**SIFGNIFICANT ROLES OF LIGHT ($H_2O$, OH)-BEARING PHASES BY THREE PHASE-STATE CHANGES: MACRO TO NANO-PHASES ON PLANETS, SATELLITES AND ASTEROIDS.** [1, 2, 3]Yasunori Miura. [1]Yamaguchi University, Yamaguchi, Yamaguchi 753-0074, Japan, [2] EUA-Al.I.C. University, [3]Caltech-J.P.L.

**Introduction:** If there are few significant scientific development of ocean water formation with life genesis in extraterrestrial bodies based on the well-studied Earth-type analyses [1], it should be also applied new methods of 1) more detailed previous analyses on the water fluids or gas ($H_2O$ or OH), and 2) reconsideration of specific condition to form and store huge amounts of ocean-water system in our Earth system by using three phase-state changes of vapor-liquid-solid phases (called as the VLS in this paper) [2-4]. The main purposes of the present paper are to elucidate the roles of 1) volatile molecules ($H_2O$ and OH) of three phase-states among solid-rich phases of the crust rocks, and 2) huge amounts of water system on water Earth by using water phase diagram by specific formation process.

**Water phase diagram with three VLS states:** Water ($H_2O$ or OH) diagram is well known by phase-state changes at the triple and critical points, which are used for the present discussion on dynamic phase-state changes with different temperature and pressure ranges. Huge dynamic reactions are not required static values of temperature and pressure, but *relative phase-state changes* beyond the triple points are so significant. Figure 1 shows in the phase diagram that there are largely four different steps for phase-state changes of $H_2O$ (including OH) VLS changes (mainly including for high and quick shock-wave condition at impact processes).

1) No.1 path of quick VLS at higher temperature.
2) No2.path of higher pressure and temperature VLS changes.
3) No.3 path of quick SV changes in lower pressure and temperature.
4) No.4 path of quick SV changes at higher pressure and lower temperature.

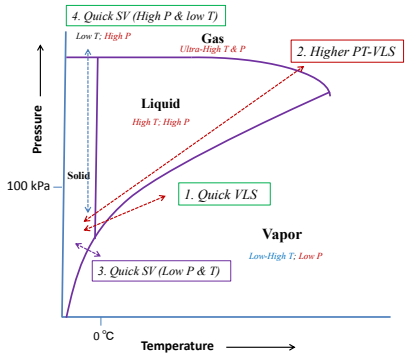


Fig.1. Phase-state diagram of $H_2O$ (in three VLS states).

**Discussion of water molecules in $H_2O$ and OH:** Water ($H_2O$ or OH) molecules should be discussed in phase diagram of $H_2O$ in composition in Fig.1 as follows (*cf.* Fig. 2):

1) Composition $H_2O$ is the same in three states of vapor (wide temperature range), solid ice (wide pressure range) and liquid water (wide temperature-pressure range), which are ways to keep light composition $H_2O$ in wider ranges in active planetary world (esp. water planet Earth).
2) Hydroxyl OH molecules found in crystalline minerals (apatite etc.) can be easily formed from gas-melting ranges (at higher temperature and pressure ranges) to lower ranges by relatively quick cooling or depression process to keep OH-bearing crystalline minerals, which are the latest remnants of relatively quenching process (not memory of lower stable temperature or pressure ranges). This suggest that OH-bearing minerals in meteorites and the lunar rocks are not direct evidences of global water system, even changes from macro to micro (nano) scales.

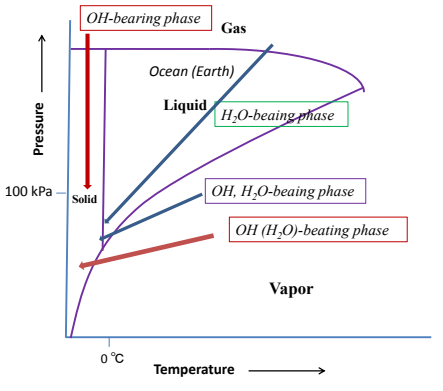


Fig.2. Phase-state diagram of $H_2O$ with OH molecules.

