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"CLEAN" VS. "DIRTY" SILICATE GRAINS AND THE STATE OF CARBON CRYSTALLIZATION IN INTERSTELLAR AND CIRCUMSTELLAR DUST

Peter R. Buseck, Departments of Geology and Chemistry, Arizona State University, Tempe, Arizona 85287

The 9.7μm spectral feature of interstellar dust has commonly been ascribed to rock-forming silicates such as olivine [$(Mg,Fe)_2SiO_4$] and enstatite pyroxene [$(Mg,Fe)SiO_3$]. However, it only approximately matches their spectra. To explain the distinction, astronomers refer to "dirty" silicates, although the meaning of this term is left vague. A common explanation is that these minerals are "disordered", but without specifying what is meant. However, terrestrial, meteoritic, and interplanetary olivine and enstatite are well ordered (aside from the Mg-Fe disorder that is typical of these minerals) and, moreover, there are no likely crystal-chemical ways in which they could disorder. We have used electron diffraction to study many interplanetary dust particles that contain olivine and pyroxene (e.g., Tomeoka and Buseck, 1984), and in none of them have we detected any sorts of anomalous disorder. It is not at all apparent what sorts of "disorder" could account for the "dirty" silicates in the interstellar dust. It thus behooves astronomers to attempt to specify more clearly what sorts of silicates, if indeed they are silicates, are indicated by the 9.7 μm spectral feature. Terminology as used at present is not compatible with standard mineralogical usage.

In another part of the spectrum, the 2175 Å spectral "bump" appears to be ubiquitous for interstellar dusts. It is commonly assigned to amorphous graphite or some similar material, although concerns have been expressed that the wavelength of the bump should shift slightly depending on grain size, and such shifts in position have not been observed (e.g., Mathis, 1985). Recently, results have been obtained of high-resolution transmission electron microscopy of both natural carbonaceous materials and organic molecules that have been heated and carbonized in the laboratory under controlled conditions (Buseck and Huang, 1985a,b). These results indicate that there are a wide range of recognizable stages during the transition from totally disorganized and amorphous carbon to good crystalline graphite.

Degree of polymerization into individual sub-planar and then planar polycyclic aromatic sheets of hydrocarbons grade into poorly stacked sets of sheets full of many edge dislocations and bonding vacancies. These, in turn, grade into the regularly stacked and laterally extensive sheets that characterize graphite. Work is required to determine whether these steps each have their own IR and UV signatures and how they may relate to the 2175 A bump. In the meantime, however, it is important to be aware that the crystallization of carbon to graphite is complex and that it would be desirable to specify the state of crystallization in the interstellar medium more precisely than just whether or not it is "amorphous".

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