CHARGE SPECTRUM ANALYSES OF LOW ENERGY SOLAR COSMIC RAY NUCLEI: (Z = 20-40; KINETIC ENERGY < 10 MeV/amu), J.N. Goswami and D. Lal, Physical Research Laboratory, Navrangpura, Ahmedabad-380009, India.

Since a study of solar cosmic rays is useful for understanding the elemental composition of the solar photosphere as well as the production and acceleration mechanisms involved in the emission of these particles, considerable emphasis has been laid on obtaining the charge and energy spectrum of medium and heavy nuclei in solar flare particles, both in ancient and contemporary flare radiations (c.f. Bhandari et al.; Price et al. 1973a). One of the important results of these experiments was the discovery of enhancement in solar cosmic rays of medium and heavy group of nuclei (e.g. O, Si, Fe) relative to He nuclei as compared to their relative abundances in solar photosphere - supposed to be the source of these particles. This enhancement is energy dependent, decreasing with increasing energies, levelling off to photospheric value at E ≥ 25 MeV/amu. First evidence for enhancement of heavier nuclei (Z ≥ 30) was obtained by Bhandari et al. (1973) who used lunar and meteoritic mineral as detectors to obtain the long term averaged flux of these nuclei of solar and galactic cosmic ray origins. Recent measurement in contemporary cosmic rays (Shirk 1974) also show that such an enhancement continues even upto Z > 40 and there may be a charge dependent enhancement pattern.

An important aspect which yet remains to be established is whether the enhancement of heavy nuclei in solar cosmic rays continues to lower energies, below 6 MeV/amu upto which a monotonic increase was established by the work of Bhandari et al. (1973). The lower limit of ~ 6 MeV/amu in their work was due to technical limitations of observing a long enough track for identifying the atomic number of the nucleus. We now present in this paper a new technique for the charge identification in common rock minerals and present our preliminary data on the long term averaged relative abundances of low energy VH and VVH group of nuclei in solar cosmic rays down to ~ 0.5 MeV/amu.

The present method of atomic number identification is based on the expected dependence of rate of etching on the velocity and atomic number of the nucleus. Charge identification based on this method has been successfully employed in the case of plastic detectors (Price and Fleischer, 1971) but has not yet been attempted for rock minerals.
So far, we have confined ourselves to observations of solar flare tracks (see Fig. 1a) in the mineral olivine since it is found to be suitable from considerations of both etching and recording characteristics (Krishnaswami et al., 1971; Bhandari et al., 1973; Price et al., 1973b). The carbon-palladium replication technique (MacDougall et al., 1971) has been used to obtain electron micrograph of palladium shadowed replicated tracks at ~10,000 X magnification. The track diameters and the projected track lengths (i.e. the length of shadow of etch-tracks produced due to low angle palladium shadowing - see Figs. 1b, 1c) were measured.
optically in magnified photographs - results are shown in Fig. 2. Two charge groups appear to be well resolved. The data are also in line with expectation based on dependence of etching rate on primary ionization. Since the track densities in the solar flare irradiated grains generally exceed $10^9$ cm$^{-2}$ near the edges, it is not possible to measure there the projected track lengths accurately due to overlaps, but the track diameters could still be measured relatively accurately and hence charge identification is possible from diameter measurement alone; see Fig. 2. So far our observations are based on samples 76501 and 12037. We will present a detailed analysis later; it suffices here to mention the main conclusion. The enhancement of VVH group over VH group of nuclei in solar cosmic ray continues down to at least 2 MeV/amu, but at lower energies, down to 0.5 MeV/amu, the enhancement levels off. This result is somewhat similar to that observed by Hovestadt et al. (1973) for relative abundances of Fe/O nuclei in solar cosmic radiation at low energies (<6 MeV/amu).

Fig. 2. Track diameters are plotted as a function of projected track lengths for replicated etch tracks in sample 76501. One scale division = 0.012 micron.