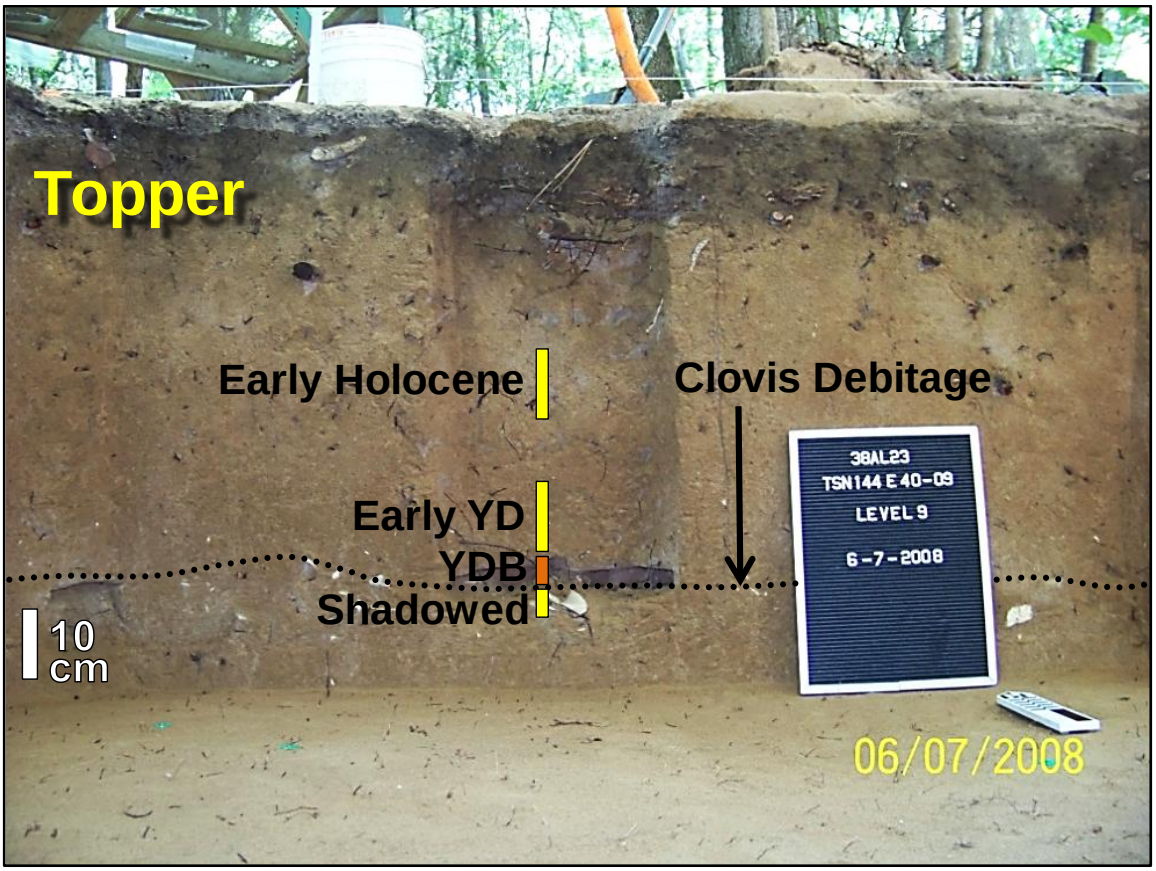
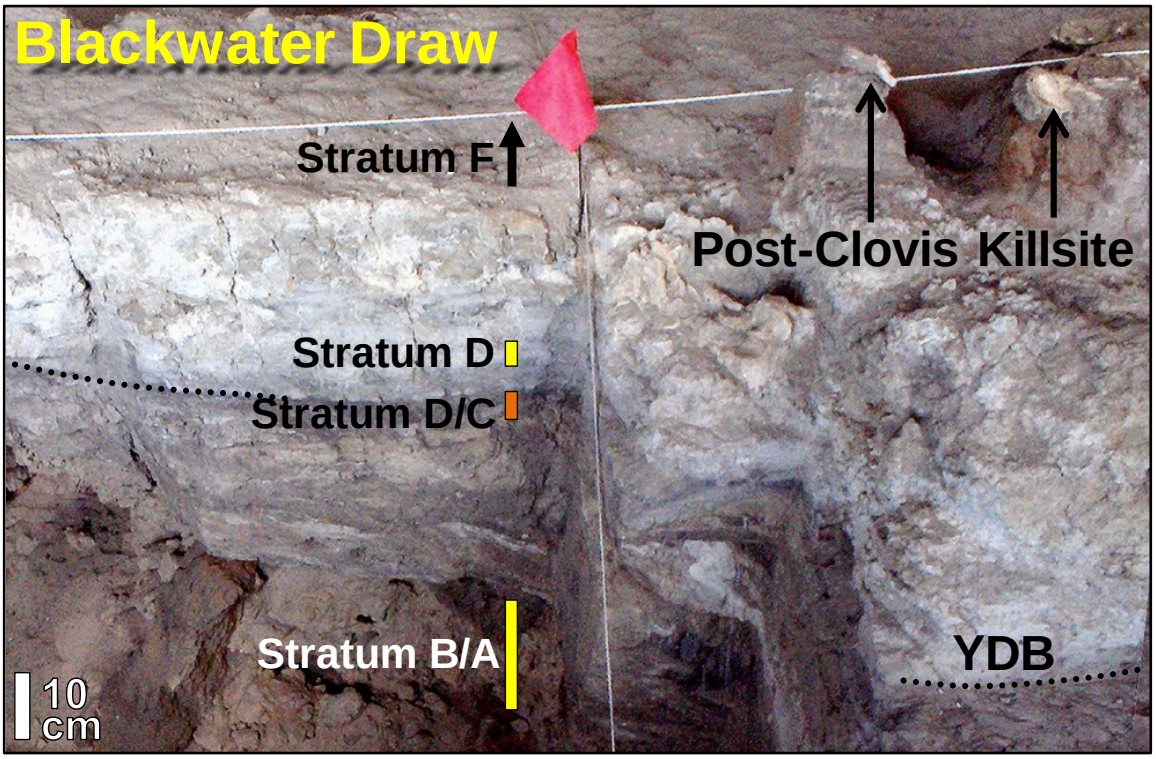
Supporting Information Corrected October 24, 2012

