ESTABLISHING METEORITE PARENT BODIES AND UNDERSTANDING PLANETARY REGOLITHS BY NOBLE GAS ANALYSIS OF RETURNED SAMPLES. J. A. Cartwright[1] and U. Ott[1]. [1]Max-Planck Institute für Chemie, Joh.-Joachim-Becher-Weg 27, Mainz, Germany. julia.cartwright@mpic.de

Meteorite vs. Returned Sample: Noble gas analysis of meteorites has helped determine different physical and chemical properties including crystallisation ages, and the resolution of different sources (planetary/cosmogenic/solar) and components (interior/atmospheric) [1-6]. Such analysis is thus significant in resolving planet/moon/asteroid-specific noble gas signatures, which can further the understanding of parent body formation and evolution. In addition, the timing and severity of parent body ejection events responsible for our meteorite inventory can be better resolved by studying cosmogenic noble gases and cosmic ray exposure (CRE) ages [7]. However, the lack of returned samples from the inner planets, moons and asteroid belt represents a clear restriction in our ability to fully assign specific meteorite groups and their noble gas signatures to specific parent bodies. Moreover, terrestrial contamination of meteorites can lead to overprinting/ masking of primary noble gas components, particularly those similar to Earth's atmosphere [8]. Such contamination issues could be reduced with appropriate storage of returned samples. Here we describe the advantages of returned samples and associated noble gas analysis with case studies of the moon, Mars and asteroids.

Lunar meteorites vs. Apollo samples: The successful return of Apollo samples led to a significant reduction in "lunar" meteorites, as studies revealed that a number of suspected samples did not share similarities with recovered material (e.g. chondrites) [9]. Of the true lunar meteorites discovered later, many showed solar wind components identical to those found in the Apollo samples [1], confirming that returned samples are vital to understanding our meteorite inventory.

Martian meteorites vs. in-situ surface analyses: Direct proof for a Martian SNC (shergottite, nakhlite, chassignite) group origin was reported following noble gas analysis of trapped gas inclusions within EET 79001 [3], where Ar, Kr and Xe elemental and isotopic ratios identical to *in-situ* Viking Martian atmosphere data [10] were observed. However, *in-situ* surface analyses have clear accuracy and detection limitations, and for Viking a number of isotopes could not be measured (e.g. $^{21-22}$Ne). In the absence of returned Martian samples (which would also clarify an SNC Martian origin), we are forced to rely on SNC's to provide a better means of studying the Martian atmosphere.

HED meteorites vs. Asteroid observations: The HED (howardite, eucrite, diogenite) group likely originated from asteroid 4 Vesta [11-12], though in the absence of both surface measurements and returned samples, this cannot be proven. Noble gas analysis of HED's has revealed implanted solar wind in addition to cosmogenic gas [4]: the comparison with returned Vesta samples would help prove its parent body status.

Solar wind and impact gardening: A further research area that requires sample return lies in resolving the extent of impact gardening on planetary surfaces. This is important for understanding regolith formation processes, better defining the "genetic make-up" of soils from planet/asteroid surfaces, and understanding "regolithic" meteorites, which can be assessed by examining the extent of trapped solar wind noble gases within returned soil samples. As solar wind is only implanted in the top nanometers of solid material, extensive impact gardening of a regolith would show solar wind components at great depths within soil samples.

Lunar regolith: Lunar soils from depths up to 2.4 m showed clear solar wind components, indicative of thorough gardening [2], and the returned soil samples provide a useful record of solar activity.

Martian regolith: In principle, whilst solar wind cannot penetrate the Martian atmosphere, cosmogenic noble gases (e.g. $^{21}Ne_{cos}$) within Martian soil samples could be used constrain surface exposure ages and erosion rates in combination with analysis of short lived radioactive nuclides (e.g. ^{10}Be, ^{26}Al). This may help improve understanding of the dichotomy between the smooth, possibly younger northern hemisphere and the heavily cratered southern highlands.

Asteroid regoliths: As regolith formation processes in the asteroid belt are poorly understood, solar wind analysis of asteroid soil samples would help determine the extent of surface gardening. Of particular interest is the asteroid 4 Vesta, whose partially-demolished south pole may represent the source of the HED's [13]. Direct comparison of north and south pole soils could confirm a later impact event, which may help refine the timing of HED ejection (with CRE ages), and thus the extent of solar wind interaction in the south since then.

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