A SEARCH FOR SOLAR ENERGETIC PARTICLE HELIUM IN INTERPLANETARY DUST PARTICLES. A. O. Nier and D. J. Schlutter, School of Physics and Astronomy , University of Minnesota, Minneapolis, MN 55455, USA

Helium was extracted from individual interplanetary dust particles (IDPs) employing a stepped pulse-heating technique, which when used for gas extraction from lunar ilmenite grains confirmed the presence of two components attributable to solar wind (SW) and solar energetic particle (SEP) implantation, respectively. Although the sensitivity was adequate, the experiment was unable to detect a second component in IDPs.

During the past few years experiments have been conducted in which helium and neon have been extracted by heating individual Interplanetary Dust Particles (IDPs) and determining the amounts and isotopic composition of the gas extracted [1, 2, 3]. In our most recent investigations [3] conventional step-heating was replaced by a sequence of short pulses of increasing temperature. The technique, while developed primarily for studying the thermal history of IDPs [3, 4, 5], has the potential for distinguishing between gas released from the surfaces of individual grains and that more deeply imbedded, as from SEP implantation.

In an ingenious experiment, Wieler et al. [6] subjected bulk samples of lunar surface grains to successive chemical etchings and analyzed the gas released after each step. They concluded that the grains contained not only a shallowly implanted solar wind (SW) component but also more deeply imbedded particles called Solar Energetic Particles (SEPs), which had energies intermediate between those of the solar wind and those associated with solar flares. Further experiments confirmed and extended the results [7]. An independent study [8] of similar lunar material, employing a combination of stepwise oxidation and pyrolysis, confirmed the likely existence of a second reservoir of gas, but led to the conclusion that the effect might also be attributed to diffusion of the implanted solar wind in the grains.

In an application of our pulse-heating technique to individual ilmenite grains from lunar samples 79035 and 71501, it was found [9] that the shapes of the gas release curves not only were consistent with the existence of an SEP component, but also the helium and neon isotopic abundance ratios were similar to those deduced in the etching experiment [7]. In cases where comparisons were possible, the results also agreed with those found in total extraction experiments on individual grains of ilmenite from the same lunar material [10].

It appeared interesting to apply the pulse-heating technique to IDPs to see if the same pattern prevailed for helium released from IDPs. In a study of 12 particles (estimated diameters 10 to 20 μm, average 11 μm) seven were found to contain sufficient gas (more than 2×10^{-10} cm^3STP each), and similar enough gas release curves, to warrant combining the results to obtain an average curve. This is shown in Fig. 1. Also shown is the corresponding curve found for a composite sample of 25 IDPs (kindly provided by D.E. Brownlee), which had an average diameter of 8.8 μm. Shown, for comparison, are the curves found in the lunar ilmenite study. Neither of the IDP curves exhibits the release of any appreciable amount of helium at higher oven temperatures as seen by the lunar ilmenite curves, and attributed to the presence of SEP imbedded gas. Moreover, in the case of the 25 IDP composite sample, unlike the findings in the ilmenite study, no change in isotopic composition of helium and neon was observed as the heating progressed. On the basis of studies to date, one is forced to conclude that either the pulse-heating extraction technique, as conducted, is not applicable to IDPs, or the particles do not contain an SEP component.

In addition to the extraction experiments described above, implantation experiments were conducted in which single grains of terrestrial ilmenite, plagioclase and pyroxene were implanted with 4000 volt helium ions to simulate solar wind implantations. The implanted gases were subsequently extracted as was done in the case of the IDPs. The extraction curves exhibited the same steepness seen in the IDP curves of Fig. 1 and fell generally in the region between the two IDP curves of Fig. 1.

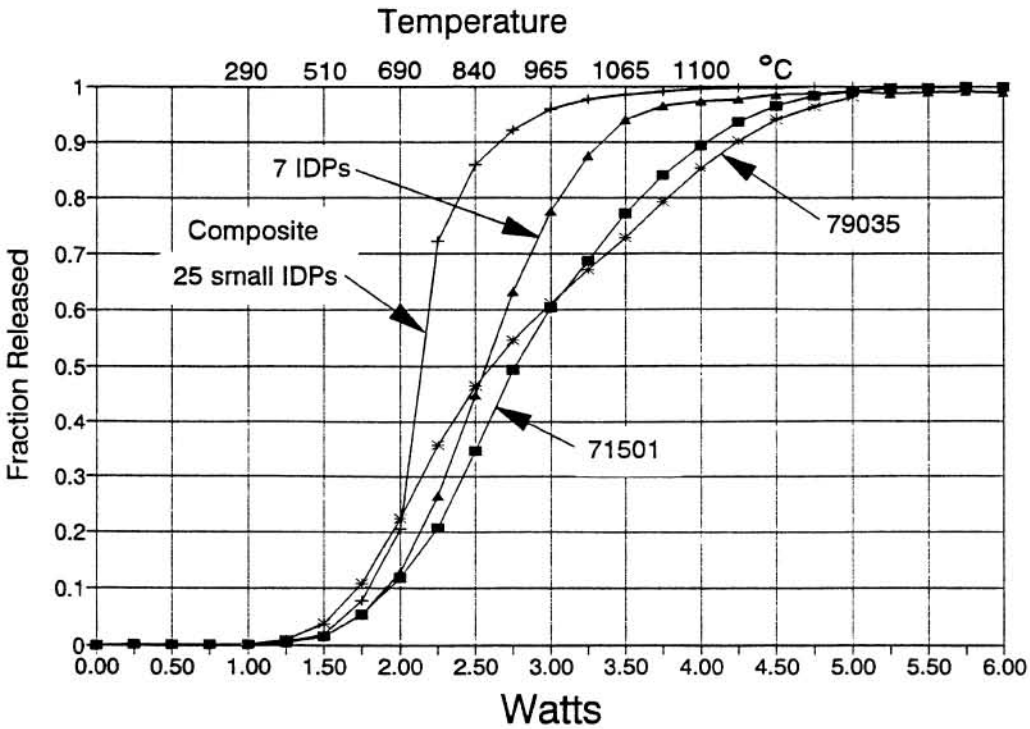

Figure 1. ^{4}He release from individual IDPs and lunar surface grains when the particles are subjected to a succession of 5-second heat pulses in an oven whose power is increased in 0.25 watt increments. The peak temperatures reached during the pulses are indicated above the figure.

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