Comparative study of near- and far-side lunar soils: Toward the understanding early evolution of the Earth

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Because of the almost total lack of geological record on the Earth for the time before 4 Ga, the Earth history during this period is still enigmatic. We propose that a comparative study of far- and near-side lunar soil would shed new light on this dark age of the Earth history.

Due to a strong dynamic coupling between the Earth and the Moon, studies of Earth-Moon dynamics have concluded that the Earth has been facing only to the near-side of the Moon since the formation of the Earth-Moon system [e.g.1]. Also, theories have suggested that due to tidal energy dissipation, the Moon has been receding from the Earth. Therefore, we infer that there may have been substantial interaction between the Earth through the atmosphere and the near-side lunar surface, especially in ancient time, whereas the far-side has remained essentially intact to the terrestrial atmospheric influence.

We suggest that the comparison of the far-side and near-side surface samples may impose unparalleled constraints on the evolution of the Earth such as those listed below. By analyzing isotopic ratios and elemental abundances of volatile elements (O, N, light noble gases) implanted on lunar surface minerals, we may tackle the following fundamental problems.

1. When did the geomagnetic field (GMF) first appear? Heber et al. [2] observed anomalous noble gas and nitrogen isotopic compositions in Apollo lunar ilmenites, which are quite different from the generally assumed solar components. Ozima et al. [3] showed that the isotopic compositions were attributable to the mixing of the Solar components with terrestrial atmospheric components. They suggested that the terrestrial components have been transported from the Earth and implanted on lunar soils during the period when the Earth had not fully developed the geomagnetic field (GMF). Therefore, if their interpretation were correct, the youngest age of ilmenite grains which show terrestrial isotopic signature in N and light noble gases would impose a crucial constraint on the onset time of the GMF.

2. When did the biotic oxygen atmosphere form? Recently, Ireland et al. [4] reported oxygen implanted in lunar metal particles, which were mass-independently positively fractionated relative to the mean terrestrial oxygen. Since the isotopic ratio of this oxygen is very close to oxygen in the ozone layer, Ozima et al. [5] suggested that oxygen generated in the ozone layer was transported from the Earth to the Moon. Therefore, if the ozone-layer like oxygen indeed came from the Earth, the oldest record of this particular oxygen would constrain the initiation of the biotic Earth atmosphere.

3. Has the day length changed in geological time?

If the Moon has been receding from the Earth due to tidal energy dissipation, we expect that the day length of the Earth should also have changed accordingly. We suggest that a final answer to this intriguing problem can be reached by examining the following two relevant problems by systematic comparison between far- and near-side lunar soils for terrestrial volatile components.

(a) We can identify the time when identical periods of rotation (Earth) and revolution (Moon) had taken place from the last appearance of terrestrial components in far-side soils. (b) We would expect a systematic decrease of terrestrial volatile components on the near-side soils, if the Earth-Moon distance has been increasing. Answers to these questions would add observational confirmation to the theory on the Earth-Moon dynamic system for the first time.

References: [1] Murray C.D. and Dermott S.F. (1999) Solar System Dynamics, Cambridge U. Press, Cambridge. [2] Heber V. et al. (2003) Astrophys. J. 597, 602-614. [3] Ozima M. et al. (2005), Nature 436, 655-659. [4] Ireland T.R. et al. (2006) Nature 440, 775-778. [5] Ozima M. et al (2007) LPSC XXXII (submitted).

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