Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2023

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Category: ☑International Joint Research ☐General Joint Research ☐Joint Use of Facility ☐Workshop

Name of the research project: Mineralogical and Spectral Characteristics of Natural and Synthesized Jarosite-Alunite Samples, and Implications for Mars' Exploration

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Affiliated institution and department: Western University, Earth Sciences

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Research report:

Short-term Objectives:

(1) Conduct comprehensive structural, chemical, and spectral analyses of synthesized and natural jarosite and alunite samples.

(2) Identify differences between synthesized jarosite-alunite samples produced under controlled hydrothermal conditions and natural samples sourced from various geological settings.

(3) Determine the detailed mineral compositions and modal abundances in natural samples originating from diverse geological environments. Additionally, elucidate how these varied geological settings have influenced the texture, mineralogy, chemistry, and morphology of these natural samples.

Long-term Objectives:

(a) Potential Application in Mars Exploration: The acquired XRD and IR data will establish a refined library for current and future Mars payload missions, such as CheMin of Curiosity and SuperCam of Mars 2020. This library will facilitate in-situ detection of jarosite-alunite minerals, particularly solid solutions and mixtures of different types of jarosites and alunites.

(b) Deciphering Geological Environments: Utilizing the observations from the natural samples acquired thus far, we aim to decipher geological environments, including acidic and aqueous conditions, both on Earth and

Mars, where jarosite and/or alunite have been discovered. Furthermore, the study of these samples may yield valuable insights into the surface geological and climatic evolution of Mars.

Research Conducted:

(1) Successfully synthesized three series (~40) of jarosite and alunite samples under hydrothermal conditions (140 to 190°C) with the assistance of Dr. Flemming from Western University. Additionally, obtained 11 natural jarosite-alunite specimens on loan from the Hutchinson Suite museum at Western University.

(2) Obtained micro-XRD data of the natural samples using Bruker-AXS D8 Discover diffractometer and initial results regarding their mineralogy and textural features under the guidance of Dr. Flemming.

(3) Prepared samples for powder X-ray diffraction (pXRD) and Fourier-transform infrared (FTIR) analyses at IPM, including grinding and drying, with instructions from Dr. Izawa.

(4) Conducted pXRD data collection on 10 jarosite and alunite samples, each taking approximately 20 hours, and acquired FTIR data (reflective and transmission modes) for six samples, under the supervision of Dr. Izawa and Dr. Yamashita, respectively.

(5) Analyzed the chemical compositions of 10 natural samples and 12 synthesized samples using inductively coupled plasma mass spectrometry (ICP-MS) with guidance and instructions from Dr. Yokoyama, Dr. Masuda, and Dr. Gautam from the Tokyo Institute of Technology.

Research Outcomes:

(1) I acquired practical experience in operating the Rigaku SmartLab powder X-ray diffraction (pXRD) machine at IPM for the first time, along with learning the procedures for micro-FTIR analysis. Additionally, I gained proficiency in the complex sample preparation techniques required for essential for conducting precise and accurate ICP-MS analysis. This comprehensive training equipped me with a diverse skill set essential for conducting advanced analytical procedures in future research endeavors.

(2) Following the consolidation of preliminary results derived from micro-XRD, powder-XRD, FTIR, and ICP-MS analyses, I organized the findings and submitted one abstract to the 55th Lunar and Planetary Science Conference (LPSC), underscoring our research's significance in the planetary science community. A copy of the submitted abstract is included with this document.

(3) I actively participated as a collaborator and research assistant in the Canadian Space Agency-funded In Situ X-Ray Diffraction (ISXRD) project, led by Dr. Flemming. My role encompassed contributing to the project's objectives by sharing preliminary X-ray diffraction (XRD) analysis results of the natural jarosite and alunite samples, particularly pertaining to mineralogical insights. This involvement underscored my commitment to advancing the project's goals and furthered my understanding of in situ XRD methodologies and applications.