ANALYTICAL STUDY OF COMET NUCLEUS SAMPLES; A. L. Albee, California Institute of Technology, 02-31, Pasadena, CA 91125.

The detailed analytical study of the Apollo lunar samples revolutionized our understanding of Moon. In addition, the analytical challenge demonstrated the capabilities of a variety of new instrumental techniques for providing precise analysis of very small samples. Electron-beam instruments with imaging and analysis capabilities, x-ray fluorescent analysis, instrumental neutron activation analysis, and high-resolution mass spectroscopy are all now considered as standard techniques.

Study of comet nucleus samples will be even more challenging, calling upon all of the standard techniques that are now used to study meteorites as well as upon new techniques that can address the special properties of these samples. Most of the lunar samples were rocks and rock fragments differing from terrestrial samples mainly in the small size of the samples. However, study of the core samples required special techniques for their dissection and analysis.

Current plans call for the return of frozen (130 K) core samples from the nucleus. Based on a variety of evidence it is believed that this ice rock sample will consist of a variety of grains cemented by interstial icy phases. These grains will include: 1) single grains of silicate, oxide, and sulfide minerals; 2) very fine-grained aggregates of poorly-crystallized phyllosilicates; 3) clumps of "tarry" (CHON) compounds; 4) composite grains of the same constituents, including "tarry" coatings. The interstial ice may include clathrates, as well as ice phases of H_2O, CO_2, NH_3, etc.

At our present level of technology each of these components requires different analytical approaches, preparation, and instrumentation to achieve adequate results. Even with new approaches it will probably be necessary to separate the components for thorough study. However this should be done only after study of the bulk core clarifies the spatial relationships and the identity of the various components. By external study of the core at cryogenic temperatures we should be able to determine the structures and bulk chemistry of the core, the fabric as exposed on its surface, and the identity of the ice phases and of representative non-volatile grains. It should be possible to obtain non-destructive 3-dimensional imaging of the core at several wavelengths ranging from sonic to x-rays. The bulk composition can be determined by neutron-activated gamma ray spectroscopy. The surface of the core can be photographed with an optical microscope and elemental composition can be obtained from electron and ion-beam analysis. Each such procedure must be considered in terms of side-effects that may be deleterious to other analyses. Identification of the ice phases and preliminary analysis of tarry material will probably require removal of small samples.

This preliminary information will be used to design a handling scheme that can be tested on a portion of the core. Cutting the core will provide additional smooth surfaces for examination. A thin slice of core can be imaged in transmission and the ices removed by a step-wise controlled devolatilization that will differentially remove the various ice phases. Complete volatilization below the freezing point of water will leave the grains in their original position relative to one another for documentation prior to removal for detailed study. Elemental, isotopic, and mineralogic study of the individual grains and their coatings can be carried out by several methods at very high precision, even with current techniques.

But, we will be surprised! We can be certain that this model is far too simple. The interstial ice may be lost on the return trip, leaving only a loose aggregate of grains in an atmosphere reflecting the ice composition. Or the core may never have contained any interstial ice--only a compacted aggregate of residual grains from the near surface of the comet. The nature of the grains may be quite different--more variety or only a single type. The design of the core tube must allow for some external examination and varied modes of core removal must be well understood. A variety of worse-case scenarios must be designed and practiced in advance of the sample return.