Independent Evaluation of Conflicting Microspherule Results from Different Investigations of the Younger Dryas Impact Hypothesis

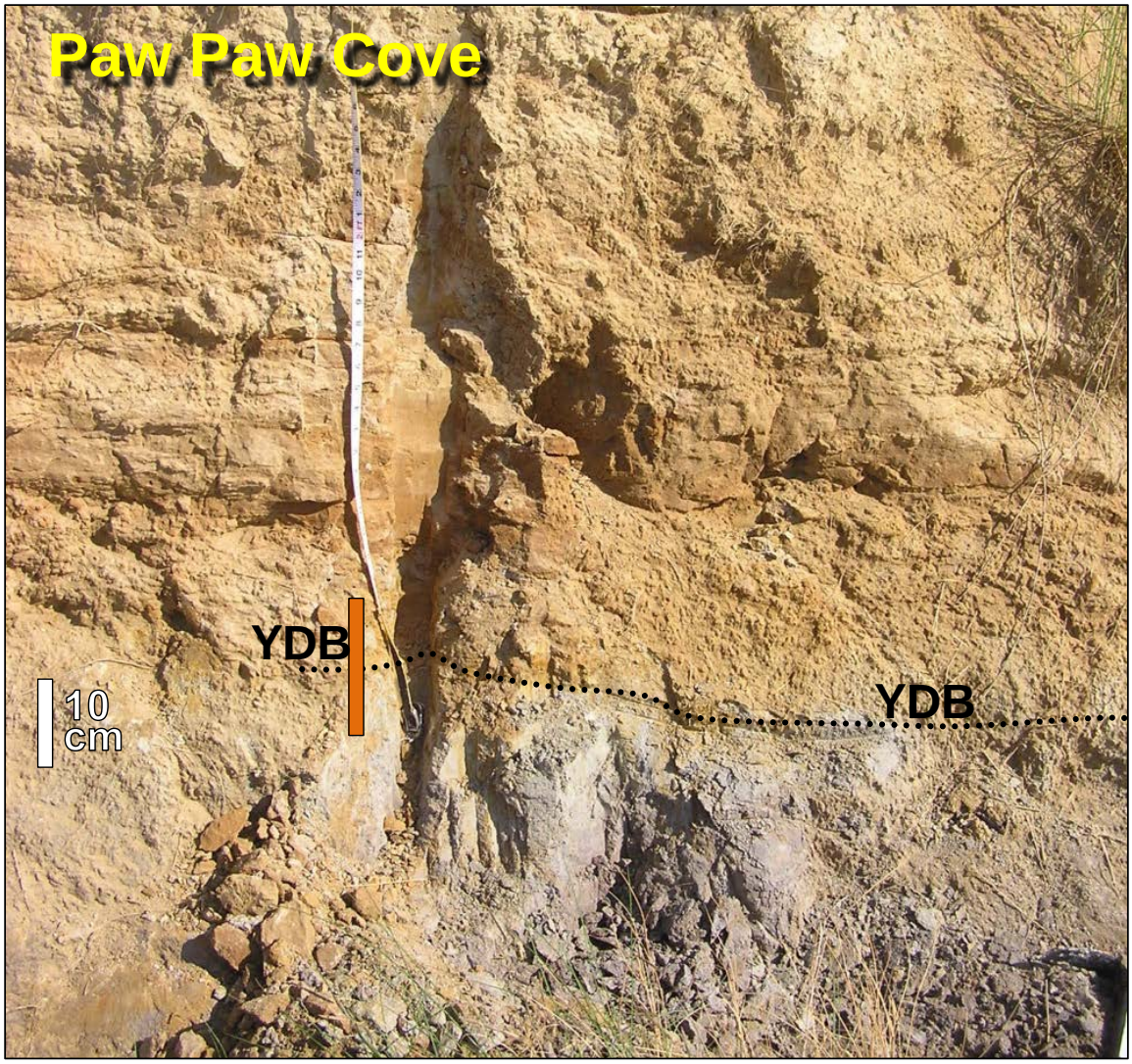
SUPPORTING INFORMATION.



