SURVIVAL OF CARBON DELIVERED TO THE MARTIAN SURFACE FROM INTERPLANETARY DUST PARTICLES. A. Zhuravlova[1], M. D. Fries[2], D. R. Locke[3] and D. Archer[3]. [1]Taras Shevchenko National University of Kyiv, Ukraine (64/13, Volodymyrska Street, City of Kyiv, Ukraine, 01601; Email: annazhuravleva7@gmail.com), [2]NASA Johnson Space Center, Houston, TX 77058, [3]Jacobs, Houston, TX 77058

Introduction: Carbonaceous asteroids, comets and small interplanetary dust particles (IDPs) are an important source of delivery of carbon to the primitive Earth [1] and the same holds true for Mars. Flynn provided an estimate of infall flux for Mars [2] that assumed that all carbon was lost from infall for particles that melted during atmospheric entry. While this is reasonable for Earth's atmosphere with 21% oxygen, Mars' 96% carbon dioxide should be expected to suppress oxidative loss of carbon from the total infall flux. Carbon loss under terrestrial and martian atmospheres needs to be examined as a potential refinement of Flynn's important results. Total Martian mass flux is estimated as 12×10^6 kg/year [2], therefore it is an important contributor to martian surface carbon and it is important to find out how much carbon gets through the Martian atmosphere and accrete on the surface of the planet.

Procedure: *Sample.* 1g of CM2 chondrite (ALH 85013) was obtained on request from the Antarctic Search for Meteorites (ANSMET) collection, which is curated at NASA JSC and the Smithsonian Institution. It is an interior meteorite piece without fusion crust, so all the carbon was preserved. We used a carbonaceous chondrite for this study because of its comparably high carbon content and generally analogous composition with IDPs and meteoritic infall.The dust was prepared by griding and then wet sieving using water as a sieving liquid. There are three size ranges 0-25 micron (fine), 25-125 microns (medium) and 125-425 microns (coarse) particles to find out the difference of atmospheric entry carbon survival for various particle sizes. These scales were chosen because comparably small particles contribute much more mass to the surface of Mars than bigger ones according to [2] and to span a range of sizes including small sizes that are projected to survive and larger particles that melt on infall.

EGA-MS. To determine carbon content EGA-MS was used. This technique slowly heats a sample to 1400K and analyzes the composition of gases released via mass spectrometry (MS). It is supposed to drive combustion of carbon to completion and evolve all the carbon as carbon dioxide by using oxygen as a carrier gas. The amount of CO_2 evolved shows how much carbon in general was in the sample.

Pyroprobe. The pyroprobe was used to simulate the thermal pulse from IDP atmospheric entry. It heats a sample from 40°C to 1327°C in 2 seconds. Rapid heating is necessary to approximate the average time of atmospheric entry for small dust particles. To compare the effect of different atmospheric compositions on carbon survival, several sets of experiments were conducted using oxygen, helium and carbon dioxide as carrier gases. Helium serves as a control measurement, and some amount of carbon can be expected to be lost via devolatilization. The oxygen carrier gas provides end-member data for the case of maximum carbon loss via combustion reaction. Finally, the carbon dioxide carrier gas approximates IDP infall into Mars' atmosphere.

Results:

Initial carbon content. Values from this measurement are different with respect to particle size (see the table below).

Size, µm	Carbon content, %
0-25	3.67%
25-125	4.79%
125-425	4.43%

Table 1. Initial carbon content of IDPs

One explanation for variance in carbon content is that it may be caused by wet sieving procedure and some of water-soluble carbon was lost during wet sieving. Other possibilities include clumping by carbon-rich small particles which then do not pass through the sieve, selectively enriching the sieved component in non-carbon components.

Carbon survival. To determine the carbon survival rate it is necessary to calculate initial and final carbon content and compare it. The table given below depicts mass percentage that survived pyroprobe treatment using various carrier gases. These values were obtained by comparing initial carbon to carbon remaining after pyroprobe heating under the various carrier gases, presented as percent survival.

Size, µm / carrier gas	He	O_2	CO_2
0-25	3.02%	1.76%	2.09%
25-125	1.86%	1.54%	1.45%
125-425	1.84%	1.73%	1.73%

Table 2. Final carbon content after pyroprobe treatment, by reactant gas.

Discussion:

Analysis of carbon survival.

1) Small particles (0-25 µm): Unexpectedly, the higher survival rate (up to 82%) was observed in tiny particles in all the atmospheric compositions. These particles may have melted rapidly due to their small size and "captured" carbon not allowing it to be released.

