Adsorption of CO and N₂ by Samples with Large Surface Area.

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Pyrolysis studies of lunar soil samples (1-9) have shown releases of N₂ and CO from lunar fines at temperatures above 600°C. (Figure 1 is a typical gas release pattern for mature lunar fines). The bimodal release of the N₂ and CO has been attributed to the release upon heating of carbon and nitrogen atoms attached to the surfaces of the grains (2, 7). High resolution mass spectrometry has shown that both CO and N₂ are present in each of the bimodal release peaks (5). Many studies have been made in an attempt to determine the sources of the CO and N₂ releases at elevated temperatures (2, 3, 10-13). These workers have generally concluded that the carbon and nitrogen result from solar wind implantation on grain surfaces and the abundances of the carbon and nitrogen are related to surface areas of the grains. In some cases, the size of the bimodal peaks observed in gas release studies are inversely related to grain sizes. A small fraction of the carbon evolved from the soils is thought to be present as carbide, possibly associated with iron (12). Upon heating, the released carbon combines with an available oxygen (presumably available from Si-O) and is released as carbon monoxide.

In a recent study of submarine basalt glasses from the mid-Atlantic ridge (14), samples of glass were analyzed for their active gases and found to release CO and N₂ in a fashion similar to the patterns released for lunar fines. Samples of the basalt glasses were pyrolysed after grinding in an agate mortar and pestle to less than 64 microns. Figure 2 shows a bimodal mass 28 peak from the sample similar in appearance to that from the lunar sample in Figure 1. These peaks were not present in a mass pyrogram of an unground fraction of the same sample, pyrolyzed under the same conditions (Figure 3). Figures 2, 3, and 4 are plotted on the same scale with no background correction. Not only do submarine basalt samples show mass 28 peaks after grinding, but other samples such as the tektite shown in Figures 5 and 6 can also be made to give this release pattern. Fragment peaks 12 and 14 indicate that both CO and N₂ are released simultaneously.

It seems possible that some of the carbon monoxide and nitrogen peaks observed from the lunar soil samples might be caused by contamination from air because the basalt and tektite samples in this study show the same type of release behavior for CO and N₂ after grinding in air, and since solar wind implantation is obviously not the CO and N₂ source for the basalt and tektite. At this time, it is impossible to determine the mechanism of chemisorption involved in retention of these volatiles by the samples. The fact that the release temperatures are so high, indeed, for the second peak approaching the melting point of the sample, indicates some very tight binding mechanism occurs.

Major changes in the volatile release patterns for water and carbon dioxide also occur when the sample is ground. In an attempt to determine which peaks were actually from the sample and which might result from adsorption of gases during grinding in air, a sample was heated to 950°C to remove the first CO₂ peak and all of the water. The mass pyrogram agreed with the original release pattern in Figure 3 to 950°C. A large 28 peak appears where none was before.

In summary, the results show that grinding the sample severely altered the apparent volatile content and release behavior of the sample, and perhaps
the method of volatile retention. Extreme care must be taken when handling samples with large, active surface areas, and when interpreting results from materials which has been mechanically altered.

References
Note: The temperatures marked on the release profiles are 150°C, 550°C and 950°C for Figures 1-6.

Figure 1 - Nature lunar fines, 1969

Figure 2 - Submarine basalt glass ground to <64µm

Figure 3 - Submarine basalt glass 0.5 to 1.0 mm

Figure 4 - Submarine basalt glass heated to 950°C, ground to <64µm

Figure 5 - Tektite, 1 large piece

Figure 6 - Tektite, ground to <64µm