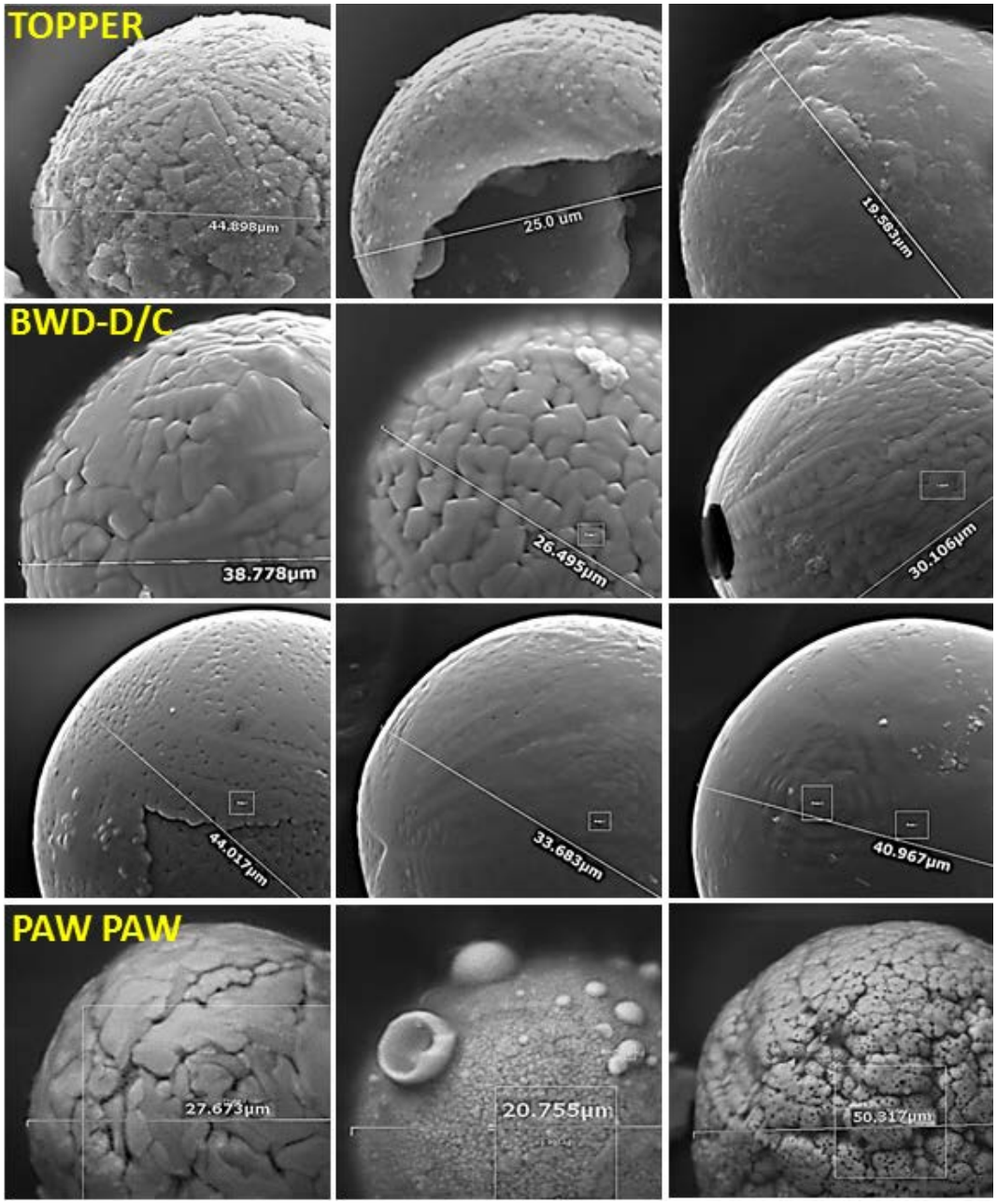
SI Fig. 1. Topper sampling site showing YDB layer as dotted black line, atop Clovis debitage. YDB sample location at orange bar; other samples at yellow bars.



