NOBLE GAS MEASUREMENTS OF EXTRATERRESTRIAL PARTICLES FROM POLAR SEDIMENTS. *Maurette M., †Olinger C., †Walker R., and †Hohenberg C.

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The concentrations and isotopic compositions of Ne have been measured in selected particles of several types found in polar sediments. The results confirm the extraterrestrial origin of many particles, and demonstrate the utility of noble gas studies for these materials.

SEM-EDS techniques were first used to characterize two types of samples: A) Polished sections of spherules and rounded grains (mount GXKL) from BL-I, the original sample of Greenland sediments [1]. The particles were selected prior to the realization that irregular, unmelted extraterrestrial particles constitute an important fraction of the sediments; the rounded particles of GXKL may thus be more severely heated than the other particles described below. B) Irregular, unmelted fragments also found in BL-I (mount MMWU-1). Most of the material in the disaggregated sediments is associated with siderophilic bacteria; selection criteria used to pick particles are thus crucial in isolating the extraterrestrial component. The fragments studied were generally dark in color, irregular and (preferably) fluffy in appearance. Particles with vivid colorations or those with adhering filamentary material were not picked. We note that the unmelted fragments are fragile and their yield depends on the techniques used to dissagregrate the sediments. The particles of MMWU were placed on Be planchettes for analysis.

Following SEM characterization, particles were picked or pried from the different substrates and weighed. They were then placed in a stainless steel sample holder and the Ne was extracted using the laser heating system previously used to study individual grains from gas-rich meteorites [2].

The concentration and isotopic composition of Ne (see Fig. 1) established the extraterrestrial nature of many of the samples. In some cases spallation produced ^{21}Ne enrichments were found, from which approximate exposure ages were determined. In other cases, the Ne isotopic composition was found to lie between the SEP composition defined by the Zurich group [3] and solar wind. Sometimes the quantity of Ne was too low to yield definitive conclusions; such particles were either terrestrial, were melted and degassed during atmospheric entry, or were exposed only briefly in space.

An important question is whether morphological and elemental abundance criteria can be used to identify extraterrestrial fragments. To check this point, the pictures and EDS data from the GXKL mount were shown to three independent observers, ignorant of the noble gas data, who were asked to identify extraterrestrial fragments. Two of the observers had many years of experience in the microscopic examination of meteorites; the third (M.M.), had the benefit of experience gained from complementary trace element and radioisotope studies of similar particles.

A total of ten out of 28 particles from GXKL with Ne contents in the range of 10^{-7} to 10^{-5} ccSTP/gm had isotopic compositions implying an extraterrestrial origin (see Fig. 1). Of these: three were categorized by all observers as "extraterrestrial"; three were labelled as "extraterrestrial" by one observer and "possible extraterrestrial" by the others; three were classified as extraterrestrial by the only observer who saw the SEM-EDS data on these three particles; and one particle was classified as "probably terrestrial" by all three observers. With this one exception, those labelled "probable terrestrial" had uniformly low Ne contents. All other low Ne particles, save one, were either obviously melted or had Ne compositions that suggested, but did not prove, an extraterrestrial origin. The only potential conflicts between "expert opinion" and the noble gas data are for particles GXKL-22 and GXKL-15. The former was categorized as "extraterrestrial" by all observers, but had an immeasurably low Ne content, and did not appear melted; it is probably an extraterrestrial particle with a short exposure age. The latter was categorized as "probable terrestrial" by all three observers, but appears to be extraterrestrial on the basis of the noble gas data.

Of 12 unmelted fragments studied from MMWU-1, eight had Ne contents and compositions implying an extraterestrial origin (see Fig 1). Seven of these eight had been rated as of "likely extraterrestrial origin," based on their generally "chondritic" elemental abundance patterns (by "chondritic" we mean that the abundances of Mg, Al, Ca, and Fe relative to Si were within a factor of two of those measured in a powdered Allende standard; however, they were generally depleted in S and, sometimes, in Ni). Three others that had immeasurably low Ne contents had been classified as "probable terrestrial."

