SIMULATION OF LUNAR CARBON CHEMISTRY IN PLAGIOCLASE, P. C. Wszolek, F. C. Walls and A. L. Burlingame, Space Sciences Lab., Univ. of Calif., Berkeley, Ca. 94720.

Solar wind ion implantation of carbon is a major source of this element on the moon and has been implicated in the formation of hydrocarbons and carbides in lunar fines. It is also apparent that the chemical and mineralogical composition of lunar material is important in determining the nature of some of the carbon species synthesized from solar wind ions. Specifically the iron and calcium contents of lunar soils are related to the yields of $CD_4$ (1) and $C_2D_2$ (2), respectively, produced on hydrolysis with deuterium labelled mineral acids. To understand the parameters significant for the formation of lunar carbide and other carbon compounds, we are simulating solar wind ion implantation in various mineral phases which are known to occur on the moon. Such studies are also expected to aid in assessing the distribution of carbon among the components of lunar soils (1, 3).

Wafers (~1 cm x 0.3 cm x 0.1 cm) of plagioclase ($An_{66}$) were sliced with a diamond impregnated wire saw and thoroughly cleaned with water, methanol, and methylene chloride and subsequent heating to 950°C under vacuum. These plagioclase targets were wrapped with clean, thin platinum wire to prevent surface charging and were then irradiated with $10^{16}$ $^{13}C^+/cm^2$ at 40 KeV and 3 x $10^{16}$ $D_2^+/cm^2$ at 12, 18, and 24 KeV. In one case, $10^{16}$ $^{14}N^+/cm^2$ at 45 KeV was used as a projectile along with $^{13}C^+$ and $D_2^+$ on one surface of the target. The irradiations have been carried out in collaboration with Dr. Michel Maurette and coworkers (4). Two targets irradiated with $^{13}C^+$ and $D_2^+$ were dissolved in 40% HF <u>in vacuo</u>. The target irradiated with $^{13}C^+$, $D_2^+$ and $^{14}N^+$ was pyrolyzed with linear temperature programming from ambient to 1400°C (5). Gases released by both techniques were analyzed continuously with a modified GEC-AEI MS-902 mass spectrometer at 10,000 resolution.

A variety of hydrocarbons and deuterocarbons were released by HF dissolution of $^{13}C^+$ and $D_2^+$ irradiated plagioclase. The deuterocarbons represent species synthesized by the implanted ions whereas the hydrocarbons are reaction products of the HF with species behaving like carbides. The major reaction product released is $^{13}C_2H_2$, strong evidence that calcium and sodium carbides have been formed in the irradiated plagioclase. $^{13}C_2H_6$ and $^{13}C_3H_6$ were present in smaller amounts. No $^{13}CH_4$ was detected among the reaction products indicating the absence of iron and aluminum carbides which produce mostly methane on hydrolysis. Methane was the only reaction product detected from hydrolysis of lunar fines, an iron film and aluminum artificially irradiated with carbon (6). These data indicate that the nature of the carbides formed in lunar fines is specifically related to the chemical composition of the substrate and that it is the cation, in the case of plagioclase at least, which is the important element. These data provide indirect evidence for the formation of iron carbide in lunar iron silicates (7) through the agency of the solar wind.

In lunar fines, indigenous methane and ethane are released during hydrolysis and are thought to be synthesized from carbon and protons in the solar wind. Our analyses of the artificially irradiated plagioclase show that both these species are formed in this way. Pillinger <u>et al.</u>, (6) have also shown that methane can be synthesized from solar wind ions. Our analysis of the irradiated plagioclase indicates the synthesis of two additional species: ethylene and propylene, $^{13}C_2D_4$ and $^{13}C_3D_6$. The corresponding hydrocarbons have been detected in lunar fines (8), in small amounts.

At present we can only give semi-quantitative data for relative quantities of the gaseous species released by dissolution of the irradiated plagioclase. We estimate that a few percent of the $^{13}C^+$ is recovered as hydrocarbons and deuterocarbons.

