SUPPLEMENTARY CALCULATIONS AND INFORMATION

Pinter, N., and S.E. Ishman, 2008. *Reply* to comments on "Impacts, mega-tsunami, and other extraordinary claims." GSA Today, vol. 18.

As part of their comment, Bunch et al. include calculations suggesting that atmospheric fallout of cosmic dust could not account for the abundances of microspherules measured by Firestone et al. (2007). Bunch's calculations are based upon some selective input values and one crucial and indefensible assumption. Bunch et al. base their calculations on an accretion rate for extraterrestrial material of 2.5 x 10^9 g/yr, citing Karner et al. (2003). A more typical value is Kortenkamp and Dermott's (1998) rate of 3 x 10^{10} g/yr, which is identical to the input rate measured by Taylor et al. (1998) and less than the rates measured by Love and Brownlee (1993; 4±2 x 10^{10} g/yr) and Peucher-Ehrenbrink (1996; 3.7±1.3 x 10^{10} g/yr). In the interest of balance, we use the smaller 3 x 10^{10} g/yr value here.

The most fundamental and least defensible assumption in the calculations of Bunch et al. is that their spherules "*accumulated within substantially less than one year.*" In making this assumption, they assume the conclusion they wish to reach. Our alternative hypothesis is the concentrations of microspherules and other presumed extraterrestrial material can be explained by <u>depositional hiatuses or periods of reduced clastic input</u>, resulting in condensed stratigraphic sections in any marine or terrestrial setting. The following calculations show this to be a physically reasonable explanation.

In order to allow easy comparison with the Bunch et al.'s calculations, we use as many of their constants as possible.

Mean spherule abundance (Bunch et al.)	389 kg^{-1} of sediment
Median spherule abundance (Firestone et al., 2007)	103 kg^{-1} of sediment
Avg. mass of one spherule (Bunch et al.)	2.71 x 10^{-6} g
Flux rate of ET material to earth's surface Kortenkamp and Dermott's (1998)	3 x 10^{10} g yr^{-1}
Surface area of the earth	5.1 x 10^8 km^2

Averaged over the earth's surface, the annual input of ET material is:

Avg. annual accumulation of ET material	5.9 x 10^{-5} g m^{-2} yr^{-1}

Using Firestone et al.'s and Bunch et al.'s mean microspherule concentration of 389/kg, their estimate of average spherule mass, and Bunch et al.'s correction factor of 0.38 (microspherules comprise just 38% of total ET material), their mean concentration suggests:

Mean mass of ET materials in Firestone et al. samples 2.77×10^{-3} g kg^{-1}

We divide this mass by the average flux of ET material, consistent with gradual accumulation, to find the number of years required to accumulate Firestone et al.'s microspherules. If the kilogram of sample was deposited over an area of 1 m^2, then:

Time to accum. 389 spherules (mean value) over 1 m^2 47 yrs

If the same abundance of microspherules accumulated instead over an area one-tenth the size, then:

Time to accum. 389 spherules (mean value) over 0.1 m^2 470 yrs

In other words, periods of inhibited clastic input just ~50-500 years in duration are sufficient to explain the microspherule concentrations in Firestone et. al (2007). In reality, depositional hiastuses of this duration are not only reasonable, but it would be highly surprising to find terrestrial sequences like those sampled by Firestone et al. <u>without</u> such depositional gaps. The hiatuses required would be even briefer to account for the median, rather than the mean, microspherule concentration from the values in Firestone et al. (2007; 103 spherules/kg) – just 12-120 years. Furthermore, as discussed in the text of our reply, spherules could be further concentrated by secondary reworking (e.g., eolian or fluvial winnowing) or by the addition of terrestrial sources such as distal volcanic input. The latter would help to explain the non-typical chemistry of the materials reported by Firestone et al. (2007) – due to the mixing of terrestrial and extraterrestrial components – as well as the low iridium concentrations in both the bulk and metallic sub-samples.

Finally, we note that the calculations in Bunch et al.'s comment as well as our calculations here are based on a certain number of assumptions (ours of course more reasonable than theirs). Rather than asserting what <u>should</u> happen, it is far more straightforward to simply look at microspherule concentrations that <u>have been observed</u> elsewhere. Hagen et al. (1990), for example, reported glassy and metallic microspherules in sediment deposited by the East Antarctic ice sheet in concentrations of 40,000 per kilogram of sediment, over ten times greater that the largest values reported by Firestone et al. The iridium concentration in a composite sample of those Antarctic spherules was 669 ppb, roughly 6 times greater than the highest value reported by Firestone et al., with individual spherules showing concentrations that ranged from 10 to >1000 ppb Ir (Hagen et al., 1990).

REFERENCES CITED

Hagen, E.H., C. Koeberl, and G. Faure, 1990. Extraterrestrial spherules in glacial sediment, Beardmore Glacier area, Transantarctic Mountains. Contributions to Antarctic Research I, 50: 19-24.

Kortenkamp, S.J., and S.F. Dermott, 1998. A 100,000-year periodicity in the accretion rate of interplanetary dust. Science, 280: 874-876.

Love, S.G., and D.E. Brownlee, 1993. A direct measurement of the terrestrial mass accretion rate of cosmic dust. Science, 262: 550-553.

Peucher-Ehrenbrink, B., 1996. Accretion of extraterrestrial matter during the last 80 million years and its effect on the marine osmium isotope record. Geochimica et Cosmochimica Acta, 60: 3187-3196.

Taylor, S., J.H. Lever, R.P. Harvey, 1998. Accretion rate of cosmic spherules measured at the South Pole. Nature, 392: 899-903.