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MAGNETIC AND ELECTRICAL PROPERTIES OF MARTIAN PARTICLES

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The only determinations of the magnetic properties of Martian materials come from experiments on the two Viking landers (Hargraves et al., 1977, 1979). The results suggest Martian soil containing 1 to 10% of a highly magnetic phase. Though the magnetic phase mineral has not been conclusively identified, the predominate interpretation is that the magnetic phase is probably maghemite (Hargraves et al., 1977, 1979; Moskowitz and Hargraves, 1982; Bell et al., 1990; Coey et al., 1990, Morris et al., 1990).

The electrical properties of the surface of Mars have only been measured remotely by observations with earth based radar (selected references: Tyler et al., 1976; Simpson et al., 1978; Pettengill, 1978; Mouginis-Mark et al., 1980; Roth et al., 1985; Harmon, 1989; Moore et al., 1987; Moore and Jakosky, 1989; Thompson, 1989), microwave radiometry (Cuzzi and Muhleman, 1972; Epstein et al., 1983; Kuz'min and Losovskii, 1984), and inference from radio-occultation of Mars orbiting spacecraft (Tang et al., 1977; Lindal et al., 1979; Simpson et al., 1981, 1984). Such determinations are consistent with the electrical properties of lunar materials (Olhoeft, 1990) and of dry or frozen terrestrial silicates (Olhoeft and Strangway, 1974; Olhoeft, 1978). Such materials have relative dielectric permittivity that is given by $k' = 1.93^d$, where d is the dry bulk density in g/cm^3 (Olhoeft and Strangway, 1975), and the permittivity is independent of frequency. Beyond this, little is known for certain -- no direct measurements of electrical properties on Martian materials have been performed.

The volume electrical conductivity of such materials should be in the range of excellent insulators, roughly 10^{-9} to 10^{-14} Mhos/m. Such low electrical conductivity means the particles will have very low electromagnetic losses, with the principle attenuation due to surface and volume scattering mechanisms -- this means radiowaves will penetrate through Martian dust and soil for great distances. However, in the absence of water, such highly insulating surface materials will also result in problems for the grounding of electrical power systems and the creation of radio antenna ground planes for communication and navigation.

Further, such highly insulating particles may exhibit high surface electrostating charging and/or photoconduction effects as observed in lunar samples (Alvarez, 1975). The Apollo astronauts reported and drew pictures of "streamers" and corona/zodiacal light extending several kilometers above the lunar surface while approaching orbital sunrise. These are best explained as electrostatic levitation of soil particles (see further discussion and references in Olhoeft, 1990). The Apollo 17 LEAM (Lunar Ejector and Meteorites) experiment (Berg et al., 1973) found increased particle counts during passage of the terminator and:

"...all of the events recorded by the sensors during the terminator passages are essentially surface microparticles carrying a high electrostatic charge." "The particle event rate increases whenever the terminator passes over the instrument. This increase starts some 40 hours before sunrise and ends about 30 hours after it." (Rhee et al., 1977).

As the electrical conductivity is lowest during lunar night, the soil will have the highest electrostatic chargeability at night. It is possible that night-time activities which disturb the soil, will create dust that will thickly coat surfaces during the night. Upon sunrise, the resultant photo-induced increase in electrical conductivity will cause most of the coatings to discharge and slough off, leaving only a thin residual coating behind. During night, the low conductivity of the soil will also create significant electrical charging hazards between mobile objects on the surface -- producing the well known winter-time "spark" electrical discharge when the charged objects meet.

Similar electrostatic charging and coating effects may be found on the surface of Mars, though no experiments have been performed or are planned to look for such effects. These effects may be exacerbated by wind blown particle movement (which fosters charge separation and accumulation, resulting in lightning discharges during terrestrial desert sandstorms) or mitigated by the presence of water (Carr, 1986; Squyres, 1989) and millibar atmospheric pressure (which tends to produce electrostatic glow discharge instead of spark discharge). The effects of electrostatic charging and discharge on electronic equipment may also be a problem, and are determined by the type of metal being charged, atmospheric pressure and composition, aerosol dust type and composition, incident radiation fields, and frequency. Some general reading on the effects of electrostatic charging and electrical properties of dust may be found in: Cox and Pearce, 1948; Brown, 1966; Whitby and Liu, 1966; Withers, 1979; John, 1980; Kunhardt and Luessen, 1983; Yeh et al., 1983).

The electrical properties of individual sand and dust particles will be dominantly those of silicate insulators. However, surface coatings on particles are possible where the activity of water has caused chemical alteration (such as clay or zeolite mineralization), desiccation (leaving behind salt), or frost. Little is known about the occurrence of such coatings, their electrical properties, or how they might modify the electrical properties of the particle substrate. In the absence of photoconductive effects, small quantities of moisture could dramatically alter the electrical behavior of Martian soil particles.

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