EARLY IRRADIATION AS A POSSIBLE CAUSE OF ^{15}N ENRICHMENT IN EARLY SOLAR SYSTEM MATTER. B. Marty[1], L. Zimmermann[1], & A. N. Krot[2], [1] CRPG-CNRS, Université de Lorraine, Vandoeuvre les Nancy France; [2] HIGP/SOEST, University of Hawaii, USA. Corresponding author : BM (bmarty@crpg.cnrs-nancy.fr)

Introduction: Some of the light elements − those that were mostly present in the gaseous form like hydrogen (H_2), nitrogen (N_2), and oxygen (CO, H_2O) − have large, sometimes extreme, variations of their isotopic ratios (e.g., D/H, ^{15}N/^{14}N, and ^{17,18}O/^{16}O, respectively) among different solar system objects and reservoirs. The cause of such variations remains unclear, in part because the initial isotopic compositions of these elements in the proto-solar gas were unknown until recently. The Genesis mission sampled solar wind ions to document the elemental and isotopic compositions of the Sun and, by inference, of the proto-solar nebula. The analysis of a Genesis Solar-Wind Concentrator target material showed that implanted solar wind N has a ^{15}N/^{14}N ratio of $(2.18\pm0.02)\times10^{-3}$ (i.e. ≈ 40% poorer in ^{15}N relative to terrestrial atmosphere) and that, by inference, the ^{15}N/^{14}N ratio of the protosolar nebula was $(2.27\pm0.03)\times10^{-3}$, which is the lowest ^{15}N/^{14}N ratio known for solar system objects [1]. Several processes have been proposed to explain the large, sometimes extreme, enrichments in ^{15}N found in all solids of the solar system [2-4]. These include : (*i*) nucleosynthetic heritage of presolar material. However, such an origin is inconsistent with mass balance calculation for other stable isotope systems, e.g., carbon; (*ii*) photodissociation of N_2 and incorporation of ^{15}N-rich molecules into forming solids; (*iii*) low temperature isotope exchange in ion-molecule reactions; and (*iv*) ^{15}N nucleosynthesis during irradiation by the early Sun. We present combined Ne-N isotope data that support the last possibility for some of the most extreme ^{15}N excesses found in primitive meteorites.

Samples & Analytical Procedures: The metal-rich CH and CB carbonaceous chondrites are rich in ^{15}N, with δ^{15}N around +1000‰ for Benccubin [5] relative to the terrestrial standard (atmospheric N), and +1200‰ for Isheyevo[6]. In Isheyevo, the largest ^{15}N excesses are found in chondrite lithic clasts [7], and δ^{15}N values up to 5,000‰ have been found in an Isheyevo clast [8]. No extreme D excesses are associated with these excesses, and overall the D/H ratio of Isheyevo appears "normal", suggesting that the N-isotope anomalies were probably not the result of isotope exchange at low temperature [2].

A thick slice of Isheyevo was prepared without epoxy for this experiment, analyzed by electron probe for the chemical composition of several clasts, loaded in the laser chamber and pumped for 2 weeks. Twenty laser spots (CO_2 infrared laser, wavelength : 10.6 µm, OD = 150 µm) were ablated in 4 different lithic clasts (~40−50 % SiO_2, 40−50 % MgO, with variable amounts of CaO, C and N). Noble gases (He, Ne, and Ar) were sequentially analyzed together with nitrogen from the same extractions by static mass spectrometry at CRPG Nancy, France [9].

Results & Discussion: The noble gas isotope data are consistent with mixing between a solar-like component and a nucleosynthetic end-member, presumbly produced by interactions with cosmic rays (Fig. 1). A Ne 3-isotope correlation permits to define ^{20}Ne/^{22}Ne = 12.9±1.0 (SW value : 13.8), ^{3}He/^{4}He ~ $(4−5)\times10^{-4}$ (SW : 4.4×10^{-4}), and ^{38}Ar/^{36}Ar < 0.2 (SW : 0.182) for the trapped component. The N-isotope composition associated with this has an extrapolated δ^{15}N value of 750±120‰, clearly different from the SW value (407±7‰) and in the range of values characterizing CN and HCN in comets. Such composition could be the result of isotope enrichment during chemical (e.g., ion-molecule) reactions in a cold environment, that would have not affected the (inert) noble gases.

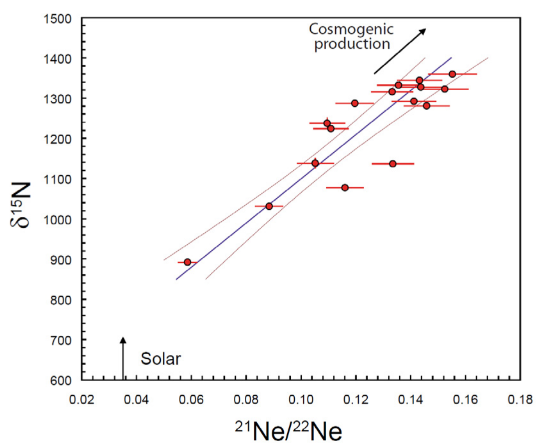

Fig. 1 : correlation between Ne and N isotopic ratiosThe solar ^{21}Ne/^{22}Ne ratio (0.033) is indicated by the vertical arrow. Spallation by interaction with cosmic rays (solar or galatic) will produce ^{21}Ne and ^{22}Ne on one hand, and ^{14}N and ^{15}N on another hand, in approximatiely equel amounts.

The other noble gas end-member is rich in isotopes produced by interactions with cosmic rays, that is, ^{20}Ne/^{22}Ne ~ ^{21}Ne/^{22}Ne, ^{38}Ar/^{36}Ar up to 0.35 and ^{3}He/^{4}He up to 1.6×10^{-3}. The associated δ^{15}N values are close to +1400‰ and comparable to the upper limit found in chondrite clasts [10]. Assuming that the correlation between noble gas (e.g., Ne) isotopes and nitrogen isotopes is linear, then an extrapolated $\delta^{15}N$ end-member value of 5,300±600‰ is computed for the pure cosmogenic noble gas end-member value ($^{21}Ne/^{22}Ne \sim ^{20}Ne/^{22}Ne \approx 0.9$), very close to the highest $\delta^{15}N$ value of 4,900±300‰ found in an Isheyevo clast [8].

Production by energetic cosmic rays, presumably from the early Sun, appears a possible mecanism to produce some of the large ^{15}N enrichments found in primitive matter. We are currently pursuing our laser abaltion experiments on other clasts in an attempt to find the pure cosmogenic end-member. Doing so, we aim to obtain its pristine noble gas composition, which will permit investigation of the nuclear reactions beyond this peculiar nucleosyntesis.

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