**Formations of solid, liquid water and air in $H_2O$:** Among three phase-sates of $H_2O$ in composition, the following formations are relatively obtained in Figs 1 and 2 (*cf.* Fig.3):

1) Vapor state of $H_2O$ is relatively formed at lower to higher temperature ranges (lower pressure condition) to produce *air (atmosphere)* system in dynamic cyclic process among three states. This indicates that air planets of Venus, Earth and Mars in the Earth-type planets are evidences of wider

temperature change of H2O in composition (mainly by meteoritic impacts and continued volcanic eruption with lip lift from the interior).

2) Solid state of $H_2O$ is relatively formed at lower to higher pressure ranges (lower temperature condition) to produce *solid ice* (in crust or surface) system in dynamic cyclic process among three states. This indicates that all solid planets, satellites, the Moon and Asteroids in the Solar System are evidences of wider pressure change of $H_2O$ in composition if there are $H_2O$ in composition (mainly by meteoritic impacts and relative shock –wave reactions).
3) Liquid state of $H_2O$ is easily considered to be stable phase because we can observe wider *ocean water* on water planet Earth. However it should be noted by the production at continued dynamic system among three phase-states (*i.e.* ice, vapor gas and liquid water). From Figs. 1-3 suggest that water liquid range is intermediate range between air (gas) and solid (ice) states which are easily changes to more stable states of gas-vapor and icy solid after liquid formation in any dynamic planetary world. Therefore, it is difficult to form *huge amounts of water liquid* (in ocean water of water-Earth) in more stable system, though *local* (to micro-nano scale) formations (with relatively instant reaction) can be obtained everywhere if there are any *shock-wave reactions* (by meteoritic and solar impacts, volcanic uplifts or quake explosions).

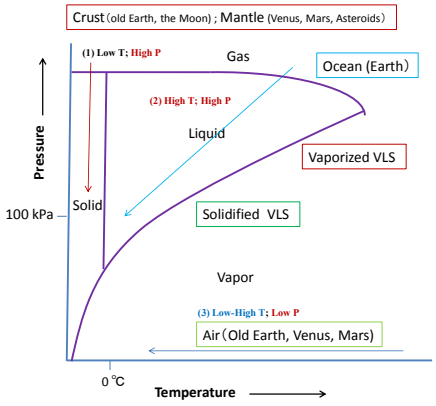


Fig.3. Phase-state changes of the $H_2O$ phase diagram.

**Formation of ocean water system of planet Earth:** Formation of ocean water of planet Earth is one of the unsolved *difficult problems* by using any geophysics and geochemical models. This is in Fig. 3 mainly because 1) intermediate range of unstable liquid $H_2O$ is easily shifted to higher temperature (vapor) or higher pressure (ice) on *progressive process* on active planet Earth, and 2) liquid $H_2O$ can be remained mainly at *quick stopping* of depression and cooling process which are generally difficult to be continued in active planet Earth.

**Formation of ocean water by giant impacts**: The most probable case for continued ocean water is as follows [1-4]:

1) Large amount $H_2O$ mainly by planetary global and giant impacts.
2) Planetary interior uplift of $H_2O$ by giant impact.
3) Global quick liquid-stopping mainly during planetary impacts [1-4].

The above three major conditions to keep $H_2O$ liquid are explained by *planetary giant impact*[1] to for ocean water system finally, which is previously studied on our water planet Earth.

**Formation of liquid $H_2O$ in any bodies:** The above discussion on formation and maintenance of $H_2O$ liquid is produced any impact to soft (regolith) surface to keep *interior reservoir* of $H_2O$ (or OH) in composition even in impact process in any bodies in space. Therefore formation of ocean water (in huge amounts) is explained as special condition to form (mainly by planetary giant impact process), which is confirmed so far on our Earth planet.

**Summary:** The followings are summary in this study.

1) $H_2O$ phase can be discussed in the phase diagram even in quick and huge reaction process relatively.
2) Although vapor (air) and solid (ice) of $H_2O$ are easily formed relatively at stable reaction (as ice air planets), intermediate $H_2O$ liquid are unstable during continued and dynamic processes in any space bodies. .
3) Only probable cause to form and keep huge amount of ocean water system is global planetary impact (in our planet Earth finally)

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[4] Miura Y. (1987): *Applied Physics Soc.* (Tokyo), Spec. Issue 1-6.

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