One great promise of the polar sediment collections is the opportunity to find new types of extraterrestrial materials which do not resemble known classes of meteorites. Particularly interesting in this regard are particles MMWU-1-I and GXKL-15. Both were classified as probable terrestrial contaminants on the basis of SEM-EDS results, but the noble gas data indicate that they are extraterrestrial.

The range of ^{21}Ne exposure ages .04 to 24 Ma is consistent with the prior ^{26}Al and ^{10}Be measurements of Raisbeck and Yiou [4]. Although these ages are longer than estimated space lifetimes for particles of this size, the prior radiochemical data indicate that most particles were irradiated as small objects in space. The concentration of SEP type Ne can be used to calculate independent "exposure ages" on the assumption that SEP-Ne is due to implanted solar flare particles. Although the "ages" agree very roughly with the ^{21}Ne data, this is likely fortuitous since many dubious assumptions are involved in deriving the "SEP-ages." In addition, several particles from the GXKL mount show solar wind Ne compositions. Since we consider it unlikely that the outer layers could have survived atmospheric entry, this result implies either that some old exposed surfaces are protected within the volume (in analogy with gas-rich meteorites) or that surface gases have been redistributed to the interior.

In summary we have established the following facts: a) Many particles picked from polar sediments, using appropriate selection criteria, contain enough Ne to permit unambiguous proof of their extraterrestrial origin. b) Sufficient Ne is retained for identification even in particles that show independent evidence for at least partial heating. c) Conventional morphological and element abundance criteria used to identify extraterrestrial fragments are generally reliable, but are not sufficient to identify all extraterrestrial particles in the sediments.

These results indicate that terrestrial contamination does not constitute a severe problem for studying the extraterrestrial fragments found in polar sediments. The relationship of these particles to meteorites and to interplanetary dust can be explored, and a search can be made for new species of extraterrestrial objects. Noble gas work on samples that show little evidence for heating should yield exposure ages that will contribute to an understanding of their space histories. Noble gas data may also give useful information on the heating of various particles during entry.

References:

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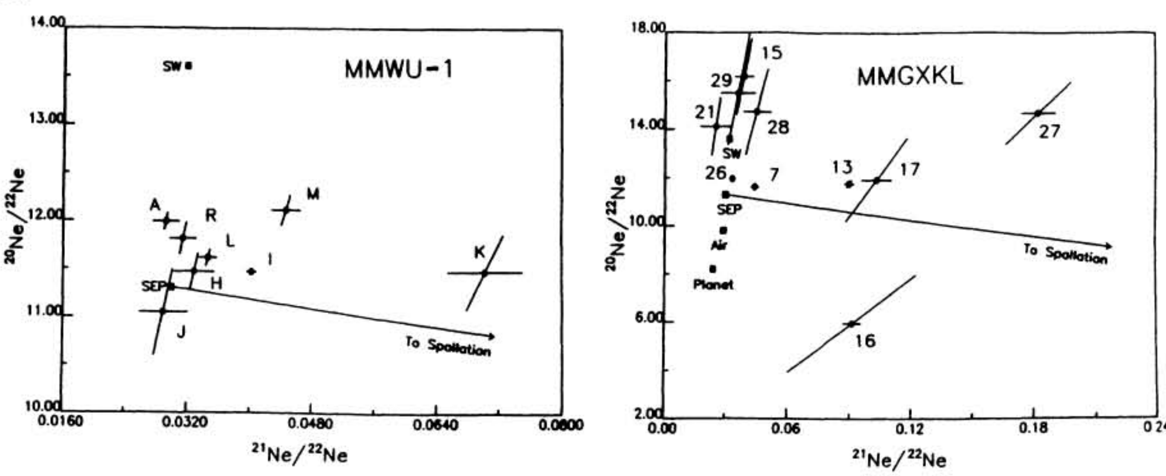

Figure 1. Ne isotopic composition of extraterrestrial particles in polar sediments.