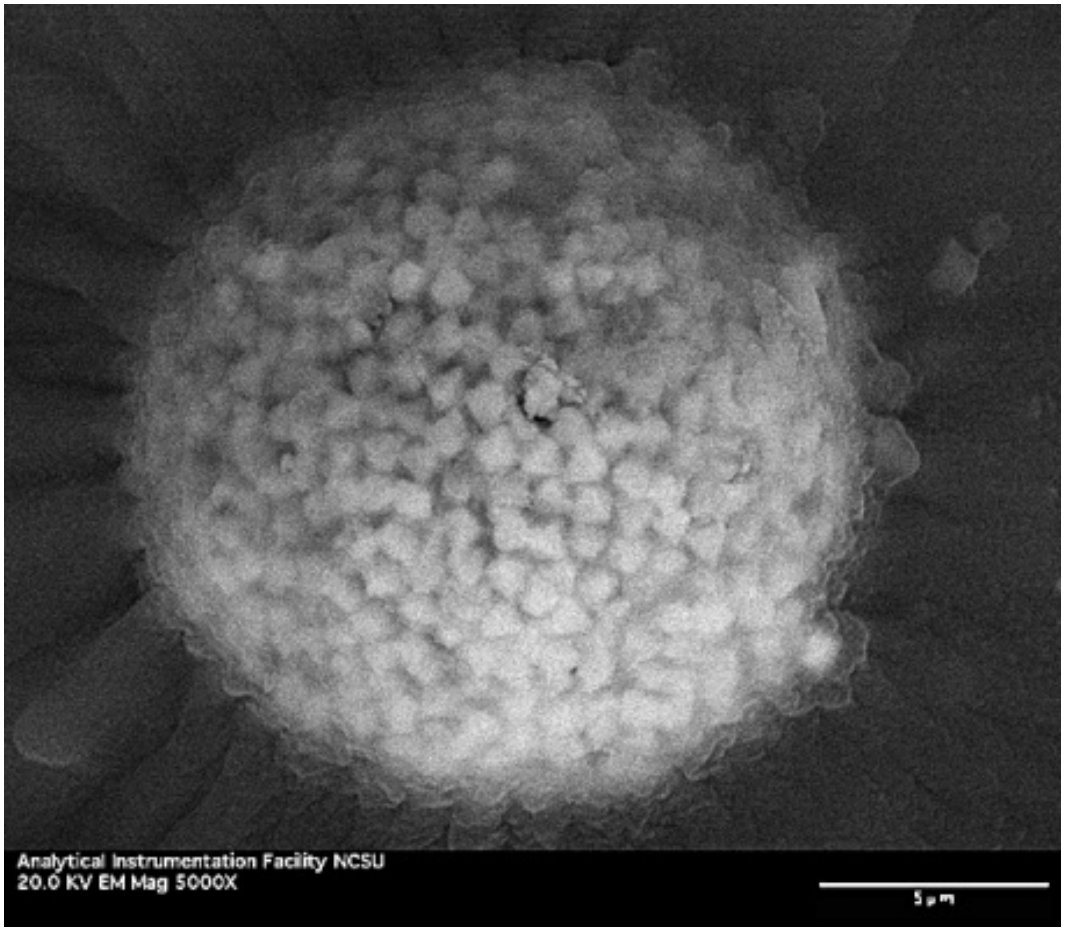
SI Fig. 2. BWD sampling site showing YDB layer as dotted line. YDB sample location at orange bar; other samples at yellow bars. Stratum F has been excavated and is not visible in this photo. Black arrows point to bones from a post-Clovis bison kill dating to many hundreds of years after 12,900 years ago. There are no artifacts known in the intervening strata.



