Ganymede; examining the possibility of life

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Ganymede is the third satellite of Jupitar, and may have an internal ocean under the thick ice rigid lid on the surface without atmosphere. Presence of silica-enriched steam suggests the internal ocean; hence the presence of life is expected. Here we examine the possibility of life inside the Ganymede based on nine requirements for the birth place of life.

Nine requirements which should be met at the birthplace of life are (1) an energy source (ionizing radiation and thermal energy, (energy density over W/cm^2), (2) a supply of nutrients (P,K, REE etc),(3) a supply of life-constituting major elements, (4) a high concentration of reduced gasses such as H2, NH3, HCN and CH4, (5) dry-wet cycle, (6) Na-poor water environment, (7) a non-toxic aqueous environment, (8) diversified surface environments, and (9) cyclic conditions such as day and night, cold and warm etc.

To evaluate the possibility of life on Ganymede, estimation of the internal structure from the surface to the central core is key. The diameter of Ganymede is 5262km, which is similar to Mars. Density of Ganymede is 1.9 g/cm^3, and lower density suggests the inner half radius is composed of rocky component, which is fractionated to have metallic core, rocky mantle and basaltic crust. The outer half is composed of ocean covered by icy crust. The low surface temperature of Ganymede, ca. minus 170-190ºC, suggests the possible occurrence of frozen NH_3 and dry ice (CO_2) together with H_2O ice. If so, major source of nitrogen and carbon could be upper crust which is above the lower crust of ice. Presence of water-dominated jets along the ice fracture of stagnant lid confirms the dynamic convection in the internal ocean which is heated over 100ºC. This also suggests the presence of heat generator below the ocean, in addition to the tidal force (not so strong as the case of Io). Ganymede is still active due to its size, and volcanic activity may still continue, helped by the remarkably concentrated radiogenic elements of U, K, and Th of rocky crust above basaltic silicate crust, which can cause strong ocean convection to generate plumes to melt the lower icy crust, and even erode the frozen atmospheric crust enriched in NH_3 and CO_2.

Based on currently available information, Ganymede seems to be unsuitable for the birthplace of life as nine requirements cannot be met. However, it will be able to find alternative or possible mechanism to meet nine requirements to bear life, for example, the presence of Si-saturated steam suggests the SiO_2 -bearing materials, such as granite or andesite, as the supplier of nutrients for life. Consideration based on nine requirements to bear life would be able to provide ideas for the next planetary plans and missions, what we should do next.

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