Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PPS004-20 Room: 201A Time: May 25 15:45-16:00

A pressure measurement method of high-temperature rock vapor plumes using atomic line broadening

Kosuke Kurosawa[1*], Seiji Sugita[1]

[1]Grad. Sch. of Fr. Sci., Univ. of Tokyo

Pressure is essential for understanding phase changes and chemical reactions. Although a number of measurement methods for impact-induced vapor plumes have been developed, no reliable method to measure pressure is available. In this study, we developed a pressure measurement method of vapor cloud using the spectral line broadening. Under the nearest-neighbor-approximation, we can analytically express the full width at half maximum (FWHM) as a function of the perturber number density. Based on these relations and spectroscopic constants of atomic emission lines of Fe I at 381.58 nm and Ca I at 646.26 nm, we found that the quadratic Stark broadening is dominant if the degree of ionization is higher than 1 %. The resonance and van der Waals broadening should be considered when the degree of ionization is lower than 1%. Based on such consideration of appropriate broadening mechanisms, we can accurately estimate the pressure in the vapor clouds. We conducted laser ablation experiments using the proposed pressure-measurement method along with the Boltzmann-plot method for temperature. The obtained pressures and temperatures agree well with theoretically predicted trends; the change in pressures and temperatures are consistent with an adiabatic expansion. This strongly suggests that the proposed method can measure pressure accurately. Because any thermodynamic quantities can be determined when both pressure and temperature are given, our method enables a complete thermodynamic description of vapor clouds. Thus, the proposed method can serve as a powerful tool in investigating thermodynamic and chemical properties of impact- and laser-induced vapor clouds.

Keywords: Impact-induced vapor clouds, Evolution of surface environment on planets, Pressure-Temperature path, Chemical reaction, Emission spectroscopy, Atomic line broadening