LEONID DUST SPHERES CAPTURED DURING THE 2002 STORM? Frans J. M. Rietmeijer[1], Melissa A. Pfeffer[1], Lysa Chizmadia[1], B. Macy[1], T. P. Fischer[1], M. E. Zolensky[2], J. L Warren[3] and P. Jenniskens[4]; [1]Dept. Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131; [2]Code ST, NASA Johnson Space Center, Houston, TX 77058; [3]Lockheed Martin, NASA Johnson Space Center, Houston, TX 77058; [4]SETI Institute, 2035 Landings Dr., Mtn. View, Ca 94043, E-mail: fransjmr@unm.edu

Introduction: An effort was made to collect dust from a known source, comet 55P/Tempel-Tuttle, in the form of Leonid meteor debris in the hours after the 2002 storm. No interplanetary dust particles (IDPs) have yet been recovered from a known source. We do not expect Leonid debris at 72 km/s to survive atmospheric entry as aggregates and our effort was predicated on the notion that mm-sized and larger meteoroids after extreme mass could survive as up to ~100 µm sized 'silicate' spheres. Two anticipated Leonid storms, rather than its annual shower activity, were the target of the last Leonid Multi-Aircraft Campaign [1,2] during the Nov. 19, 2002 storm. Flying westwards from Spain to the US the mission covered both the 1767 and 1866 dust trails whereby early in the flight the aircraft flew several hours across the region exposed to the first storm peak that did not include the continental US of the second peak with 5,400 meteors.

Dust Collection: We deployed four collectors at ~20 cm distance from the hull through a front-row window a window port on the FISTA aircraft [1]. For each stage of the mission a new collection substrate was fitted inside the collector housing prior to take-off. Opening and closing of the collector was manually controlled from inside the plane. The collection substrates, transparent 26 cm^2 plastic plates, were coated with silicone oil at the JSC Curatorial Facility. The flight from CA to NE was used to test collector performance during take-off and landing. We did not suffer measurable dust contamination >10 µm. The collector cut-off size is unknown. Dust was collected during three stages of the MAC campaign: (1) Omaha (NE) to Torrejon (Spain) at 10.7 km altitude, (2) the return flight during the storm (*Fig. 1*), and (3) Omaha to Edwards AFB (CA) on Nov. 20 that when debris from both storm peaks occurred in the atmosphere. Flights #1, and probably #3, represent a dust background. Collection times in the lowest stratosphere were limited (Table 1). Stratospheric dust collection on flight #2 occurred when the Leonid meteors entered the atmosphere at grazing angles.

TABLE 1: *Collection times in the lower stratosphere (a) and upper troposphere (b); number (N) of particles*

Collection flight	Hours[a]	Hours[b]	*N*
#1 NE to Spain	0.6	0.0	160
#2 Spain to NE The Storm	2.0	6.2	612
#3 NE to CA	1.8	0.0	214

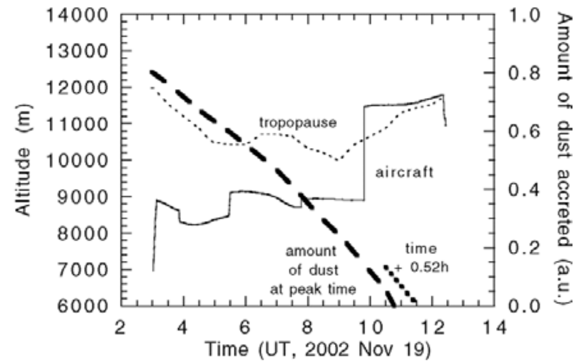

Fig. 1*: Aircraft flight altitude profile at storm night. Troposphere heights are approximate. Also shown is the amount of Leonid dust accreted during the storm peak at 4h UT above the aircraft location.*

Collected dust: We made a full inventory of 986 collected particles >10 µm using the criteria, e.g. shape, color, transparency and luster, of the Cosmic Dust Program. These properties offer a first clue to possible particle origin. The optical properties show three different dust groups, viz.

(1) Transparent to translucent, light reddish-brown to dark brown, irregular thin flakes and thick shards. They are generally about ~25 µm in size. Distinctly larger particles are ~100 µm up to (rare) 300 x 150 µm. They are natural terrestrial, i.e. volcanic dust,

(2) Small, ~10 µm, mostly equi-dimensional, dull dark particles. The small size contributes to a dark appearance in reflected light. They may include tiny, very dark brown volcanic ash, and

(3) Opaque, typically sharp angular flakes, rods and needles with a distinct metallic luster. They are mostly of anthropogenic origin.