As for difference in gases used, the result matches the assumption to some extent: the lowest survival rate is seen under oxygen (48%), the highest in helium (82%) and something in between in carbon dioxide (59%).

2) Medium particles (25-125 µm): This dust appeared to be the least resistant to severe heating, which may be explained by higher carbon-rich matrix proportion in these particles. Less carbon was retained under helium than in the smaller particles (39% carbon remained) and oxygen and carbon dioxide perform almost the same survival rate (32 and 30% respectively).
3) Coarse particles (125-425 µm): The difference among various carrier cases is minimal in this case. Carbon loss must not have been oxidation-dependent, and may have relied on devolatilization processes. Alternatively, larger sieve fractions contain a more refractory form of carbon than finer fractions, and are more resistant to oxidation so devolatilization processes dominate. See the Figure 1 to compare carbon remaining in different particles under various conditions.

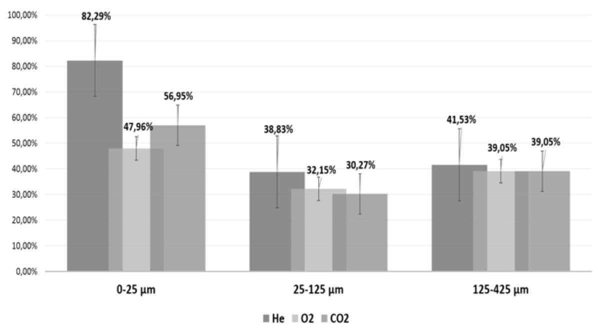

Figure 1. Surviving carbon percentage using different carrier gases.

Comparison with theoretical assessments. We used the surviving mass calculation approach from [2] and applied it to studied samples. Survival rate of fine particles was calculated as 90.15%, which is 33.2% more than shown in the experiment. It may be that small particles do not reach the high pyroprobe temperature on infall due to their small mass and the pyroprobe temperature should be revisited. The theoretical approach implies that carbon content does not change through atmospheric entry in small particles (up to 10 µm). Also, all the experiments were conducteds under Earth atmospheric pressure because pyroprobe pressure is not adjustable. These limitations should be addressed in future study.

As for medium size dust, a significant carbon survival rate gap is observed too (30.27% experimental and 53.63% theoretical). This may be caused by reasons above or possibly because medium sized particles may contain more volatile carbon due to higher matrix content.

The coarse particle carbon was more resistant than expected. Experimental rate is 39.05% survival and calculated one is only 13.25%. It may be caused by procedure restrictions (for example, reduced active surface of the particle during exposure), theoretical model drawbacks (it does not take into account composition difference in various particles) and/or bigger particles reach higher entry temperature than applied. Also size range does not coincide perfectly and it may shift the results (125-425 µm vs. 120-580 µm), although the trends will remain comparable. See Figure 2 for comparison.

These preliminary results show there is calculated carbon delivery onto Mars' surface from experimental data and from theoretical ones (using chondrite data):

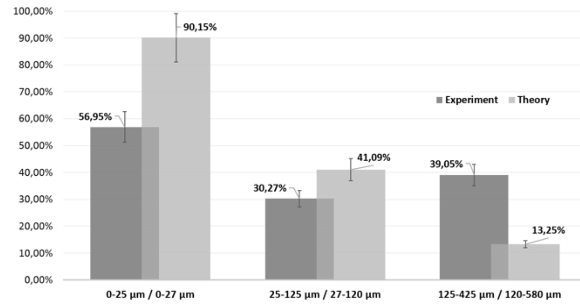

Figure 2. Theoretical and experimental carbon survival in particles of different size.

Size, µm	Theory, $\times10^3$kg/year	Practice, $\times10^3$kg/year
0-25	9.24	5.85
25-125	53.9	30.5
125-425	35.2	103.7

Table 4. Calculated carbon delivery onto Martian surface from different size particles.

Conclusion: We analyzed carbon alteration of CM2 chondrite through simulated atmospheric entry model and compared it with theoretical assessment done in [2]. We found significant differences, and carbon survival in coarse dust is greater than expected, but fine dust is more sensitive than the assessment predicted. Total carbon loss was is similar between O_2 and CO_2 carrier gases and the small difference diminished with increasing particle sizes, indicating that other factors may predominate over oxidation. Additional study can follow from this point and should refine these results with more size fractions, better control of pressure and temperature, and refinement of sample geometry.

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References: [1] Anders E. (1989) *Nature, 342,* 255 – 257. [2] Flynn G. J. (1996) *Earth, Moon and Planets, 72,* 469–474.