**SHOCK VAPORIZATION/DEVOLATILIZATION OF EVAPORITES IN AN OPEN SYSTEM.** K. Kurosawa¹, R. Moriwaki¹, G. Komatsu¹,², T. Okamoto³, H. Sakuma⁴, H. Yabuta⁵, and T. Matsui⁶, ¹Planetary Exploration Research Center, Chiba Institute of Technology (2-17-1, Tsudanuma, Narashino, Chiba 275-0016, Japan, kosuke.kurosawa@perc.it-chiba.ac.jp), ²Int. Res. Sch. of Planet. Sci., Università d’Annunzio, Italy, ³ISAS/JAXA, Japan, ⁴Res. Center for Functional Mat., NIMS, Japan, ⁵Dept. Earth and Planet. Sys. Sci., Hiroshima Univ., Japan.

**Introduction:** The presence of evaporitic minerals, such as halite (NaCl) and gypsum (CaSO₄·2H₂O) on a planet can be interpreted as evidence that the planet has had a wet condition in the past. The sedimentation of evaporites is an inevitable outcome, for example, when a lake is dried up [e.g., 1]. The minerals interpreted to be of evaporitic origins have been found on Mars [e.g., 2].

Here, we consider a situation that hypervelocity impacts occur on ancient dry lakes such as playas. The threshold of vaporization/devolatilization of evaporites against growing shock pressure are important to understand the response of the atmosphere/hydrosphere after an intense perturbation due to impacts. In addition, shock-induced water loss from gypsum has been attracted attention as a new shock indicator [e.g., 3]. Recently, we developed an ideal experimental system to investigate the shock vaporization/devolatilization in an open system without any diaphragms [4]. In this study, we applied the system to halite and gypsum samples.

**Experiments:** Impact experiments were conducted using a two-stage light gas gun placed at the hypervelocity impact facility [5] of Planetary Exploration Research Center of Chiba Institute of Technology (PERC/Chitech), Japan. The system for gas analyses and the experimental procedure have been introduced in the previous abstract [4].

**Experimental conditions:** Natural samples of halite and gypsum were used as targets. The targets were shaped as blocks. The masses of halite and gypsum blocks were ~1 kg and ~0.6 kg, respectively. We also used a natural basalt block for a blank experiment. Spheres made of oxides, which are fused quartz and Al₂O₃, with the diameter of 2 mm and 1.5 mm were used for the halite and gypsum, respectively. The impact velocity was ranged from 1.9 to 7.2 km/s. A nylon-slit sabot [6] was used to accelerate the projectile. The peak pressures at the impact point are estimated to be 10–110 GPa by the one-dimensional impedance method [e.g., 7]. Hereafter, the peak pressure is called as 1-D pressure. The shock Hugoniot parameters are taken from [8-10]. We produced a He gas flow using a rotary pump directed to a quadrupole mass spectrometer (QMS, Pfeiffer vacuum, Prisma plus QMG220) to introduce impact-generated vapor into the QMS efficiently. An experimental chamber was pressurized by the equilibrium pressure determined by a balance between He gas injection and the evacuation by the pump to prevent the intrusion of the contaminant gases from the gun [4]. The equilibrium pressure was set to 500 Pa. To detect water vapor from the gypsum targets, we used a cold trap that uses liquid nitrogen in the experiments with gypsum. The temperature of the gypsum prior to a shot was ~250 K.

**Results:** We describe the results of the mass spectrometry of shock-generated gases. Note that the ion current for the mass number M/Z = i is denoted as Iᵢ.

**Halite:** Figure 1a shows a typical example of the time variations of the ion currents of selected mass numbers. We detected the rise in I₁₈ (NaCl⁻) and I₇₀ (Cl⁻) after the impact although the peak current ratios I₈/I₄ and I₇₀/I₄ were only 1–10 ppm. The current ratio to I₄ (He⁺) is roughly approximated as the partial pressure of the species with the mass number i of the experimental chamber because the total pressure in the chamber was mostly supported by He.

Figure 2a shows the time variations of the current ratios of I₁₈/I₄ at different shock pressures. We found that halite initiates vaporization between 18 GPa and 31 GPa against growing 1-D shock pressure.

**Gypsum:** Figure 1b is the same as Figure 1a except for the target material. The cold trap allowed us to largely reduce the background level of I₁₈. The shock-generated water vapor was clearly detected. In contrast, sulfur-bearing gases, such as SO₂, were not clearly risen after the impact even at 7.2 km/s. The estimated 1-D pressure of this shot reaches 114 GPa.

Figure 2b shows the same as Figure 2a except that the target was gypsum and that the current ratio I₁₈/I₄ is shown. We observed the rises in I₁₈/I₄ even at 2.0 km/s. In contrast, I₁₈/I₄ were staying at the background

![Figure 1](image-url) **Figure 1.** Time variations of selected species for (a) halite and (b) gypsum. The impact velocities of the shots are indicated in the figure.
level in the blank experiment at 2.0 km/s, suggesting that gypsum suffers the water loss at <11 GPa.

Discussion and Conclusions: In the current experimental system, the quantitative measurements of the gases produced are not available. Here, we discuss the initiation of the vaporization/devolatilization of the evaporites with increasing 1-D pressure and the chemical composition of the generated vapor.

Vaporization/Devolatilization threshold: The vaporization/devolatilization of NaCl and gypsum occur at ~1,200 K [estimated by a thermodynamic calculation, e.g., 11] and ~370 K [e.g., 12] under a vacuum condition. Thus, if the post shock temperatures $T_{\text{post}}$ exceed the above temperatures, vaporization/devolatilization should occur [e.g., 13]. Figure 3 shows the post shock temperature as a function of the 1-D pressures $P_{\text{ID}}$. Note that an isentropic release from the peak shock state, the constant isochoric specific heat of the Dulong-Petit value were assumed and that the Mie-Grüneisen EOS was used in the $T_{\text{post}}$ calculation [e.g., 14]. We found that the vaporization/devolatilization from the evaporites occurs at systematically lower $P_{\text{ID}}$ than expected by the simple thermodynamic estimate. These results imply that local energy concentration due to jetting [e.g., 15] and shear banding [16], and/or irreversible heating due to friction and plastic deformation [17], play a key role to determine the thresholds.

Gas composition: Sulfur release from the gypsum targets were not clearly detected even at $P_{\text{ID}} = 114$ GPa. Nevertheless, the required shock pressure for incipient/complete sulfur release from anhydrite (CaSO$_4$) has been estimated to be 32.5 GPa/122 GPa

[18]. This difference between gypsum and anhydrite suggests that the stability of sulfur against impact shocks is largely different depending on the initial form of the sulfur-bearing sedimentary rocks.

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