TOWARDS A COMPLETE INVENTORY OF STRATOSPHERIC DUST PARTICLES, WITH IMPLICATIONS FOR THEIR CLASSIFICATION, Michael E. Zolensky, Ian D.R. Mackinnon and David S. McKay, SN4/NASA Johnson Space Center, Houston, TX. 77058

Several investigators have recently proposed classification schemes for stratospheric dust particles [1-3]. In addition, extraterrestrial materials within stratospheric dust collections may be used as a measure of micrometeorite flux [4]. However, little attention has been given to the problems of the stratospheric collection as a whole. Some of these problems include: (a) determination of accurate particle abundances at a given point in time; (b) the extent of bias in the particle selection process; (c) the variation of particle shape and chemistry with size; (d) the efficacy of proposed classification schemes and (e) an accurate determination of physical parameters associated with the particle collection process (e.g. minimum particle size collected, collection efficiency,variation of particle density with time). We present here preliminary results from SEM, EDS and, where appropriate, XRD analysis of all of the particles from a collection surface which sampled the stratosphere between 18 and 20km in altitude. Determinations of particle densities from this study may then be used to refine models of the behavior of particles in the stratosphere [5].

Particle collection surface W7017 was selected for detailed examination. This particular flag was flown for a total of 45 hours from July 7 to September 15, 1981. This sampling was prior to the El Chichon eruption of March to April, 1982, although inclusion of volcanic material from other sources (e.g. Mount St. Helens) may be unavoidable. Prior to this study 104 particles had been removed from flag W7017 and are described in the Cosmic Dust Catalog [6]. Particle collection surface W7017 was washed free of all remaining particles with freon and hexane, and the residue was then directed onto a series of vertically stacked nucleopore filters (filter sizes 5um, 1um and 0.4um, respectively). This filtering arrangement efficiently prevented the particles from piling up on each filter, and facilitated later particle sizing.

Examination of the 5um and 1um nucleopore filters suggests that there are a total of 900 and 9500 particles on these filters, respectively. Optical studies gave no indication that such a large number of particles would be found on this flag. We suspect that large numbers of particles will also be found on the 0.4um filter. This suggests that the size cut-off for the collection process may be considerably less than 2um [7]. While it may be possible that many of the smaller particles may be pieces of broken aggregates, we think this explanation is unlikely. The fact that many of these fragile aggregates survive impact onto the flags demonstrates that the sampling process in the stratosphere is not an important process for particle disaggregation. The small particles we see in such abundance are on the order of a couple of microns in diameter. Therefore, the aggregates necessary for the production of such particles would originally have been much larger. Such large and interesting looking particles would certainly have been noted optically, and would now be in the Cosmic Dust Catalogs. Therefore, the disaggregation of these particles during sample washing would have been precluded. The particle populations found for the >10um, 5-10um and 2-5um size fractions imply stratospheric particle densities of 1.7×10^{-3}, 1×10^{-2} and 1×10^{-1} particles/cubic meter, respectively. These figures are in considerable excess of previous estimates [4].

As there are only 104 particles from this flag in the Cosmic Dust Catalog, of predominantly larger sizes, it is probable that this catalog does not contain a representative sample of the particle population of this flag. Consequently, a statistical analysis of the particle type/size distribution from flag W7017 is shown below in Table 1. The stratospheric particle classification developed by Mackinnon et al. [1] and Kordesh et al. [2] is used in a slightly ammended form. To eliminate sampling bias, all of the particles in randomly selected filter areas were identified. Particle groupings based only upon chemistry are used in Table 1. Thus, categories are: chondritic, silicate, aluminum, aluminum prime (aluminum rich with lesser amounts of other elements), Fe-S (predominantly iron without sulfur), Fe+S (predominantly iron with sulfur), CAS (predominantly a calcium aluminum silicate), and other (a catch-all category). In this study a significant number of particles containing only low Z elements were encountered, and are therefore included in their own catagory. A fruitless attempt was made to equate this low Z material with any of the known possible sources of contamination. The following possible contaminants were characterized: plastic from the filtering arrangement, the flag itself and petri dishes; plastic and nylon bags, teflon tape, tar, epoxide resin used to hold the nucleopore filters to the SEM mount, and carbon from the carbon coating apparatus.

Table 1 shows that silicate particles are common on flag W7017, in increasing relative abundance with decreasing particle size. A terrestrial volcanic source cannot be ruled out for this material. However, the average composition of the Mount St. Helens ash and glass, for example, shows higher levels of iron (4 to 6 wt.% Fe_2O_3 [4]) than is characteristic of the material in the silicate category (0 to 4 wt.% Fe_2O_3). Chondritic material is also observed to increase in relative abundance with decreasing size. There is a concommitant decrease in the relative abundance of the aluminum and aluminum prime material with decreasing particle size.

The last line of Table 1 indicates the relative abundance for each stratospheric particle type solely on the basis of the entries for W7017 in the Cosmic Dust Catalog [6]. In the case of W7017 and particles >1um in size the Cosmic Dust Catalog [6] is shown to be biased toward the material most common among the largest particle size fraction (e.g. aluminum and aluminum prime particles). Although not shown in Table 1, the Cosmic Dust Catalog contains an unrepresentatively large number of spheres compared with the total particle abundance on flag W7017.

While previous tabulations of stratospheric particles [3, 6] may be accurate in their descriptions of the variation in particle chemistry and morphology, they are probably not representative of the particle distribution in the stratosphere. Accordingly, studies of stratospheric particle distributions should take account of the smallest particle size fractions.

References: 1. I.D.R. Mackinnon, et al., JGR, 87, A413-A421, 1982; 2. K.M. Kordesh, et al., Lunar and Planet. Sci. XV, 387-388, 1983; 3. P. Fraundorf, et al., JGR, 87, A403-A408, 1982;4. P. Fraundorf, Meteoritics, 17, 214-215; 5. L.D. Strand, et al., Proc. 18th Aerospace Sciences Meeting, 1980; 6. C.D.P.E.T., Cosmic Dust Catalog, 1 , 1982; 7. D.E. Brownlee, et al., Science, 191, 1270-1271, 1976; 8. Sarna-Wojcicki, A.M., U.S.G.S. Prof. Paper 1250, 667-682, 1981;

Table 1 Stratospheric Dust Size-Type Distribution for Flag W7017

sample	chondritic	silicate	Al	Al prime	Fe-S	Fe+S	CAS	low Z	other
>10um	7%	31%	19%	15%	4%	7%	<1%	7%	9%
5-10um	8%	38%	21%	9%	1%	3%	<1%	14%	5%
1-5um	15%	61%	3%	6%	3%	6%	<1%	3%	3%
entire flag	14%	59%	5%	6%	3%	6%	<1%	4%	3%
catalog-W7017	19%	17%	29%	19%	7%	5%	2%	0	2%