

Noble Gases in Lunar Farside: Insights into Solar Wind Dynamics and Isotopic Variations

XUHANG ZHANG¹, FEI SU² AND HUAIYU HE¹

¹Key Laboratory of Earth and Planetary Physics, Institute of
Geology and Geophysics, Chinese Academy of Sciences, Beijing
100029, China

²Institute of Geology and Geophysics, Chinese Academy of
Sciences

The origin and distribution of lunar volatiles remain subjects of debate, particularly regarding hemispheric differences and isotopic fractionation mechanisms. The Moon's lack of an atmosphere and a global magnetic field for most of its history means that the volatiles in its soils mainly originate from solar wind implantation and impacts from meteorites and comets. However, the potential differences in volatile composition between the near and far sides of the Moon have not been thoroughly investigated, leaving the current understanding of volatile origins ambiguous. In this study, we present the noble gas compositions of lunar soil samples from the farside, collected by Chang'e-6 mission. Ne isotope data suggest the presence of a highly fractionated solar wind compositions, while solar wind-derived Kr and Xe isotopes are clearly distinguishable from meteoritic and cometary contributions. These findings, in contrast to those obtained from Chang'e-5 and other nearside samples, indicate that solar wind implantation is deeper on the farside of the Moon. This hemispheric variation can be attributed to the presence of slower solar wind arriving at the Moon's nearside, as it interacts with Earth's magnet, which is absent on the farside. Therefore, the Earth's magnetosphere plays a crucial role in modulating the velocity of the solar wind impacting the Moon, influencing the distribution and isotopic diversity of volatiles. The observed differences on the lunar farside provide new insights into the evolution of the Sun-Earth-Moon system.