Temperature release profiles for the major species released during the pyrolysis of plagioclase irradiated with $^{13}C^+$, $D_2^+$, and $^{14}N^+$ are shown in Figure 1. Implanted carbon is evolved primarily as $^{13}CO$ and $^{13}CO_2$ as is the case for most lunar fines. The ratio of $^{13}CO$ to $^{13}CO_2$ for the targets was 5. $^{13}CO$ is released mostly between 800-900°C with a smaller amount from about 1050-1200°C. The same pyrolysis pattern was observed for CO released by plagioclase and the finest grains separated from 10086D fines (3). Most of the $^{13}CO_2$, on the other hand, is evolved from 1000-1200°C with another smaller evolution at 800-900°C, and a very minor evolution around 400°C. Our data confirm that the low temperature $CO_2$ in lunar fines does not derive to any significant extent from solar wind. Our results the evolution of $^{13}CO$ from irradiated plagioclase differ from those of Chang et al.(12) for irradiated mature lunar fines. In their experiments most of the $^{13}CO$ was released above 900°C. The apparent discrepancy may be due to one or more of the following: (1) different total doses of $^{13}C$ ($10^{16}/cm^2$ vs. $> 10^{17}/cm^2$); (2) different mineralogical composition of the targets; (3) chemical state of the metal in the targets. The two studies should complement each other and represent solar wind carbon implantation into lunar materials with varying degrees of surface exposure. Other species detected during the heating of the plagioclase were HOD and $H^{13}C^{14}N$ (Figure 1) which were released at about 400-600°C and 800-900° C, respectively. HCN is typically evolved from 400-700°C in mature lunar fines (5), and both HCN and DCN are observed among the gaseous products released when lunar fines are dissolved in DF (9). Our detection of HOD in irradiated plagioclase and quartz lends support to proposals (10, 11) that hydroxyl groups and water can be synthesized from solar wind hydrogen and the oxygen of lunar materials. Fifty-six hundredths percent of the $^{13}C^+$ and $^{14}N^+$ was evolved as $H^{13}CN$ and 0.25% of the $D_2^+$ was recovered as HOD. Note that these molecules contain labile, exchangeable hydrogen probably deriving from water in the mass spectrometer.

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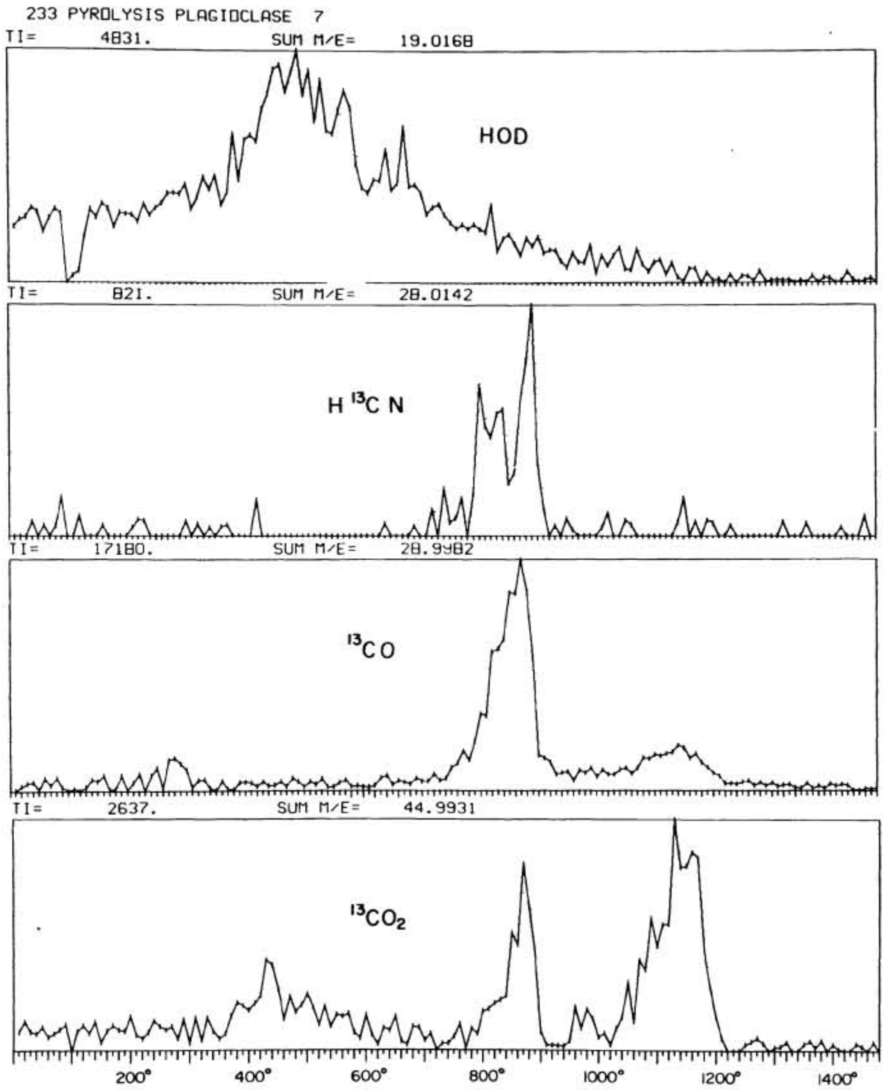


Fig. 1: Species released by pyrolysis of plagioclase irradiated with $^{13}C^+$, $^{14}N^+$, and $D_2^+$.