PROTON TO NEON RATIO IN ANCIENT SOLAR FLARES BASED ON FAYETTEVILLE AND KAPOETA, M.N.Rao and J.T.Padia, Physical Research Laboratory, Navrangpura, Ahmedabad 380 009, India.

We have analysed etched pyroxene grain size separates from dark as well as light portions of two gas-rich meteorites Fayetteville and Kapoeta mass-spectrometrically, with a view to decipher the long term average solar flare (SF) neon fluxes as well as solar cosmic ray (SCR) proton fluxes from the ancient Sun, during the early solar system. The pyroxene grain size fractions (90-200 um) were chemically etched to remove the surficially-sited solar wind noble gases. By determining the Mg and Fe contents in the resulting acid leach by atomic absorption spectrophotometry, we estimate an average etching dapth of 6 um and 4 um for Kapoeta (dark) and Fayetteville (dark) pyroxenes respectively, considering an average radius of 60 um for the 90-200 um size fraction of the samples studied here. This average etching depth corresponds to an approximate energy E_0 1MeV/amu for the flare implanted SF-^{20}Ne particles which are essentially retained in the etched pyroxene residue.

The experimental data for the neon in the pyroxenes from the dark protons of Fayetteville and Kapoeta are corrected for the GCR contributions based on the corresponding light sample neon in these meteorites and the resulting neon mixtures are partitioned into SF and SCR neon components using the three component neon decomposition systematics (Padia and Rao, 1988). We make an attempt here to determine the proton to neon (p/Ne) ratio in ancient solar flares by deducing the solar flare proton flux from the partitioned SCR-^{21}Ne and solar flare neon flux from the partitioned SF-^{21}Ne in the irradiated pyroxenes of Fayetteville and Kapoeta. We compare these results with the corresponding average particle fluxes and their ratios from the contemporary Sun, based on lunar sample studies.

The integrated SCR proton fluences to which the irradiated pyroxenes in Fayetteville and Kapoeta were exposed are estimated as follows. The SCR-^{21}Ne excess observed in Fayetteville and Kapoeta pyroxenes are normalised to 100% SF-irradiated grains i.e. appropriate correction for the percentage of irradiated grains in the samples under study is made. The corrected values for Fayetteville and Kapoeta pyroxenes are 12.4×10^{-8} and 20.7×10^{-8} ccSTP ^{21}Ne/g respectively. From the SCR-^{21}Ne production rates of Hohenberg et al. (1978) for 0 g.cm^{-2} shielding and pyroxene chemistry (i.e. 0.053 and 0.084 $\times 10^{-8}$ccSTP ^{21}Ne.g^{-1}, my^{-1} for Kapoeta and Fayetteville chemistries respectively), the integrated proton fluences to which the irradiated grains in Fayetteville and Kapoeta were exposed on their parent body regoliths are deduced to be about 4.4×10^{16} and 1×10^{17} protons. cm^{-2} respectively (These production rates are based on the average proton flux of p(E 10MeV) = 100 $p.cm^{-2}.sec^{-1}$ and Ro = 100 MV at 1 A.U. and they are lower by a factor of about 10 at 3 A.U.). These proton fluences deduced here are consistant with those deduced by Caffee et al. (1987) by independant techniques using irradiated and unirradiated pyroxenes in these meteorites.

We discuss below the estimation of implanted SF-^{20}Ne. From the partitioned SF-^{21}Ne in Fayetteville and Kapoeta dark pyroxenes, we get the SF-^{20}Ne based on the solar flare neon composition deduced by us i.e. 20/22=11.6 ± 0.2 at 21/22 = 0.030 (Padia and Rao, 1988). These observed values are corrected for the percentage of irradiated grains and the resulting SF-^{20}Ne in Fayetteville and Kapoeta are found to be 3712 and 903 X 10^{-8} ccSTP ^{20}Ne/g respectively. For calculating the surface area of the pyroxene grains under study, we consider about 60 um for their average radius. Using these data, we estimate an integrated fluence of implanted SF-^{20}Ne (E 1MeV/amu) in the case of Fayetteville and Kapoeta dark pyroxenes to be 3.0 and 0.72 X 10^{12} atoms $^{20}Ne.cm^{-2}$ respectively, considering 2 irradiation geometry.

Based on these results, we find that the ratio p(E 10MeV/amu)/Ne(E 1MeV/amu) in Fayetteville and Kapoeta irradiated pyroxenes to be 1.5 X 10^4 and 1.4X10^5 respectively. The p/Ne ratio, based on solar abundances given by Anders and Ebihara (1982) is 10^4. The reason why the p/Ne ratio in the case of Kapoeta is higher than that of Fayetteville may be due to the possibility that we might have removed relatively more SF-^{20}Ne from Kapoeta pyroxenes compared to Fayetteville pyroxenes, because of relatively more etching, as retained SF-Ne is sensitive to the degree of surface etching. On the otherhand, small differences in surface etching do not influence the integrated proton fluences estimated here because the spallation component is uniformly distributed throughout the volume of these grains. These values are compared with the p/Ne ratio deduced from the lunar sample studies and their implication to the activity of the early Sun is discussed.

(a) E. Anders and M. Ebihara (1982), Geochim. Cosmochim. Acta. 46, 2363.
(b) Caffee et al. (1987), Ap. J. (Leet). 313, L31.
(c) C.M. Hohenberg et al. (1978), Proc. LPSC. 9th, 2311.
(d) J.T. Padia and M.N. Rao (revised m.s.) submitted to G.C.A. (1988).