SI Fig. 3. PPC sampling site showing YDB layer as dotted line. YDB sample location at orange bar.



SI Fig. 4. YDB spherules displaying some of the wide range of surface microstructures indicative of melting and rapid quenching. Top three are from above the debitage layer at Topper. Middle six are from Blackwater Draw (BWD) in the D/C layer. Bottom three are from Paw Paw Cove (PPC).



SI Fig. 5. SEM Micrograph showing a Topper 17-µm-diameter framboidal spherule. At these three sites, framboids are morphologically different but chemically indistinguishable from the apparently melted microspherules described in the foregoing. On the other hand, Israde et al. (2012) reported that sulfur-rich framboids from Lake Cuitzeo, Mexico are chemically different from the ones we observed.

SI Table 1. Oxide percentages of microspherules analyzed from Topper, SC.

	Layer and spherule #	Microns	FeO	Al_2O_3	MgO	CaO	SiO_2	K_2O	Na_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	NiO	SO_3
1	TU2-YDB-Sph-1-110505	33	8.66	24.64	0.02	0.45	63.78	1.64	0.01	0.74	0.00	0.01	0.00	0.03	0.01
2	TU2-YDB-Sph-2-110505-28mic	28	66.53	14.87	0.07	0.53	11.58	1.74	0.41	0.64	3.06	0.22	0.00	0.00	0.35
3	TU2-YDB-Sph-3-100514	17	88.64	6.15	0.00	0.63	4.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	TU2-YDB-Sph-4-110505	26	96.31	1.86	0.00	0.38	0.45	0.00	0.00	0.68	0.00	0.00	0.18	0.00	0.14
5	TU2-YDB-Sph-5-110505	45	75.34	12.39	0.81	0.15	9.99	0.01	0.33	0.92	0.00	0.02	0.01	0.03	0.00
6	TU2-YDB-Sph-6-110505	25	91.78	3.60	0.47	0.25	2.96	0.20	0.65	0.01	0.00	0.00	0.01	0.00	0.07
7	TU2-YDB-Sph-8-110506	20	96.86	1.51	0.00	0.39	0.47	0.00	0.00	0.22	0.02	0.00	0.42	0.00	0.11
8	TU2-YDB-Sph-9-110506	30	54.25	16.60	0.22	0.58	27.29	0.50	0.31	0.23	0.00	0.00	0.02	0.00	0.00
9	TU2-YDB-Sph-17-110314	23	49.00	4.53	4.98	0.07	3.48	0.13	1.52	34.98	0.98	0.33	0.01	0.00	0.00
10	TU2-YD-Sph-1-110314	26	37.38	6.63	1.55	0.07	3.30	0.00	0.86	47.02	0.62	2.55	0.01	0.00	0.00
11	TU2-YD-Sph-2-110314	48	4.70	39.09	0.57	0.08	54.56	0.25	0.44	0.01	0.28	0.00	0.01	0.01	0.00
	AVERAGES (25):	**29**	**60.86**	**11.99**	**0.79**	**0.33**	**16.59**	**0.41**	**0.41**	**7.77**	**0.45**	**0.28**	**0.06**	**0.01**	**0.06**

SI Table 2. Oxide percentages of microspherules analyzed from Blackwater Draw, NM.

