DATA REPOS ITORY ITEM

General Sampling Methodology

M.C. Harvey collected samples from New Zealand and Italy. C.M Belcher collected samples from all North American locations except Teapot Dome (Wyoming). Sources of other samples are detailed below.

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New Zealand (Woodside Creek) and Italian (Umbria/Marche) Sections

The K/P boundary clay layer was not wide enough (~ 10 mm width) to make on-site division and sub-sampling of the boundary layer practical, so the clay was removed as bulk, undifferentiated sample. No horizontal sampling was undertaken.

i) Small pieces of K/P boundary clay were extracted from the clay layer using a metal alloy peg (~20 cm length) that was first cleaned with water and cotton cloth. The extracted clay pieces were transferred onto aluminum foil by gloved (latex) hand. The peg was able to extract clay to a maximum depth of approximately 5 cm from the exposed surface material.

ii) The extracted K/P boundary clay (~100g) was then wrapped in two layers of aluminum foil and the foil parcel labeled and placed in plastic zip-lock bags.

Additional control samples were collected from adjacent top-soils. Samples were collected from sediments spanning the K/P boundary from Late Cretaceous (0.5 m below boundary), through Early Paleocene (0.5 m above the boundary), at regular intervals (0.1 m).

For the New Zealand boundary sediments only, prior to chemical pre-treatment, the boundary clay was subdivided into three sub-samples: (a) darker crusty basal layer, (b) middle red layer, and (c) hard, darker upper layer.

Denmark (Stevns Klint)

Samples of the K/P boundary fish clay, layers 3 and 4+ were provided by Crawford Elliot of Georgia State University, USA. K/P boundary sediment was extracted from the outcrop using a hammer and chisel. The K/P boundary clay was located beneath an under-hang of ~0.5 m. Fresh block sample was obtained from a depth of > 5 cm. Samples were transferred by hand into plastic bags. All sample material was collected from the same outcrop accessible from car park path south of Hojerup Church. There were no horizontal distances between samples (Elliot, pers. comms.).

Spain - Caravaca

Samples of the K/P boundary at Barranco del Gredero were provided by Cristiano Lana, Department of Earth Science and Engineering, Imperial College, London. Fresh sample was obtained using a pocketknife with an aluminum handle. Samples were transferred by hand into plastic bags. All sample material was collected from the same outcrop, located 500 meters from a gravel road and approximately 5km from the nearby town of Alicant. There were no horizontal distances between samples.
Prior to chemical pre-treatment, the boundary clay was subdivided into two sub-samples: (i) darker crumbly material, and (ii) lighter material with more homogenous texture.

North America

Four K/P sections were excavated and encased in plaster (Ricks Place [Montana], Mud Buttes [North Dakota], Rock Creek East [Saskatchewan], Wood Mountain Creek [Saskatchewan]). Teapot Dome (Wyoming) was provided by Margaret Collinson, Department of Geology, Royal Holloway University of London, Egham, Surrey, UK.

	Fireball Layer Samples									Controls	
	(i)		(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ii)	(iii)
	5	4	10	3	5	16	3	21	5	70	35
	2	2	25	20	5	8	9	5		68	
	4	2	14	20	5		7	5		55	
	2	4			7		6	6		30	
	3	2			10			2		23	
	3	5			15			20			
	2	2			8.5						
	2	3			6						
	2	3			12						
	2	2			10						
	2	2			8						
	4	2			16						
	4	2			10						
	2	2			9						
	3	2									
	4	2									
	3	3									
	5										
	1										
	2										
	4										
	5										
Mean (µm)		**2.8**	**16.3**	**14.3**	**9.0**	**12.0**	**6.3**	**9.8**	**5.0**	**49.2**	**35**
Std Dev		1.2	7.8	9.8	3.5	5.7	2.5	8.4		21.6	

	Boundary	Control
Overall Mean (µm)	**6.1**	**46.8**
Std Dev	**5.5**	**20.2**

Table DR1: WOODSIDE CREEK CARBON CENOSPHERE DIAMETERS

	Layers 3&4 sample (iii)	Layers 4+ sample (v)
	5	12
	4	9
	6	7
	7	6
	6	
	4	
	4	
	3	
	4	
	8	
	6	
	4	
Mean (µm)	**5.1**	**8.5**
Std Dev	1.5	2.6

Overall Mean (µm)	**5.9**
Std Dev	**2.3**

Table DR2: STEVNS KLINT CARBON CENOSPHERE DIAMETERS

	Ejecta Layer Samples			**Lower Satiny Layer Samples**			
	(i)	**(iii)**	**(iv)**	**(i)**	**(ii)**	**(iii)**	**(iv)**
	18	30	40	25	60	5	18
	30	23		15	25		9
	40	22		35	50		15
	30	10		12	45		20
	30	17		25			45
	25	12					18
							30
Mean (µm)	**28.8**	**19.0**	**40.0**	**22.4**	**45.0**	**5.0**	**22.1**
Std Dev	7.2	7.5		9.2	14.7		11.9

