

**JOINT RESEARCH PROJECT**

**FINAL REPORT**  
**For Japan-Korea Joint Research Project**

AREA	1. Mathematics & Physics 2. Chemistry & Material Science 3. Biology 4. Informatics & Mechatronics ⑤ Geo-Science & Space Science 6. Medical Science 7. Humanities & Social Sciences
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1. **Research Title:** Study of Geochemical Evolution and Radiation Environment with KAGUYA Lunar Gamma Ray Spectrometer \_\_\_\_\_

2. **Term of Research:** From 1th, July, 2009 To 30th, June, 2011

3. **Total Budget**

a. Financial Support by JSPS: Total amount: 2400 thousand yen

1<sup>st</sup> Year 600 thousand yen      2<sup>nd</sup> Year 1200 thousand yen

3<sup>rd</sup> Year 600 thousand yen

b. Other Financial Support : Total amount: 5,000 thousand yen

4. **Project Organization**

<b>a. Japanese Principal Researcher</b>	
Name	Nobuyuki HASEBE
Institution / Department	Research Institute for Science and Engineering, Waseda University
Position	Professor
<b>b. Korean Principal Researcher</b>	
Name	Kyeong Ja KIM
Institution / Department	Korea Institute of Geoscience and Mineral Resources
Position	Senior Researcher

**c. List of Japanese-side Participants (Except for Principal Researcher)**

Name	Institution/Department	Position
Yoshitaka AMANO	Research Institute for Science and Engineering, Waseda University	Professor
Hiroshi NGAOKA	Research Institute for Science and Engineering, Waseda University	JSPS Research Fellow (DC1)
Kanako HAYATSU	Research Institute for Science and Engineering, Waseda University	JSPS Research Fellow (DC2)
Jiro Machida	Research Institute for Science and Engineering, Waseda University	Student (M2)
Manabu KATO	Japan Aerospace Exploration Agency	Professor
Makoto HAREYAMA	Japan Aerospace Exploration Agency	Researcher
Shigo KOBAYASHI	Japan Aerospace Exploration Agency	JSPS Research Fellow (PD)
Yuzuru KAROUJI	Japan Aerospace Exploration Agency	Researcher
Mitsuru EBIHARA	Tokyo Metropolitan University,	Professor
Kunitomo SAKURAI	Kanagawa University	Professor

**d. List of Korean-side Participants (Except for Principal Researcher)**

Name	Institution/Department	Position
Takao KOBAYASHI	Korea Institute of Geoscience and Mineral Resources	Researcher
Sung-Soon LEE	Korea Institute of Geoscience and Mineral Resources	Senior Researcher
Robert C. REEDY	Planetary Science Institute	Senior Scientist
Darrell DRAKE	Tech Source	Scientist
A.J. Timothy JULL	University of Arizona	Professor
Hyun-Ju OH	Yonsei University	Graduate Student
Seung Ryeol LEE	Korea Institute of Geoscience and Mineral Resources	Senior Researcher
Kwang-Eun KIM	Korea Institute of Geoscience and Mineral Resources	Senior Researcher
Su-Yeon Oh	Chungnam National University	Scientist
Jong-Dae Sohn	Chungnam National University	Graduate Student
Jae-Woo Park	Korea Aerospace Research Institute	Researcher
Tai-Sik Lee	Hangyang University	Professor

**5. Number of Exchanges during the Final Fiscal Year\***

**a. from Japan to Korea**

\*Japanese fiscal year begins April 1.

Name	Home Institution	Duration	Host Institution
Hiroshi Nagaoka	Research Institute for Science and Engineering, Waseda University	From 29 <sup>th</sup> , May, 2011 to 18 <sup>th</sup> June 2011	Korea Institute of Geoscience and Mineral Resources
For Final Fiscal Year(FY2011) Total: <u>  1  </u> persons		For Final Fiscal Year(FY2011) Total: <u>  21  </u> man-days	
Numbers of Exchanges during the past fiscal years			
FY2009: Total <u>  6  </u> persons			
FY2010: Total <u>  4  </u> persons			

**b. from Korea to Japan**

Name	Home Institution	Duration	Host Institution
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For Final Fiscal Year(FY2011) Total: <u>  0  </u> persons		For Final Fiscal Year(FY2011) Total: <u>  0  </u> man-days	
Numbers of Exchanges during the past fiscal years			
FY2009: Total <u>  2  </u> persons			
FY2010: Total <u>  7  </u> persons			

## 6. Objective of Research

Japan is leading the world by the success in a large-scale moon exploration, Kaguya, now. It can be said that this program is in a very advantageous situation in which every country in the world is paying a great attention to the excellent scientific data observed by Kaguya. Therefore, the lunar researchers in Japan think that they can positively contribute to the development of the moon and the planetary explorations in Asia in the future. It is amazed in a rapid progress of the moon exploration of China and India toward the utilization of lunar resources. South Korea has the strong interest in the space development, and is promoting the moon exploration. Energies not only is devoted to the development of an original satellite to the moon but also the importance of the lunar network formation in the Asia countries is emphasized.

