PRECOMPACTION IRRADIATION EFFECTS: PARTICLES FROM AN EARLY ACTIVE SUN?

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Two recent studies have shown that solar flare irradiated grains from Murchison and Kapoeta have excess spallogenic $^{21}$Ne compared to unirradiated grains, indicating large precompaction particle irradiation effects. The quantity of cosmogenic neon in these grains presents serious difficulties for either galactic cosmic ray or normal solar flare sources. In the first study it was suggested that the effect might be the result of exposure to an early active sun [1]. The more recent experiment both confirms the earlier results and provides constraints on the characteristic energy spectrum of the irradiation [2].

The first results were obtained from Murchison olivines and Kapoeta pyroxenes by mass spectrometric analysis of sets of grains selected on the basis of the presence or absence of solar flare particle tracks. In the second work plagioclase feldspar grains from Kapoeta were studied, in addition to more olivine grains from Murchison. The feldspars were chosen because the cosmogenic $^{21}$Ne/$^{22}$Ne ratio expected from lower energy (present day) solar flare irradiation is about .5, compared to about .8 for the cosmogenic neon produced by the more energetic particles found in galactic cosmic rays [3, 4].

As in the earlier experiment, large precompaction exposure effects were observed. The feldspars show a substantial abundance of cosmogenic neon from high energy particle irradiatons, with measured isotopic compositions populating a mixing line between a trapped (solar-type) endmember and a cosmogenic endmember similar in composition to GCR-produced neon (see figure). For both Kapoeta and Murchison the irradiated grains contain at least an order of magnitude more cosmogenic neon than their unirradiated counterparts. This enrichment is somewhat smaller than that observed in the previous study and may reflect statistical variations in precompaction irradiation effects among individual grains.

The size of the effect in the first study precludes easy explanation in terms of precompaction exposure to galactic cosmic rays, since grains from both meteorites have two orders of magnitude more cosmogenic neon than predicted by most models for the formation of gas-rich meteorites. Little solar wind neon was detected. If the effects are due to galactic cosmic ray exposure, then either the flux of galactic cosmic rays was anomalously high (by at least two orders of magnitude), or models for the formation of gas-rich meteorites have seriously underestimated the duration of exposure of individual grains to cosmic rays.

Solar cosmic rays have even more difficulty. An SCR origin requires a similarly long pre-compaction exposure time (in excess of 100 m.y. at 3 A.U. under present conditions [1]). In addition, the observed isotopic composition of the cosmogenic neon suggests production by more energetic particles and solar wind effects are small. These observations led to the suggestion that pre-compaction irradiation effects may have been due to an early active sun. The most recent results better constrain the energy spectrum of the nuclear-active particles. If the effects are indeed due to an energetic primitive sun, it must have had both a higher flux and a harder energy spectrum than is currently observed.

[1] Caffee, M.W., et al. (1983) Cosmogenic neon from precompaction irradiation of Kapoeta and Murchison. Proc. Lunar Planet. Sci. Conf. 14th, in J. Geo-

phys. Res., 88, B267-B273.

[2] Caffee, M.W., et al. (1984) Confirmation of cosmogenic neon from precompaction irradiation of Kapoeta and Murchison (abstract). In Papers Presented to the 47th Meteoritical Society Meeting, Albuquerque.

[3] Hohenberg, C.M., et al., (1978) Comparisons between observed and predicted cosmogenic noble gases in lunar samples. Proc. Lunar Planet. Sci. Conf. 9th, 2311-2344.

[4] Walton, J.R., et al. (1974) Evidence for solar cosmic ray proton produced neon in fines 67701 from the rim of North Ray Crater. Proc. Lunar Sci. Conf. 5th, 2045-2060.

