Development of stepwise heating gas extraction system for the analyses of noble gases in mission-returned samples

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Introduction: Being chemically inert, noble gases are ideal tracers for unveiling the origin and chronology of planetary objects [1-5]. Noble gas isotopes can be trapped, implanted, and produced in-situ, the distribution of which reflects the integrated history of the material. Grains exposed on the surfaces of planetary bodies have complex histories and carry multiple noble gas components. These components have been resolved using stepwise gas extraction or surface etching technique. Laser heating is suitable for analyses of returned samples which are limited in mass as it causes minimal warming of vacuum walls which results in lower background signals compared to conventional resistance furnaces. However, this typically comes at the cost of inaccurate temperature control capability. By precisely controlling the temperature steps during laser gas extraction, we aim to separate different noble gas components of the surface-implanted, indigenous and in-situ (cosmogenic, radiogenic and nucleogenic) origins, which maximizes the information acquired from each analysis of returned samples.

Design and implementation: Various types of laser systems including diode, CO_2 and Nd-YAG lasers have been used for noble gas extraction. Here, we use a Nd-YAG fiber laser widely applied for welding and cutting metals. Fiber lasers are also commonly used in the field of mineral physics for heating minerals during high pressure experiments [6]. Following the methodology developed in geochronology [7,8], samples are encased in small metal packets to attain a homogeneous temperature. Two optical pyrometers of different temperature ranges cover 100 °C to 2600 °C and are implemented in a feedback loop with the laser power supply for accurate temperature controls. Towards the goal of acquiring diffusion-controlled gas release spectra from which the initial gas distribution can be reconstructed, the temperature stability and accuracy of the heating system will be reported.

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