	Layer and spherule #	Mic.	FeO	Al_2O_3	MgO	CaO	SiO_2	K_2O	Na_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	NiO	SO_3
1	BWD-DC-Sph-1-100514-33mic	33	57.63	1.46	0.18	1.90	6.32	1.81	8.92	0.95	0.11	4.17	2.10	2.32	12.13
2	BWD-DC-Sph-1-100621-29mic	29	94.08	2.00	0.63	0.20	1.72	0.00	0.86	0.08	0.27	0.15	0.00	0.01	0.00
3	BWD-DC-Sph-2-100621-33mic	33	93.74	2.18	0.88	0.21	1.77	0.01	0.93	0.05	0.00	0.00	0.02	0.00	0.21
4	BWD-DC-Sph-3-100621-34mic	34	93.15	2.83	0.96	0.07	1.56	0.10	1.22	0.00	0.00	0.11	0.00	0.00	0.00
5	BWD-DC-Sph-4-100621-37mic	37	87.74	2.69	1.22	0.13	4.52	0.00	1.03	0.02	0.10	2.10	0.15	0.04	0.26
6	BWD-DC-Sph-1-110314-36mic	36	65.35	2.54	2.13	2.32	25.67	0.05	1.09	0.07	0.17	0.00	0.00	0.00	0.60
7	BWD-DC-Sph-2-110314-30mic	30	97.15	1.07	0.00	0.25	1.00	0.00	0.00	0.01	0.34	0.18	0.00	0.00	0.00
8	BWD-DC-Sph-3-110314-44mic	44	91.71	1.39	1.02	0.27	2.81	0.02	0.56	0.00	0.41	1.78	0.02	0.01	0.00
9	BWD-DC-Sph-4-110314-27mic	27	94.42	1.62	0.99	0.28	1.51	0.10	0.65	0.00	0.21	0.21	0.00	0.01	0.00
10	BWD-DC-Sph-5-110314-34mic	34	95.39	2.16	0.50	0.21	0.84	0.00	0.32	0.01	0.17	0.38	0.00	0.02	0.00
11	BWD-DC-Sph-6-110314-26mic	26	95.48	1.05	0.45	0.37	1.18	0.00	0.47	0.22	0.31	0.44	0.02	0.01	0.00
12	BWD-DC-Sph-7-110314-31mic	31	95.72	0.95	0.87	0.24	1.17	0.02	0.54	0.11	0.36	0.00	0.00	0.02	0.00
13	BWD-DC-Sph-8-110314-39mic	39	94.91	1.25	0.90	0.19	1.54	0.00	0.52	0.00	0.26	0.43	0.00	0.00	0.00
14	BWD-DC-Sph-8-110314-39mic	39	94.07	1.39	1.04	0.20	1.98	0.00	0.77	0.00	0.21	0.34	0.00	0.00	0.00
15	BWD-DC-Sph-9-110314-41mic	41	95.70	1.35	0.81	0.28	1.03	0.01	0.51	0.02	0.25	0.03	0.00	0.01	0.00
16	BWD-DC-Sph-9-110314-41mic spot	41	93.46	1.86	1.20	0.17	1.82	0.05	1.00	0.02	0.34	0.00	0.00	0.08	0.00
17	BWD-DC-Sph-10-110314-30mic	30	96.59	0.85	0.44	0.27	1.22	0.06	0.27	0.01	0.08	0.21	0.00	0.00	0.00
18	BWD-D-Sph-1-110314-32mic spot 1	32	94.85	1.93	0.68	0.25	1.46	0.00	0.43	0.08	0.25	0.06	0.01	0.00	0.00
19	BWD-D-Sph-1-110314-32mic-spot 2	32	89.79	2.83	1.59	0.27	2.95	0.13	1.43	0.55	0.29	0.07	0.00	0.10	0.00
20	BWD-D-Sph-2-110314-30mic spot 1	30	96.72	1.22	0.03	0.29	1.09	0.06	0.00	0.09	0.00	0.31	0.00	0.00	0.19
21	BWD-D-Sph-2-110314-30mic spot 2	30	96.37	1.17	0.09	0.27	1.56	0.02	0.00	0.09	0.00	0.28	0.00	0.00	0.15
22	BWD-D-Sph-3-110314-35mic spot 1	35	92.56	2.30	1.00	0.33	1.61	0.10	0.68	0.01	0.43	0.96	0.00	0.02	0.00
23	BWD-D-Sph-3-110314-35mic spot 2	35	93.29	2.00	0.61	0.37	1.89	0.00	0.51	0.00	0.32	0.99	0.00	0.02	0.00
24	BWD-D-Sph-4-110314-34mic	34	94.99	1.51	0.87	0.28	1.24	0.13	0.64	0.01	0.07	0.25	0.00	0.01	0.00
25	BWD-D-Sph-5-110314-39mic	39	93.17	2.01	1.21	0.12	2.14	0.06	0.69	0.02	0.33	0.25	0.00	0.00	0.00
26	BWD-D-Sph-6-110314-23mic	23	94.21	1.72	0.94	0.23	1.58	0.00	0.87	0.00	0.31	0.14	0.00	0.00	0.00