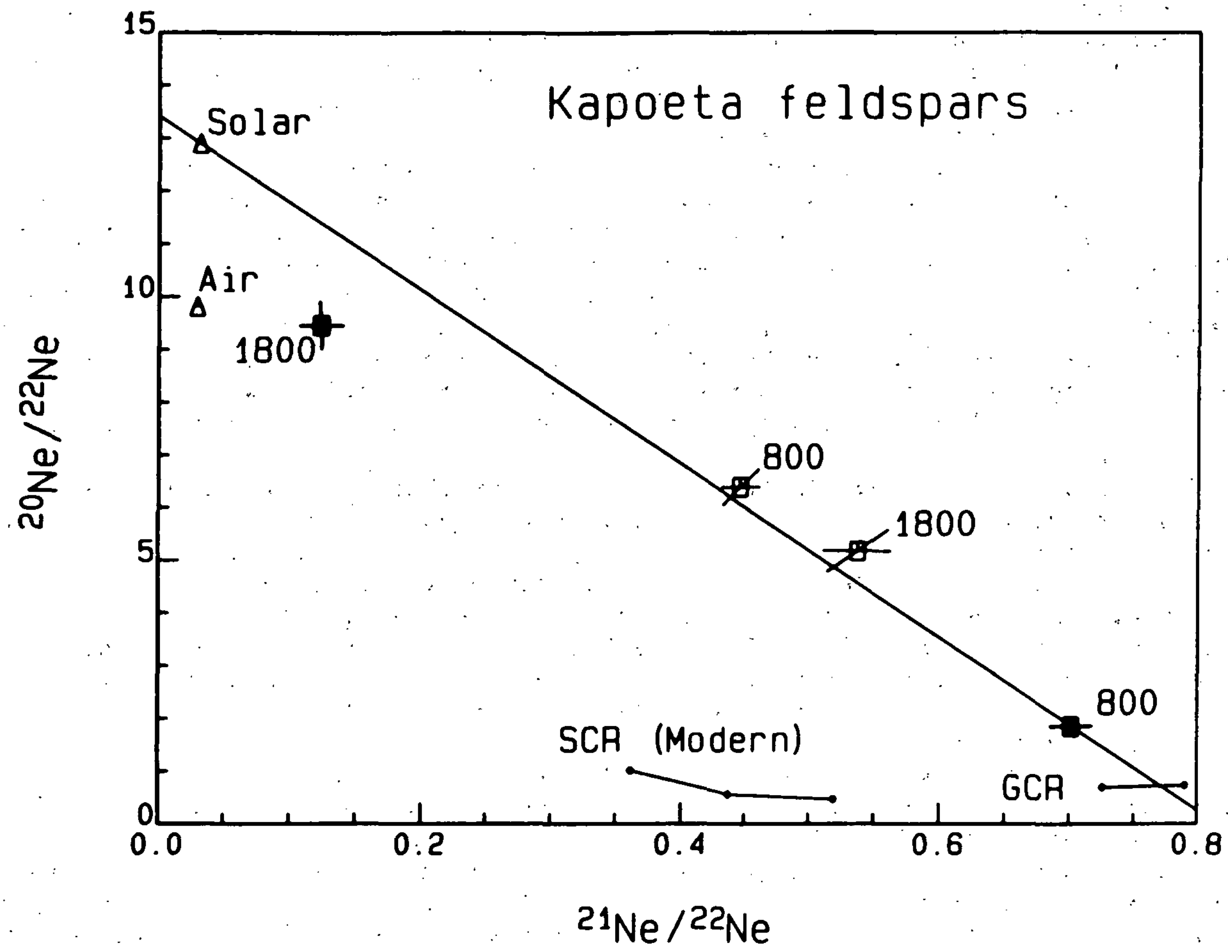


Figure caption: Neon from selected Kapoeta feldspar grains. Closed symbols are solar-flare irradiated grains (identified by the presence of heavy ion tracks), open symbols are grains which do not show solar flare irradiation effects. Numbers represent extraction temperatures in degrees Celsius. Line marked 'GCR' gives range of compositions expected for galactic cosmic ray spallation on targets with the chemistry of the Kapoeta feldspars with shielding of 0 to 40 $g/cm^2$. Curve marked 'SCR (Modern)' gives expected compositions from solar cosmic ray irradiation under present solar conditions for shielding depths of 0 to 10 $g/cm^2$. Predicted spectra computed from [3].