	Ejecta	**Lower Satiny**	**Combined**
Overall Mean (µm)	**25.2**	**26.6**	**26.0**
Std Dev	**9.4**	**15.6**	**13.1**

Table DR3: ROCK CREEK EAST CARBON CENOSPHERE DIAMETERS

Table DR4: RAW DATA

Areas used in calculations:

Stub (mm^2)	126.61265	mm^2
Stub area	126,612,650	μm^2
Screen Area 200x	1620000	μm^2
Screen Area 400x	405000	μm^2
Screen Area 800x	101250	μm^2
Screen Area 1600x	25312.5	μm^2

Note: [1]Explanations for column headings are given below table in italics.

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Furlo Pet (Italy)	Thin Platey Coarse	84	sample (i)	1.00	0.5	0.5	0	400x	8100000	15.6	0	0	0	0
		84	sample (ii)	1.00	0.1	0.1	0	1600x	405000	312.6	0	0	0	0
		84	sample (iii)	1.00	0.1	0.1	2	200x	50220000	2.5	50	20	0	2
	Thin Platey Fine	85		1.00	0.5	0.5	0	400x	8100000	15.6	0	0	0	0
	Rounded Aggregates Coarse	86	sample (i)	1.00	1	1	5	200x	45360000	2.8	14	18	14	6
		98	sample (ii)	1.00	0.375	0.375	0	1600x	405000	312.6	0			
		98	sample (iii)	1.00	0.375	0.375	5	200x	72900000	1.7	23	21	24	5
		105	sample(iv)	1.00	0.5	0.5	2	1600x	1012500	125.0	500	13	7	2
		105	sample (v)	1.00	0.5	0.5	6	200x	25920000	4.9	59	25	9	6
	Rounded Aggregates Fine	87	sample (i)	1.00	1	1	5	200x	24300000	5.2	26	12	1.6	4
	Furlo Control	107	sample (i)	1.00	0.5	0.5	9	1600x	506250	250.1	4502	17	31	9
		108	sample (ii)	1.00	0.5	0.5	17	1600x	506250	250.1	8503	6	15	17

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Woodside Creek Below Boundary (Late Cretaceous) (New Zealand)	0.4 M Below	23b	400x	1.00	1	1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	1	1	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	1	1	0	1600x	506,250	250.1	0	0	0	0
	0.3 M Below	22	400x	1.07	1	1.07	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.07	1	1.07	0	1600x	405,000	312.6	0	0	0	0
		22b	400x	1.02	1	1.02	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.02	1	1.02	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.02	1	1.02	0	1600x	506,250	250.1	0	0	0	0
	0.2 M Below	21	400x	0.99	1	0.99	0	400x	6,480,000	19.5	0	0	0	0
			1600x	0.99	1	0.99	0	1600x	405,000	312.6	0	0	0	0
		21b	400x	0.94	1	0.94	0	400x	12,150,000	10.4	0	0	0	0
			800x	0.94	1	0.94	0	800x	2,025,000	62.5	0	0	0	0
			1600x	0.94	1	0.94	0	1600x	506,250	250.1	0	0	0	0
	0.1 M Below	20	400x	0.95	1	0.95	0	400x	6,480,000	19.5	0	0	0	0
			1600x	0.95	1	0.95	0	1600x	405,000	312.6	0	0	0	0
		20b	400x	0.97	1	0.97	0	400x	12,150,000	10.4	0	0	0	0
			800x	0.97	1	0.97	0	800x	2,025,000	62.5	0	0	0	0
			1600x	0.97	1	0.97	0	1600x	506,250	250.1	0	0	0	0

Table DR4: ***continued***

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (µm)	+/- (2σ)	n
Woodside Creek Boundary Layer (New Zealand)	Middle Soft	62	(i)	1.00	0.5	0.5	61	1600x	810000	156.3	19070	3	2	38
	Coarse	96	(ii)	0.50	0.375	0.188	3	1600x	1215000	104.2	1667	16	16	3
	(Fireball Layer)	97	(iii)	0.50	0.5	0.25	4	1600x	405000	312.6	5002	14	20	3
		101	(iv)	1.00	0.25	0.25	3	1600x	405000	312.6	3751	9	7	14
		B1	(v)	0.90	0.1	0.09	2	400x	6480000	19.5	434	12	-	2
		B2	(vi)	1.02	0.1	0.102	1	1600x	405000	312.6	3065	3	-	1
			(vi)	1.02	0.1	0.102	1	400x	6480000	19.5	192	9	-	1
			(vi)	1.02	0.34	0.347	2	800x	3037500	41.7	240	6	-	2
			(vii)	1.02	0.34	0.347	2	400x	6480000	19.5	113	13	-	2
			(vii)	1.02	0.34	0.347	2	800x	1518750	83.4	481	6	-	2
			(vii)	1.02	0.34	0.347	2	1600x	632812.5	200.1	1154	11	-	2
	Top Dark	102	(viii)	1.00	0.25	0.25	1	1600x	405000	312.6	1250	5	-	1

