gradient depends on processes below ice shell. Such parameters as i.e. the average geothermal flux into the sea beneath Enceladus' south polar terrain, ocean's pH, salinity, ice shield and ocean thick, depending on them pressure and temperature gradients are still under discussion. Possible similarities of physical and chemical conditions between Enceladus ocean bottom and the carbonate mineral matrix of actively venting chimneys of the Lost City Hydrothermal Field (LCHF) at a depth of ~750 m give opportunity to create a mathematical model of bacteria and archaea ascent process through the ice shell [3]. Davila et al. (2019) have recommended inclusion the developing simulations of plume formation and ejection in the next NASA Astrobiology Strategy, [2]. Habitable conditions of the Enceladus' subsurface ocean are research object in the Institute of Aviation in Warsaw (Poland). Our paper present first result of kinetic (Particle-in-cell) simulation of the ocean parameters (shallow version, ~10.0 km thick) and microbes - described as special kind of particles – route to the top of the ocean.

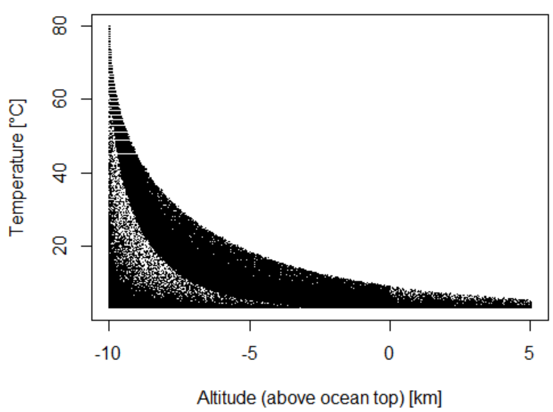

Fig. 1. "Microbe-type" particles temperature vs altitude.

Particle-in-Cell model and boundary parameters: according to Porco et al. (2018) we assumed oceans bottom heat flux similar to the LCHF $\Phi \sim 0.1$ W m^{-2}, salinity ~ 1.0%, microbes concentrations at hydrothermal vents on Enceladus ~10^5 cells/mL [4], oceans density dependence on three main factors: temperature, salinity and pressure. We also set basic ocean temperature T_{ocean} = 276.15 K and surface gravity g= 0.114 m s^{-2}.

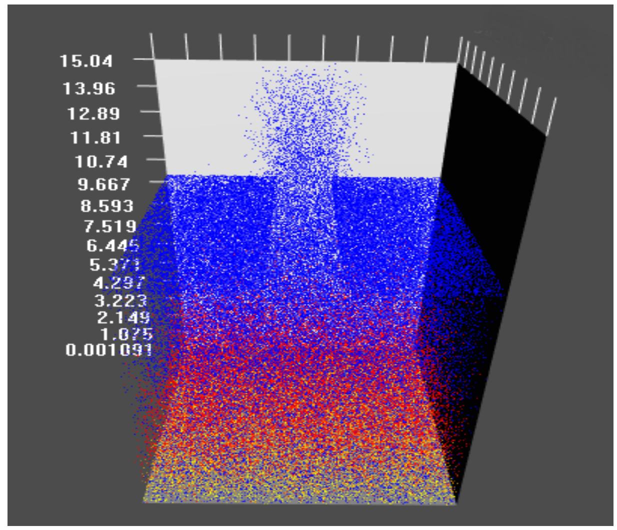

Fig. 2. "Microbe-type" particles location and temperature (EMMA PiC model result): 0°C < blue particles < 10°C red particles < 30°C < orange particles < 50°C < yellow particles.

Results: We found two classes of "microbe – type" particles: a) main class with temperature ~ 40 – 80 °C near ocean bottom (below 8.5 km deep) and ~ 5 – 10 °C near surface and b) with temperature ~ 0 – 10 °C near oceans bottom (see fig. 1). For z > 0.0 an average particles vertical velocity $v_{z,ocean}$ = 2.43 (±1.05) m s^{-1} and temperature $T_{particles}$ = 3.99 (±0.99) °C (see fig. 2). This implies potential particle velocity in plume $v_{z,plume}$ = 1.072 (±0.002) km s^{-1} what is consistent with the Cassini *in-situ* observations. An average available biological mass escaping flux rate was estimated as is 1.547 10^{-7} kg s^{-1} m^{-2} (~ 0.5 % of microbes concentration on the ocean bottom, 20 times less than in Porco at al. (2018)).

References: [1] Iess, L.et al. (2014). The gravity field and interior structure of Enceladus. Science, 344(6179), 78-80. [2] Davila, A.et al. (2018). Follow the Plume: Organic Molecules and Habitable Conditions in the Subsurface Ocean of Enceladus. [3] Brazelton, W. J.et al. (2010). Archaea and bacteria with surprising microdiversity show shifts in dominance over 1,000-year time scales in hydrothermal chimneys. Proc. of the Nat. Academy of Sci., 200905369. [4] Porco, C. C., et al. (2017). Could it be snowing microbes on Enceladus? Astrobiology, 17(9), 876-901.