"DEEP HABITAT" IN THE ICY MOONS: STRUCTURE AND EVOLUTION OF THE INTERNAL OCEAN. J. Kimura[1], [1]Earth-Life Science Institute, Tokyo Institute of Technology (junkim@elsi.jp).

Introduction: Outer solar system may have a potential habitat of extra-terrestrial life. Most moons orbiting planets in the outer Solar System, at orbits beyond the snow-line, such as Jupiter or Saturn, are covered with water ice and they are called icy moons. Recent explorations (e.g., Galileo and Cassini spacecraft) have found direct or indirect evidences for that many icy moons may harbor an ocean underneath the icy surface. Internal oceans in the icy moons are speculated below the sold icy crust of the moons which means that the oceans exist independently of the stellar energy input and are located well outside the conventional habitable zone of the Sun. It may possess "a deep habitat", a different style of habitability from Earth-like biosphere. In this talk, observational facts and current understanding for the internal ocean in the icy moons provided by the spacecraft observations and theoretical models for the evolution will be reviewed.

Jovian icy moons and Galileo exploration: *Europa* is the smallest and second nearest of the four large Jovian moons, called Galilean moons, and its surface is mainly consists of water ice. The lack of large impact craters on the surface indicating relatively young (20-200 Myr [1]) implies that tectonic processes had erased old craters. Though Europa's surface appears to be extremely smooth from the images taken by spacecrafts, actually it is dominated by a cracked and ruptured features which need existence of the internal ocean for the formation of these surface features [e.g., 2, 3]. Also, disrupted terrain "Chaos" may be a sign of the subsurface lake of liquid water [4]. Moreover, magnetometer onboard Galileo spacecraft has detected a signal of electromagnetic induction during Europa flybys. It can be interpreted that a global electrically conducing layer, which means salty ocean, must lie within 200 km of the icy surface [5]. Europa's internal ocean must be directly contacted with underlying rocky mantle which means that an interaction between liquid water and rocks and associating various reactions can be sustained [6]. At the surface, sulfate and carbonate of magnesium and sodium considered to be a result of such seafloor interaction have been found [7].

Ganymede is the largest moon in the Solar System with a radius of 2,634 km, which is larger than the planet Mercury. Although Ganymede's surface is relatively older than Europa, signal of magnetic induction has been founded which means the existence of subsurface salty ocean. However, larger amount of water in Ganymede (half water and half rocks) than Europa would mean that the internal ocean would be sandwiched between an upper floating icy crust and lower layers of higher density ice polymorphs.

Callisto is farthest and second largest of the Galilean moons, and its surface is most heavily cratered in the solar system and no tectonic features suggesting that the surface is extremely ancient (~ 4 Gyr [1]). In addition, large value of the moment of inertial factor (0.3549 ± 0.0042) indicates that its interior is imperfectly differentiated [8], which means that it has never been heated well. However, Galileo spacecraft detected an electromagnetic signal implying an existence of the internal ocean like Europa and Ganymede.

Saturnian icy moons and Cassini exploration: *Titan* with a radius of 2575 km, is unique among the moons in having a thick atmosphere composing of mainly nitrogen (~95 %) and methane (~5%), and also having organic aerosols as minor components. At the surface, lakes and seas of liquid hydrocarbon exist and change with the seasons which implies Titan possibly has a circulation system and cycle of methane. In addition Titan has a possibility of the subsurface ocean which has been suggested by measurements of large periodic changes of Titan's quadrupole gravity exerted by tidal interaction with Saturn [9]. Such large response requires that Titan's interior is deformable, which is consistent with a global internal ocean.

Enceladus is actively erupting water-rich plumes from warm fractures near the south-pole region [10] though its radius is only 252 km. The plumes consist mainly of water vapor with large amounts of CO_2, NH_3, CH_4, and organics in a gaseous state, and H_2O ice, sodium salts, silicates, organics, and carbonates in a solid state [11, 12]. Although these activities need to have a subsurface water region, the structure of the ocean or the depth of a localized water reservoir is highly unclear.

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