DISAGGREGATING IDPS. D. E. Brownlee and D. J. Joswiak, Dept. of Astronomy, University of Washington, Seattle, WA 98195

One of the highly significant aspects of IDPs is the simple fact that some of them are microporous weakly consolidated materials. Preservation of the original pore spaces between grains can be a subtle but highly significant indicator of the primitive nature of early solar system materials. A subset of IDPs seem to be simply porous aggregates of sub-micron and larger components that accreted by gentle processes. Unlike chondrites they are not strong relatively compact materials, their original void spaces have not been diminished by compression and they have not had significant closure of inter-grain spaces by heating, aqueous alteration or other internal parent body processes. Some IDPs seem to be simply collections of original accreting grains with the pores perhaps originally occupied with ice. If these particles can be appropriately disaggregated the liberated components are likely to be early generation grains from the solar nebula.

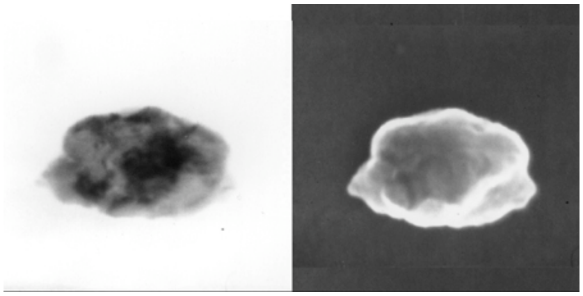
Many IDPs partially disaggregate during their 200 m/s impact onto stratospheric aircraft collection surfaces. In the case of “cluster IDPs” (the most fragile IDPs) the aggregates can break into dozens to thousands of components although most components are just smaller aggregate structures and not the fundamental grains the particles originally formed from. In very rare cases particles break into many thousands of submicron grains although these are rarely removed from collection surfaces because of numerous unsolved technical difficulties. The “natural” break-up of these rare particles has encouraged us to explore means of cleanly disaggregate other IDPs to liberate individual grains for detailed study. The goal of this work in to separate IDPs into their original components without damaging components such as single mineral grains. We wish to cleanly separate weakly adhering materials, and expose original grain surfaces in ways that do not damage the fundamental building blocks of IDPs. Most primitive IDPs seem to be aggregates of 200nm and larger solid components and most smaller components are inside solid composite materials such as GEMS that are not themselves porous. Separation of these submicron and larger grains should provide new insight into the nature of the materials that accreted to form IDP parent bodies.

The availability of disaggregated IDPs will compliment work done on microtome thinsections. Most of the detailed studies of IDPs are done with microtome sections but this highly successful technique does obscure several important properties. Data from microtome sections can be supplemented by TEM study of disaggregated but unsectioned particles. Examples of new kinds of information include surface properties of grains, such as growth steps or even microcraters that might reveal past history. It is also a technique that can expose certain types of grains that are almost never seen in sections because of their geometry, grains such as En platetets, ribbons and whiskers. A major goal of this work is to expose all components of a given IDP so that an accurate accounting of a particles contents can be done. Using typical methods, serial microtome sections cut from a particle edge usually only sample a few percent of a particles contents and even then the process produces artifacts. Large mineral grains are often missed and are under accounted for or at the other extreme they often shatter and their composition is over represented. With an entire disaggregated IDP mounted on a TEM film, all of the components can be quantitatively accounted for without problems of sampling or crushing of large grains. The disaggregation approach also provides a means of finding and isolating rare and unusual components that ideally can be studied without overlap or superposition of other components.

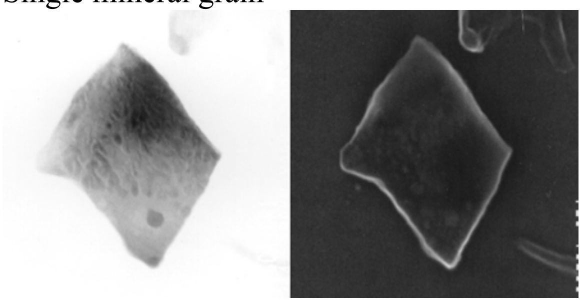
We have explored a number of techniques for disaggregating IDPs, most of which have not been fully successful. The challenge is to gently pull individual IDPs apart into their original components and then mount the pieces on to a carbon film for TEM investigation. We have tried ultrasonic disruption of particles sandwiched between nucleopore films and particles suspended in plastic microcapillary tubes. These approaches have not been adequate because of the difficulty of keeping grains isolated in a small volume of solution. Our most successful method has been crushing between glass slides using a small amount of solid hydrocarbon such as octadecane ($C_{18}H_{38}$) or docosane ($C_{22}H_{46}$). These are solid low melting point hydrocarbons that behave like waxy materials at room temperature. IDPs crushed between glass without a filler simply compress into solid pancakes but when crushed with a small amount of octadecane, the wax-like material fills the void spaces and prevents compaction. When the glass plates are pushed within a few microns of each other the octadecane and embedded IDP smoothly flow outwards somewhat similar to a glacier. The shear in the flowing semi-solid material literally rips the particle apart. With practice it is possible to repetitively crush the particles by gathering octadecane from the edge of the sample and moving it back to the particle mass. This repeated “kneading” of the sample can cleanly tear the particle into its fundamental components and remove unbonded surfical materials. The octadecane can be moved to a TEM grid where the hydrocarbon carrier is removed by sublimation.

This method has had good success in dissagregating IDPs into individual submicron components that can be well studied in the TEM. In particular it has been quite successful in isolating and cleaning enstatite plates. For a future development we plan to extend the technique so that the octadecane is ultimately melted so that we can magnetically separate grains in a low viscosity liquid between closely spaced glass plates. The final goal of this effort is to separate GEMS from materials that do not contain nanophase metal grains.

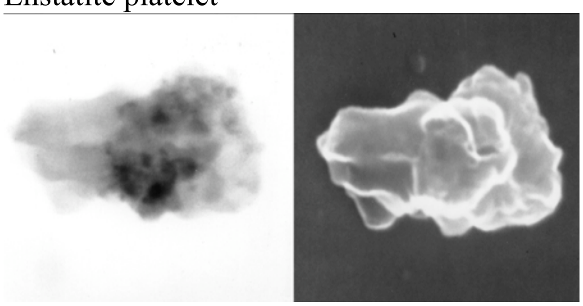
TEM left and SEM right of separated 200nm to 300 nm grains



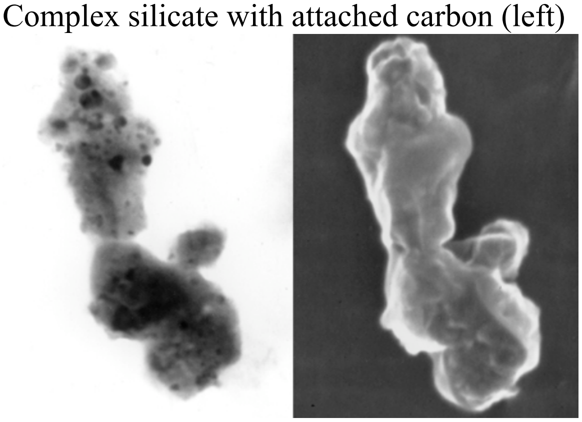
Single mineral grain



Enstatite platelet



Complex silicate with attached carbon (left)



Three GEMS