27	BWD-D-Sph-7-110314-29mic	29	95.12	1.63	0.83	0.12	1.25	0.04	0.60	0.01	0.24	0.16	0.00	0.00	0.00
28	BWD-D-Sph-8-110314-33mic spot 1	33	93.55	2.03	1.22	0.31	1.48	0.00	0.98	0.00	0.20	0.19	0.00	0.04	0.00
29	BWD-D-Sph-8-110314-33mic spot 2	33	93.51	1.81	1.42	0.33	1.24	0.09	0.79	0.00	0.31	0.50	0.00	0.00	0.00
30	BWD-D-Sph-9-110314-49mic spot 1	49	96.12	1.12	0.47	0.14	1.29	0.08	0.28	0.03	0.24	0.23	0.00	0.00	0.00
31	BWD-D-Sph-9-110314-49mic spot 2	49	96.83	0.75	0.45	0.15	0.90	0.00	0.42	0.04	0.26	0.20	0.00	0.00	0.00
32	BWD-D-Sph-10-110314-20mic	20	91.79	1.88	1.10	0.55	3.08	0.00	0.91	0.00	0.62	0.04	0.00	0.03	0.00
33	BWD-D-Sph-11-110314-35mic	35	96.63	1.18	0.45	0.31	0.76	0.00	0.45	0.06	0.15	0.01	0.00	0.00	0.00
34	BWD-D-Sph-12-110314-27mic	27	93.68	1.68	0.90	0.27	1.01	0.07	0.77	0.00	0.36	1.23	0.01	0.02	0.00
35	BWD-D-Sph-13-110314-28mic	28	96.76	1.51	0.17	0.09	0.68	0.00	0.28	0.01	0.18	0.27	0.02	0.00	0.03
36	BWD-D-Sph-14-110314-29mic	29	93.54	1.85	1.08	0.33	1.77	0.09	0.82	0.01	0.24	0.27	0.00	0.00	0.00
37	BWD-D-Sph-15-110314-34mic spot 1	34	37.12	2.42	1.59	0.13	3.33	0.03	1.02	53.89	0.20	0.26	0.01	0.00	0.00
38	BWD-D-Sph-15-110314-34mic spot 2	34	36.49	1.10	0.27	0.25	2.29	0.03	0.43	57.70	0.26	0.58	0.00	0.00	0.60
39	BWD-D-Sph-15-110314-34mic spot 3	34	25.47	5.16	2.58	0.53	14.06	0.37	0.82	50.79	0.00	0.05	0.01	0.00	0.16
40	BWD-D-Sph-16-110314-31mic	31	96.60	0.79	0.21	0.16	1.12	0.00	0.30	0.01	0.47	0.23	0.01	0.00	0.10
41	BWD-D-Sph-17-110314-23mic	23	91.71	1.39	1.02	0.27	2.81	0.02	0.56	0.00	0.41	1.78	0.02	0.01	0.00
42	BWD-D-Sph-18-110314-41mic spot 1	41	59.86	2.19	2.69	0.14	1.68	0.03	0.02	32.65	0.33	0.12	0.00	0.00	0.29
43	BWD-D-Sph-18-110314-41mic spot 2	41	55.29	3.41	4.68	0.38	2.99	0.00	0.78	31.95	0.37	0.07	0.03	0.02	0.03
44	BWD-D-Sph-18-110314-41mic spot 3	41	48.19	4.41	6.77	0.17	4.35	0.00	1.17	34.52	0.34	0.02	0.01	0.05	0.00
45	BWD-D-Sph-19-110314-25mic	25	96.51	0.90	0.12	0.12	1.43	0.01	0.34	0.44	0.13	0.00	0.00	0.00	0.00
46	BWD-D-Sph-20-110314-48mic	48	96.29	0.83	0.91	0.09	0.90	0.03	0.51	0.04	0.27	0.13	0.00	0.00	0.00
47	BWD-D-Sph-21-110314-34mic spot 1	34	94.10	1.57	0.44	0.27	1.79	0.11	0.68	0.01	0.41	0.49	0.00	0.00	0.13
48	BWD-D-Sph-22-110314-37mic spot 1	37	98.63	0.22	0.00	0.17	0.84	0.01	0.00	0.08	0.00	0.05	0.00	0.00	0.00
49	BWD-D-Sph-22-110314-37mic spot 2	37	45.22	2.37	6.30	0.01	4.27	0.02	1.33	39.41	0.00	1.01	0.05	0.01	0.00
50	BWD-D-Sph-22-110314-37mic spot 3	37	41.88	6.80	4.96	0.58	15.48	0.22	0.85	27.00	0.04	1.95	0.03	0.00	0.21
51	BWD-D-Sph-22-110314-37mic spot 4	37	73.37	3.09	3.43	0.04	5.28	0.01	1.42	12.26	0.37	0.59	0.00	0.00	0.14
52	BWD-D-Sph-23-110314-25mic	25	95.95	0.69	0.53	0.20	1.73	0.06	0.33	0.03	0.10	0.31	0.00	0.03	0.04
	AVERAGES (52):	**34**	**85.05**	**1.89**	**1.27**	**0.31**	**2.90**	**0.08**	**0.80**	**6.60**	**0.23**	**0.47**	**0.05**	**0.06**	**0.29**

