ilar to curves of Antonova *et al.* (*12*) for nonintercalated $NbSe_2$.

It is not yet clear how much of the observed transition widths are caused by fluctuations which might be inherent in the two-dimensional system, particularly since the x-ray diffraction powder patterns indicate the presence of a small amount of a second intercalated polymorph. The transition for NbS_2 which has been intercalated with two layers of aniline and in which the Nb planes are 18 Å apart is quite similar to that of NbS_2 intercalated with only one layer of pyridine. It is remarkable that neither the shape of the transition nor the transition temperature is markedly affected by the number of organic layers intercalated.

Heat capacity results confirm that the superconductivity is a bulk property. All, or at least a substantial fraction, of the Ta atoms are involved in the transition. Efforts to observe a Meissner expulsion of flux as intercalated samples become superconducting when cooled in various magnetic fields have so far been negative.

We have found a new class of layered metallic conductors, the limiting compositions of which frequently correspond to stoichiometric compounds. The conducting layers are separated by organic molecules and they can be spaced apart by large distances. If the layers are superconducting before intercalation then the superconductivity persists when the layers are moved apart. Whereas the transition temperature is usually observed to increase upon intercalation this is not always so. The change in the superconducting transition temperature is found to be small when the number of organic layers between each metallic layer is increased beyond the first. This indicates that the superconductivity is either a property of the two-dimensional metallic layer itself—we have indeed observed two-dimensional superconductivity—or, as is less likely, the layers couple in the third-dimension via the organic intercalate by some interaction that depends upon the distance only weakly.

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Radiation Effects and Oxygen Vacancies in Silicates

Abstract. *Proton and electron irradiation of silicates, minerals, and rocks produces a paramagnetic defect whose resonance spectrum is identical to that of the singly charged oxygen vacancy in silica glass and α-quartz. It is suggested that this defect is characteristic of all structures containing* SiO_4 *tetrahedra. Cracks, fracturing, and electric discharges have been observed after irradiation in planes determined by the particle ranges. These processes may contribute to the erosion and transport of lunar surface materials.*

We report some effects of proton and electron irradiations on various terrestrial silicate minerals and rocks, which are primary constituents of lunar (*1*) and terrestrial materials and most of which have well-known crystal structures (*2*). Energetic charged particles irradiating a solid can displace atoms from their initial positions or excite electrons, or both (*3*). The displaced atoms and vacancies may then trap excited electrons which, if unpaired, may show electron paramagnetic resonance (EPR) absorption (*4*). The EPR spectra of singly charged oxygen vacancies have been observed in irradiated silica glass, quartz, and other oxides (*5, 6*). In some solids, irradiation can also produce electrically charged regions by trapping of the irradiating particles and of the excited electrons. Dielectric breakdown may occur, leaving in an insulator the path along which the breakdown took place (*7*). Because lunar surface material is subjected to the direct radiation (photons and particles) from the sun and because the energies and fluxes of solar protons are sufficient to produce defects in solids (*8*), it is valuable in an investigation of the properties of lunar material to determine the effects of these particles on different solids.

Samples of olivine, sanidine, tektite, silica glass, basalt, and altered rhyolite were irradiated with 40-Mev protons in the Oak Ridge isochronous cyclotron. The intensity of the current was ~ 1 μa and the integrated flux ranged from 10^{16} to 3×10^{17} proton/cm^2. The samples were immersed in flowing water for cooling, and the temperature, measured by a thermocouple sealed in a quartz tube and placed in the beam, was $< 100°C$. Samples of tektite, silica glass, and tempered aluminosilicate glass were irradiated with 2-Mev electrons in a Van de Graaff accelerator. The intensity of the current was ~ 1 μa, and the integrated flux ranged from 10^{12} to 10^{17} electron/cm^2. The samples were cooled by air flow, but the temperature during irradiation was not measured. The EPR spectra were measured at 9 and 35 Ghz and at room temperature with spectrometers of standard design.

Prior to irradiation, each of the samples had distinctive EPR spectra which were due, in most of the samples, to the absorption of Fe^{3+} or Mn^{2+}, or both (*9*). After irradiation, changes in shape and intensities of these resonance absorptions were small or not detected. However, in all of the samples, a new spectrum was detected with an intensity which was proportional to the integrated particle flux. The shape, width, *g*-values ($g = h\nu/\beta H$; h is Planck's constant, ν is frequency, β is

Bohr magneton, and H is magnetic field), and relaxation time of this resonance are, within experimental error, the same as those of the singly charged oxygen vacancy (E′ center) observed in silica glass and α-quartz (*5*). Therefore, this defect seems to be characteristic of all irradiated silicates with SiO_4 configurations ranging from that of α-quartz to olivine. We expect that this defect will be observed in other silicate compounds under appropriate experimental conditions.

