GIS-Based Geological Investigation of the South Pole-Aitken Basin using KAGUYA (SELENE) Gamma-Ray Spectrometer. K. J. Kim[1], J. M. Dohm[2], J.-P. Williams[3], J. Ruiz[4], T. M. Hare[5], N. Hasebe[6], N.Yamashita[7], Y. Karouji[6], S. Kobayashi[8], M. Hareyama[8], E. Shibamura[9], M. Kobayashi[10], C. D'Uston[7], O. Gasnault[7], O. Forni[7], R. C. Reedy[11]. [1]Korea Institute of Geosciences & Mineral Resources, Republic of Korea (kjkim@kigam.re.kr), [2]Dept. Hydrology and Water Resources, Univ. of Arizona, Tucson, AZ, 85721, USA, [3]Dept. of Earth and Space Sciences, University of California, Los Angeles, CA90095, USA, [4]Dept of Geodinámica, Universidad complutense de Madrid, Spain, [5]U.S.G.S., Flagstaff, USA, [6]RISE, Waseda University, Japan, [7]IRAP, Toulouse, France, [8]JAXA Japan, [9]Saitama Prefectural University, Japan, [10]Chiba Institute of Technology, Japan, [11]Planetary Science Institute, USA

Introduction: Large impact events have significantly influenced the geologic history of the Moon. The South Pole-Aiken basin (SPA) is the one such event that resulted in a ~2,500-km-diameter impact crater during the pre-Nectarian period. The basin is the largest unambiguously recognized impact structure in the Solar System, centered at 56°S, 180°W on the farside of the Moon [1,2]. The SPA basin region is one of two lunar regions with conspicuous elemental abundances (e.g., iron (Fe)) when compared to other parts of the Moon [3,4]. FeO and TiO_2 concentrations in the SPA basin region indicate the presence of possible upper mantle materials [5] or noritic (lower crust) material [6]. The noritic material is also seen in central peaks in SPA impact-melt [7]. Localized and minor abundances of olivine possibly suggest otherwise [6,8,9] or alternately a unique mantle composition for this part of the Moon.

Based on the size of the SPA basin and its certain influence on the geologic evolution of the Moon, as well as its distinct Fe signature, we performed a comparative analysis among the stratigraphy, as defined using published USGS geologic maps and the Kaguya (SELENE) Gamma Ray Spectrometer (KGRS) elemental information of the basin region using Geographic Information Systems (GIS) [10].

Methods: Our method to compare the geologic evolution of the SPA region with elemental data requires that we determine the spatial and temporal extent of the rock materials (mapped units) and the total area of the SPA basin region. To determine the temporal extent of the SPA basin region, our approach requires the definition of major stages of geologic activity for the region. Based on the geologic investigation of Wilhelms (1987) and radioactive dates determined from Apollo rock samples, we choose Pre-Nectarian and Nectarian activity, which includes surfaces resulting from the SPA event (stage 1: type locality is Apollo 17 with an absolute date of 4.5 Ga), the Imbrium and Orientale impact events (stage 2: type locality is Apollo 14 with an absolute date of 3.9 Ga), and mare volcanism that occurred subsequent to the Imbrium and Orientale impact events (stage 3: type locality is Apollo 12 with an absolute date of 3.5 Ga) as the major stages of geologic activity of the Moon (Figure 1) [1].

The SELENE mission is the first to employ a germanium (Ge) detector to observe lunar Gamma Rays of Al, Mg, Si, Ca, Ti, Fe, Th, and U in a 100 km and 50 km lunar polar orbits. [11-13]. The major elemental maps of Fe, Ti, Si, and O have been more recently compiled and made available for comparative analysis. 10 degree KGRS data were used to produce the elemental maps, and the gamma-ray energy of each element was chosen to be 7631, 984, 4934, and 6129 keV for Fe, Ti, Si, and O, respectively. We performed a comparative analysis among stratigraphy and KGRS natural radioactive element (K) and major elements (Fe, Ti, Si, and O) data using GIS.

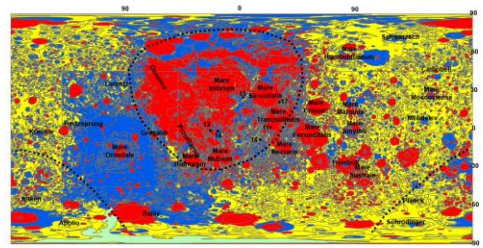

Figure 1. Stage 1 (yellow), stage 2 (blue), and stage 3 (red) assignments of the map units of published USGS geologic maps [10].

Results: From an elemental perspective, when compared to the rest of the Moon, the SPA basin region is one of two elementally distinct regions (the other is Procellarum-Imbrium), which includes enrichment in Fe, FeO, and TiO_2 [14], and Mg [15,16]. The GIS-based results indicate that the materials within the basin region exhibit similar K abundance when compared to those outside of the basin region, though there are visibly local highs and lows (Figure 2). Very little change in K concentrations through time indicates that SPA materials have not been significantly altered since impact [1].