Dr Kyeong Ja Kim in South Korea is the leader to establish the Korean Lunar and Planetary exploration Program. She devotes her energies to the development of Korean missions to the moon. Dr. Kim, PI in South Korea counterpart is one of co-investigators (Co-Is) of the Kaguya Gamma Ray Spectrometer team (KGRS-team) .She is also a Co-I in the it and Mars Odyssey GRS. South Korea has recently emphasized the exploration of the Moon. Because Dr. Kim, research representative in South Korea in this bilateral program, is one of Co-Is in Kaguya Gamma Ray Spectrometer KGRS team and also a Co-I in Mars Odyssey GRS, she is eligible in the cooperation programs between the Japan-South Korea. We Japanese team cooperates to foster and establish Korean lunar and planetary group and Korean lunar missions toward the near future.

From the point of Scientific aspect, the distribution of major and trace elements in the lunar surface is essential to understand the origin and evolution of the crust of the moon. Gamma-ray spectrometers carried on the previous lunar missions are a powerful instrument to determine the chemical element abundances over the lunar surface.

In the first Japanese lunar polar orbiter, Kaguya, launched on September 14, 2007, a HP-Ge detector was firstly used as a main detector of the Kaguya Gamma Ray Spectrometer (KGRS) to globally observe the lunar surface. The KGRS has been providing precise global abundances of natural radioactive nuclides such as K, Th and U, and major elements such as O, Mg, Al, Si, Ca, Ti and Fe with a high precision in the lunar subsurface and the precise data for the future utilization of lunar resources.

The purpose of this research is to promote our understanding of the Moon using new elemental data measured by KGRS as well as other observation data obtained by Kaguya mission. Furthermore, we aim to develop new instrument for the measurement of elemental abundances on the lunar surface for the future missions in Japan and Korea, and assist Korea team to foster and develop the technology of nuclear planetology for the Korean lunar missions.

By holding international symposiums, workshops and exchanging scientist and students between the countries, the promotion of young scientists and understanding of the Moon can be achieved through this JSPS program.

## 7. Methodology

### [1] The support for Korean lunar exploration in future (nuclear selenology)

Korean space exploration has been growing rapidly. South Korea has the much interest in the lunar exploration as mentioned before. Dr. K.J. Kim is the leading driving forces of lunar and planetary missions in Korea. Korea will send lunar missions to the Moon in the early 2020s. She and her colleagues has a strong intent and has been making every effort to carry nuclear spectrometers on lunar orbiters or rovers. We Japanese team cooperates to foster and establish Korean lunar and planetary group toward the near future. Then, we held an International Symposium, four International Workshops, and Education School at KIGAM. We invited leading lunar and planetary scientists from Asia, Europe, and US to the symposium and workshops.

#### 1) An International Symposium :

International Symposium of the Science and Utilization of the Moon --- Based on Scientific Achievements from Kaguya and Other Missions and Future Planning of Lunar Resources --- (SUM 2010)

#### 2) Four International Workshops : The Korea-Japan Collaborative Lunar Exploration Workshops Two times in Waseda (FY 2009 and 2010) and two times in Kigam (FY 2009 and 2010)

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### **[2] The Analysis of Kaguya Gamma Ray Spectrometer**

One of important purposes of this research is to analyze the KGRS data observed by Kaguya and to derive global distributions of major elements on the lunar surface. We analyzed calcium (Ca), Aluminum (Al), silicon (Si) and oxygen (O) peaks in the energy spectra measured by KGRS. These light elements are difficult to make the precise analysis, because careful correction and calibration are quite necessary. Japanese and Korean sides independently created the distribution maps of Si and O on the lunar surface, and checked/adjusted them and then finally reached a good agreement within the error. Their results will be published in the academic journal soon.

Japanese team sent young and active scientists and students to KIGAM and Korean team send scientists to Japan in order to promote the activities.