NOBLE GASES IN RECENTLY FOUND HOT AND COLD DESERT LUNAR METEORITES.

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Introduction: The Moon preserves a unique record of early planetary formation and differentiation processes, and serves as a valuable archive of impact cratering in the inner solar system, cosmic radiation and solar wind (SW) over billions of years. Lunar exploration missions have provided large amounts of sample material from several regions on the lunar nearside. Samples from the lunar farside, however, are so far only available by lunar meteorites. Their noble gas isotopic and elemental compositions reveal the nature of the SW as well as the lunar surface exposure, impact, and transport history, respectively. Here we present the first noble gas data on seven relatively recently found lunar meteorites and attempt to elucidate their pre-terrestrial histories.

Samples: Noble gas analyses were carried out on six Antarctic lunar meteorites (LaPaz Icefield LAP 02205 (L05 hereafter), 02224 (L24), 02226 (L26) and 02436 (L36), Meteorite Hills MET 01210 (MET), and Pecora Escarpment PCA02007 (PCA)) and a recently (2015) found Northwest African lunar meteorite (NWA10404 (NWA)). The four LAP meteorites are unbrecciated, low-Ti crystalline mare basalts [1]. Launch crater pairing is inferred by cosmogenic nuclide concentrations [2], bulk chemical compositions [3], petrography, and mineral chemistry [4]. MET has been classified as regolith breccia with a mare basalt and highland component [5,6]. NWA represents a lunar feldspatic breccia that exhibits a unique, mostly vitric and highly vesicular matrix [7-9]. Remarkable angular to rounded glass fragments indicate a regolith breccia origin of NWA [8]. PCA comprises a feldspatic regolith breccia composed of mature regolith [10]. All studied samples lack fusion crust.

Methods: Sample masses for suitable noble gas amounts were estimated based on literature noble gas concentrations from launch-paired meteorites [11-13]. Fragments with weights of 1 to 100 mg were separated, wrapped in Al foil, and degassed in a UHV system at 80 °C for several days prior to measurement. Noble gases were extracted by fusion in one heating step to ~1700 °C for 20 minutes. Gas separation into three phases containing He-Ne, Ar, and Kr-Xe was achieved with activated charcoals held at -196 °C, and -125 °C, respectively. Several getters and cold traps were applied for gas purification. Measurements of all stable noble gas isotopes from He to Xe were carried out in static vacuum on a custom-built single-collector magnetic-sector noble gas mass spectrometer equipped with a Baur-Signer ion source [14]. For all samples, total gas release was verified by re-extraction at temperatures of about 1750 °C.

Results and Discussion: The seven studied lunar meteorites can be divided into two groups with different pre-terrestrial histories. The Ne three-isotope plot yields a pure cosmogenic component for L26 and L05 while L24, L36, MET, NWA, and PCA exhibit significant amounts of fractionated SW. Minor offsets in the Ne isotopic compositions of L24, L36, and MET towards higher ^{21}Ne and ^{22}Ne concentrations indicate admixture of small quantities of cosmogenic Ne. Argon and Kr isotopic ratios confirm the essentially pure cosmogenic component in L26 and L05 and an additional SW component in all other samples. The distinct noble gas patterns of the four LAP meteorites with only two containing abundant SW is surprising, since previous studies proposed launch crater pairing of all samples and an unbrecciated mare basalt origin [see, e.g., 15 and references therein]. Interestingly, L24 exhibits a vesicular fusion crust that has been suggested to originate from SW-implanted gases and, hence, a lunar near-surface origin for this lunar meteorite is indicated [16]. In contrast, Kr in the SW-free L26 and L05 reveals a neutron-induced production of ^{80}Kr and ^{82}Kr and, therefore, a comparatively high shielding depth, in agreement with the lack of SW and conclusions by [2]. The detailed study of the cosmogenic and SW record in the He-Xe isotopic and elemental compositions will be presented at the meeting. It will shed more light on the issue of the surprising presence of SW in L24 and L36, will assess source crater pairing and irradiation history, and will provide nominal gas-retention ages.

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