SI Table 3. Oxide percentages of microspherules analyzed from Paw Paw Cove, MD. Note REEs for one spherule.

	Layer and spherule #	Mic.	FeO	Al_2O_3	MgO	CaO	SiO_2	K_2O	Na_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	NiO	SO_3	La_2O_3	CeO_2	Pr_6O_{11}	Nd_2O_3
1	PPC-YDB-Sph-1-100707-17mic	17	42.4	2.89	1.25	0.43	1.87	0.2	2.67	45.9	0.97	0.96	0.00	0	0.5	0.00	0.00	0.00	0.00
2	PPC-YDB-Sph-2-100707-21mic	21	48.24	4.79	6.11	0.12	2.66	0.03	4.90	0.03	0.00	0.84	0.12	0.01	0.21	10.10	21.83	0.00	0.00
3	PPC-YDB-Sph-2-100707-21mic Rim	21	24.00	7.37	2.40	0.72	4.85	0.13	1.18	1.07	0.06	0.38	0.00	0.00	2.17	22.17	27.56	3.72	2.21
4	PPC-YDB-Sph-2-100707 21mic Bulge	21	47.23	5.07	5.05	0.26	3.68	0.04	5.94	0.39	0.04	0.00	0.00	0.03	0.86	9.59	21.81	0.00	0.00
5	PPC-YDB-Sph-3-100707 36mic	36	22.89	6.82	0.73	0.25	2.55	0.05	0.64	52.23	0.28	13.20	0.01	0.00	0.35	0.00	0.00	0.00	0.00
6	PPC-YDB-Sph-4-100707 50mic	50	41.00	6.83	0.67	0.12	2.59	0.05	0.61	47.5	0.12	0.01	0.01	0.00	0.45	0.00	0.00	0.00	0.00
7	PPC-YDB-Sph-5-100707 28mic	28	39.22	3.64	0.00	0.35	2.14	0.22	0.00	50.85	0.67	2.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	PPC-YDB-Subround-100707-27mic	27	51.10	3.42	1.80	0.27	2.77	0.08	0.29	39.71	0.02	0.29	0.05	0.05	0.15	0.00	0.00	0.00	0.00
	AVERAGES (8):	**27**	**39.51**	**5.10**	**2.25**	**0.32**	**2.89**	**0.10**	**2.03**	**29.72**	**0.27**	**2.32**	**0.02**	**0.01**	**0.58**	**5.23**	**8.90**	**0.47**	**0.28**

SI Table 4. Table below provides a summary comparison of each group's application of the Firestone et al. protocol.

Protocol Measure	Firestone et al. (2007) + 08/07/2007 Protocol	Surovell et al. (2009)	LeCompte et al. (2010)
NdFeB Magnet Strength	N-42	N-42	N-52*
Sediment Sample Amount	0.5 - 1.0 kg	0.2 to 0.5 kg	0.2 - 0.3 kg
Magnet's Plastic bag thickness	4 mil	4 mil	2-3 mil
Magnetic Grain Extraction Cycles	5 - 10 immersions	Up to 30 @ 1-minute immersions	20 @ 45-second immersions
Magnetic Grain Rinse Cycles **	As needed	Series of baths as needed	10 @ 45-second immersions with 20-µm paper filtration
Microscope Magnification (power x)	100-150x/150x	100x/100x***	130x/180x****
Sieve for Size-Sorting	Recommended <150 µm	1 mm	250 & 53 µm
Magnetic Grain -- total aliquot size	100 - 200 mg, up to total magnetic fraction	10-40 mg	20-40 mg of the <53-µm magnetic fraction
Spherule Visual Characteristics	Unfaceted; usually spherical; usually reflective surface	Unfaceted; perfectly spherical; only highly reflective surface	Unfaceted; nearly all spherical; mostly highly reflective surface

*N-42 exerts about 75% the magnetic force of N-52

** Protocol did not provide explicit instructions regarding a rinse cycle

***300x using electronic pixel zoom (pixel density increase)

**** Scanning at >130x was necessary to detect spherules <15-20 µm diameter

SI Table 5. Topper quarry. Shows number and type of artifacts found during and after Clovis times (data from Anderson et al., 2011).

	Site#	St.	Clovis	Post Clovis	Type of Site
Topper Clovis Quarry	38AI23	SC	4 Clovis points	1 Instrument-assist. pt.	Quarry, Workshop, Habitation
			170 Preforms		
			257 Blades		
			22 Blade Cores		