In all of the white and transparent proton irradiated samples, the irradiated end was darkened to a depth approximately equal to the expected range of the protons (~ 5 mm for 40-Mev protons in SiO_2). Cracks were noted in some samples at this penetration depth, and all the samples with or without cracks fractured at this depth when strained. Electron irradiation of many materials produces electrical discharge patterns [Lichtenberg figures (*10*)] in the plane determined by the particle ranges. These discharges occur when the electrical fields due to the trapped charges exceed the dielectric strength of the trapping material. For example, electron irradiation of a tempered aluminosilicate glass sample (1 by 10 by 10 cm) produced a spectacular effect. A beam current of ~ 1 μa at 2 Mev, incident on 3 cm² of the 10- by 10-cm face for 10 seconds, completely shattered the sample. Electrical discharges and additional fracturing were observed for 30 minutes after the initial event. In well-annealed glasses such irradiations will produce, when the integrated flux is sufficient, electrical discharges which do not fracture the glass. When strains are present, the discharge can fracture the material as in the case of the tempered aluminosilicate glass. None of these effects are observed in pure SiO_2 glass after either proton or electron irradiation.

We suggest that these electrical discharge effects may occur in materials on the lunar surface. In many cases the integrated flux of charged particles from a solar flare event exceeds, by at least an order of magnitude, that necessary to produce the effects in the laboratory. These processes may contribute to the erosion and transport of lunar surface materials.

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Solar Activity Index: Validity Supported by Oxygen Isotope Dating

Abstract. *A significant correlation between oxygen-18 concentration in a Greenland ice core and an index of solar activity supports the validity of the solar index. The correlation may result from an apparent control of temperature by solar activity.*

The pattern of variation in ^{18}O concentration (from A.D. 300 to the present) found by Dansgaard *et al.* in the Greenland Camp Century ice core (*1*, fig. 2) is strikingly similar to variation in the solar activity index (*2*) over the same period. The solar index was computed from data summarized from oriental observations on sunspots and aurorae by Schove (*3*) and has been used to test variation in ^{14}C activity (*2*) and in climatic studies (*4*). Concentration of ^{18}O (*1*, fig. 2) and the solar activity index are shown in Table 1 for the 17 centuries since A.D. 300. The negative correlation ($r = -0.55$, $P < .05$) between the two distributions indicates a positive relationship since the ^{18}O values were presented on a negative scale.

Division of the ^{18}O nomograph into periods of alternating higher and lower ^{18}O concentration (*1*, fig. 2) resulted in a temporal pattern similar to the solar activity periods (*2*, table 1). Nine intervals closely overlapped, including the ^{18}O minimum from about 1590 to 1750 and the solar activity minimum from 1587 to 1723. In two instances one ^{18}O period embraced two or three solar activity periods, and in four instances a solar activity period embraced two or three ^{18}O periods. In every case, however, the mean values for the combined periods varied in phase, so that there was a symmetrical sequence of alternating higher and lower ^{18}O concentration and solar activity.

The positive correlation between ^{18}O in the Camp Century core and solar activity may be the result of a positive relationship between solar activity and temperature over the same period (*4*). This relationship was supported by evidence from glacial activity and other climatic indexes (*4, 5*) and is most effectively demonstrated over longer-term cumulative solar activity trends. The ^{18}O content in precipitation is determined mainly by its temperature of formation (*1*). Lower ^{18}O contents occur during lower temperatures, particularly at higher latitudes, which explains the positive correlation between

Table 1. Solar activity index and ^{18}O concentration in the Greenland Camp Century ice core.

Century (A.D.)	Solar index	$\delta^{18}O$ (‰)
20	117	28.5
19	86	29.1
18	97	28.7
17	69	29.7
16	114	29.1
15	65	29.0
14	98	28.8
13	91	29.1
12	114	28.6
11	92	28.5
10	102	28.5
9	106	28.5
8	102	28.6
7	88	28.4
6	110	28.7
5	94	29.1
4	104	28.7