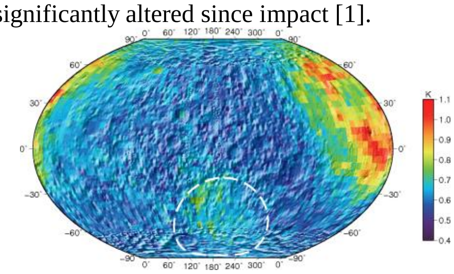

Figure 2. Modified from Kobayashi et al. (2010). The global map of K gamma-ray counting rate (in counts per second) as measured by KGRS. Note that the SPA basin (dashed line) is relatively indistinct in K.

There is an notable increase in elemental abundance of Fe, Ti, Si, and O when comparing these elements to stage 1 rock materials. This is interpreted to indicate post-SPA impact cratering and mare basaltic volcanism (Figures 3-4). For example, O is clearly shown to be depleted during the early stage of SPA with respect to the later stages of activity. Interpretations of this signature include resurfacing of the more ancient materials by impact cratering (including ejecta from Orientale) and basaltic mare volcanism, oxygen depletion of stage 1 materials due to the SPA impact event of SPA (Figure 4), and/or geomchemical differences which reflect different sources of the various rock materials (e.g., SPA-event materials vs. maria).

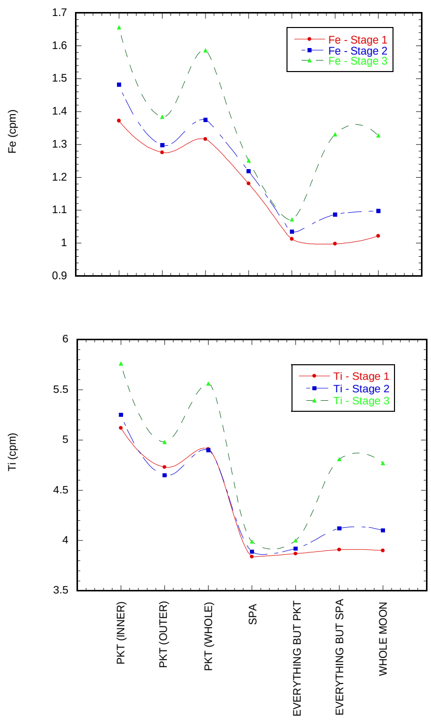

Figure 3. This plot shows an increase in both Fe and Ti concentrations in SPA during stages 2 and 3 interpreted in part to mark resurfacing by both impact cratering and volcanism during stages 2 and 3, respectively.

Discussion: Our study shows that while the SPA basin materials are elementally distinct mostly in Fe, and Ti, O, Si with respect to their changes through the time, it is much less distinct when considering K and Th with the rest of the Moon, with the exception of the prominent Procellarum-imbrium region as shown by this investigation. We interpret the results of our investigation as marking an ancient period (mostly pre-Nectarian) of impact crater mixing during the period of heavy bombardment (a large percentage of the rock surfaces reflect pre-Nectarian SPA and subsequent impact crater events of regional extent outside of SPA basin region such as Orientale). More work is required which includes a GIS-based investigation among the stratigraphy, elemental compositions, and topographic, structural, and geophysical characteristics of the SPA basin and the Procellarum-Imbrium region. This study confirms that the elemental signatures of major elements of SPA are key evidences in unraveling geological history of SPA when these elemental signatures are represented with respect to stratigraphic information.

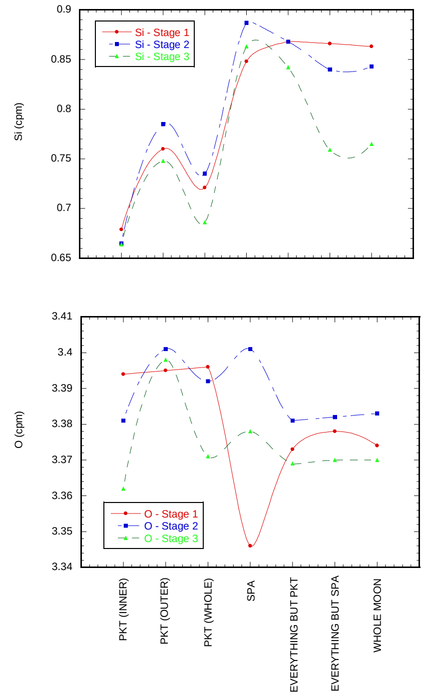

Figure 2. The two plots show the average count of Si and O for each of the regions of interest, respectively. The Si plot shows that Si has been significantly increased in stage 2 (heavy bombardment period) and Si concentration for stage 1 was lower than that of stages 2 and 3. In the case of O, significant depletion of O is clearly visible in stage 1

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