TABLE 2: *Percentage of dust types on the collectors*

Collection flight	Volc. Ash	Dark	Black
#1 NE to Spain	52	34	14
#2 The Storm	11	87	2
#3 NE to CA	51	34	15

There was a consistent stratospheric dust background (Table 2). About 45% of dark and black particles during flights #1 and #2 are equi-dimensional or spheres; ~30% during flight #3. The largest collected dusts are mostly irregular particles. They were rather abundant during flight #3. The Strom flight contains particles from the upper troposphere.

Based on the optical properties probable cosmic particles included two black aggregates and two spheres, all ~25-µm (flight #1); a 10 µm black sphere and a tiny dark sphere on flight #3. Their abundance is consistent with an IDP background flux [3].

Criteria for Leonid debris: The Leonid MAC missions offered exciting new insights in meteor behavior. For example, millimeter-size Leonid meteoroid debris with a temperature <450K at 84 km altitude survived at the luminous meteor ablation phase. Fragments were seen traveling at very high speeds down to 56 km. They had yet to lose the orbital velocity prior to gravitational settling. Collected 'silicate' IDP spheres have an abundance peak coincident with the annual Leonid and Orionid meteor showers [4]. Based on this shower collection rate, i.e. particles per collector area per hour ($p/cm^2/h$), we anticipated collecting 2 or 3 spheres (5-64 µm) for an 8h period. During the storm, the total influx is comparable to the integrated influx of annual showers but deposited in a short time. It causes a significant increase in the number of spheres at the collection altitude at a time corresponding to the settling rate. Only >100 µm spheres will reach the collection altitude after 6-8 hours settling from 60 km. On flight #3, 26 hours after the second peak, Leonid 'silicate' spheres will be >65 µm.

Results: The 'storm' collector had 46 dull dark, ~10 µm sized spheres and two big (~50 µm) metallic spheres. Their normalized abundance indicates is a 'catastrophic' dust event. We rinsed all particles off the 'Storm' collector using ultrapure Freon. We prepared a very small fraction of the sample for SEM analyses. Preliminary analyses show a fair amount of Si-rich volcanic dust a few microns and larger. We found two ~5 µm spheres, Ti,O (tr: Si,Al,Fe) and Fe,O (tr: Si,Ca,Mn); a ~10 µm (Al,K,Ca)-silicate (tr: Mg, Fe,Na) sphere; a Mg-silicate sphere (20 µm), and a 25 µm, quenched metallic Si sphere with relic grains.

The JSC Leonid 2002 Collection: A NASA ER-2 aircraft flew at ~20 km over the SW USA, for a period of 4 days beginning on Nov 19 in an attempt to collect Leonid storm debris. These flights began on the day of the shower peaks, and continued for the next 3 days. The two small collection surfaces, U2108 and U2109, each collected for a total period of 8 hours and 3 minutes. Preliminary inspection of the collectors showed nothing out of the ordinary, that is ~1 (probable) large chondritic IDP per collector per collection hour. There was one apparent black sphere on one of the collectors; none on the other. These collection surfaces are available for particle allocations as part of the routine JSC Stratospheric Particle Curation Program (http://curator.jsc.nasa.gov/dust/dust.htm). After ~75 hours settling from 60 km the smallest 'silicate' spheres on the JSC collectors would be ~25 µm. After this time the peak influx was probably sufficiently dispersed to prevent the collection of such spheres during an 8-h period.

Conclusions: It appears there were no surviving 'silicate spheres >65 µm the from fast-moving Leonid storm meteoroids that can be up to several cm-in size, not even when entering at grazing angles. The comet-dust spheres collected in the stratosphere are only from slow-moving comets. Considering the dispersal of the Leonid storm meteors and the settling rates of surviving spheres there is only a narrow window of collection opportunity. Settling rates will an important variable for success. The exact window of opportunity will be more critical for collections of shower debris.

The ~10-µm dark and black spheres during the 'Storm" flight could only have been collected when they reached terminal velocity ~2 km above the collection altitude. These sphere compositions alone cannot rule out an extraterrestrial origin but their small size appears to be inconsistent with a Leonid meteor origin. But, it might be suggested that fast-moving, kinetically fractionated (mass-loss) meteors at grazing incidence angles could penetrate more deeply into the atmosphere than was previously considered possible. We will continue our SEM and TEM analyses.

References: [1] Jenniskens P. (2002) *WGN* 30, 218-224. [2] Jenniskens et al. (eds.) (2000) *Leonid Storm Research*, Kluwer Acad. Publ., Dordrecht, 606p [3] Rietmeijer F. J. M. (1997) *LPSC XXVIII*, 1167-1168. [4] Rietmeijer F. J. M. and Jenniskens P. (2000) *Earth, Moon, Planets 82/83*, 505-524.

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