LASER EXTRACTION OF COSMOGENIC NEON FROM MICROGRAM SIZE GRAINS; C. T. Olinger, D. H. Garrison, C. M. Hohenberg, McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, MO 63130 USA.

Previous investigations have shown that different microgram sized mineral grains from a common gas rich meteorite display surprisingly large variations in cosmogenic neon concentrations (1,2). The obvious interpretation is that, while each grain of the meteorite has been identically irradiated with energetic particles during the recent cosmic ray exposure, some (a few percent) contain orders of magnitude more cosmogenic Ne from a pre-compaction exposure to energetic particles. Although previous interpretations have been hindered by experimental difficulties, new calibrations of extraction efficiency of the ruby laser system indicate the presence of excessively irradiated grains which require an enhanced early irradiation source, such as a T-Tauri sun.

In this experiment microgram-sized pyroxenes and feldspars from the howardite Kapoeta were hand-picked, weighed using a Cahn microbalance, and the mineralogy confirmed with a JEOL-840A SEM equipped with an energy-dispersive X-ray system. The grains were subsequently pressed into Indium foil, which was then mounted in the laser extraction cell. After this, the grains were individually destroyed by a single ruby laser pulse. The released neon was cleaned by exposure to a titanium flash getter, and isotopically analyzed in an ion counting mass spectrometer in the presence of a liquid nitrogen finger to minimize argon and CO_2 interference (3).

Previous limitations of similar grain studies include the need to analyze a collection of many individually selected grains as a set to meet sensitivity requirements. This averages out the effects of individual grains, making interpretation that of the average and it prevents detection of spectacular enhancements from single heavily irradiated grains(1). The current study has overcome this sensitivity requirement, with signals significantly above blank from grains as small as .9μg,and less than 200,000 atoms of extracted ^{21}Ne. Such sensitivity has unfortunately been accompanied by an uncertainty in the absolute amount of gas contained in the grains. Ruby lasers deposit all of their energy (~10J in this case) in one short pulse (~20microsec). Rather than directly vaporizing the sample much of this energy goes through the translucent feldspars and pyroxenes, rapidly heating the underlying foil. This results in a plasma plume which appears to shock and fragment the grain, liberating <u>some</u> of the neon, but leaving the rest trapped in the micron-sized fragments. Since the grains are not vaporized, the gas extraction efficiency of the technique must be determined.

Extraction efficiency was first estimated by analyzing the Ar released from laser shots at grains of the hornblende standard Hb3gr, which is homogeneous in its radiogenic ^{40}Ar concentration (4). This has two obvious shortfalls. First, argon and neon do not necessarily have the same extraction efficiency. More importantly, hornblende is an opaque mineral, so primary heating becomes more important in the extraction of gas than in the case of the transparent feldspars and pyroxenes. This procedure overestimated the extraction efficiency at 49%.

The current means of determining extraction efficiency comes from the analysis of olivines from the meteorite Springwater. Neon from the large olivines of Springwater is dominated by spallation due to the long exposure age of this pallasite. Therefore, a single olivine should, to first order, have a homogeneous and high cosmogenic neon concentration. Large olivines from Springwater were individually crushed, and the fragments weighed. Sufficient mass was loaded into a platinum boat for conventional heating to determine the absolute cosmogenic neon concentration. Complimentary fragments from the same parent olivine were mounted for laser extraction, and were shot under the same conditions as the optically similar Kapoeta pyroxenes and feldspars. Gas released from both extraction procedures was analyzed under identical conditions, so the apparent neon concentration from the laser technique divided by the true concentration determined through conventional heating provides the laser extraction efficiency. This procedure yielded an extraction efficiency for the more transparent Springwater olivines of only 3.5%.

The figure is a histogram of all of the shots on Kapoeta grains made to date. Note that the central peak corresponds to a recent cosmic ray exposure of about 5 My for Kapoeta, consistent with the

previous values of 3-6 My (5). Such agreement provides a degree of confidence for the measured extraction efficiency. The points to the far right, on this logarithmic scale, represent grains which would require a pre-compaction exposure of over 600 My in a regolith if irradiated by any contemporary particle source! Such long exposures do not fit the constraints of any model for the evolution of the early solar system and they are incompatible with measured compaction times of meteorites. If confirmed, the presence of these extensively irradiated grains would require an enhanced flux of energetic particles in the early solar system, like that associated with a T-Tauri phase of the sun. However, because of the low and perhaps variable extraction efficiency, along with the possibilty of small systematic differences between the extraction efficiencies of olivines, pyroxenes and feldspars, such interpretations must still be made with a degree of caution.

Future approach: If the grains are completely vaporized, total extraction of the neon can be assured, providing more precise cosmogenic neon concentrations. As we have found, the ruby laser does not do this, but the continuous argon-ion laser seems particularly well suited for melting and vaporizing grains (6). We have obtained a Spectra-Physics argon-ion laser and have constructed a video monitoring system so the process can be monitored and controlled in real time. Due to complete gas recovery, this should improve our sensitivity by a factor of about 30, providing higher precision and the ability to study even smaller grains. If such highly irradiated grains are confirmed by this newer technique, its sensitivity along with a constant 100% gas extraction efficiency should establish, beyond a doubt, the existence of an enhanced flux of energetic particles in the early history of the solar system (ie, a T-Tauri sun).

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