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (µm)	+/- (2σ)	n
Woodside Creek Above Boundary (Early Paleocene) (New Zealand)	0.1 M Above	8	400x	1.00	1	1	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.00	1	1	0	1600x	405,000	312.6	0	0	0	0
	0.2 M Above	7b	400x	1.05	1	1.05	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.05	1	1.05	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.05	1	1.05	0	1600x	506,250	250.1	0	0	0	0
	0.3 M Above	6	400x	1.00	0.2	0.2	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.00	0.2	0.2	0	1600x	405,000	312.6	0	0	0	0
	0.4 M Above	5	400x	1.00	0.2	0.2	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.00	0.2	0.2	0	1600x	405,000	312.6	0	0	0	0

Table DR4: ***continued***

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm²)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Woodside Creek Control Samples (New Zealand)	Control #1	94	sample (i)	0.50	0.5	0.25	0	400x	1215000	104.2	0	0	0	0
		103	(ii)	1.00	0.5	0.5	5	200x	113000000	1.1	11	49	42	5
		C1	400x	1.00	0.21	0.21	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.00	0.21	0.21	0	1600x	405,000	312.6	0	0	0	0
	Control #2	95	400x	0.50	0.5	0.25	0	400x	1215000	104.2	0	0	0	0
			1600x	0.50	0.5	0.25	0	1600x	405000	312.6	0	0	0	0
			200x	0.50	0.5	0.25	0	200x	40500000	3.1	0	0	0	0
		104	(iii)	1.00	0.5	0.5	1	200x	113,000,000	1.1	2	35	0	1
		C2	400x	1.00	0.98	0.98	0	400x	6,480,000	19.5	0	0	0	0
			1600x	1.00	0.98	0.98	0	1600x	405,000	312.6	0	0	0	0
Caravaca (Spain)	Darker Coarse	64	sample (i)	1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
		64	(ii)	1.00	0.125	0.125	0	1600x	405,000	312.6	0	0	0	0
	Darker Fine	65		1.00	1	1		400x	8,100,000	15.6	0	0	0	0
	Caravaca Lighter Coarse	66	sample (i)	1.00	1	1		400x	8,100,000	15.6	0	0	0	0
		66	(ii)	1.00	0.25	0.25	0	1600x	405,000	312.6	0	0	0	0
	Caravaca lighter Fine	67		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Caravaca Ochre	1		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0

Table DR4: ***continued***

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Stevns Klint (Denmark)	Layers 3-4 Coarse (Fireball Layer)	68	(i)	1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
		68	(ii)	1.00	0.05	0.05	0	1600x	405,000	312.6	0	0	0	0
		2	(iii)	1.01	0.1	0.101	12	800x	23,287,500	5.4	646	5	3	12
	Layers 3-4 Fine	69		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Layers 4+ Coarse (Fireball Layer)	70	(iv)	1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
			(iv)	1.00	0.125	0.125	0	1600x	405,000	312.6	0	0	0	0
		4	(v)	1.00	0.5	0.5	1	400x	20,250,000	6.3	13	12	-	1
			(v)	1.00	0.5	0.5	3	800x	5,062,500	25.0	150	7	3	3
	Layers 4+ Fine	71		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
Petriccio (Italy)	Green Basal Coarse	72	sample (i)	1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
		72	(ii)	1.00	0.25	0.25	0	1600x	405,000	312.6	0	0	0	0
	Green Basal Fine	73		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Red Upper Coarse	74		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Red Upper Fine	75		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0

Table DR4: ***continued***

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (µm)	+/- (2σ)	n
Frontale (Italy)	Green Basal Coarse	78	sample (i)	1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
		78	(ii)	1.00	0.5	0.5	0	1600x	405,000	312.6	0	0	0	0
	Frontale Green - Basal Fine	79		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Frontale Red - Upper Coarse	80		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Frontale Red - Upper Fine	81		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
Fonte d'Olio (Italy)	Fonte d'Olio Coarse	82		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
	Fonte d'Olio Fine	83		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0
Fornaci East (ITA)	Coarse	110		1.00	0.5	0.5	2	400x	8,100,000	15.6	63	12	4	2
Lake Griffy (USA)	Coarse	76	sample (i)	1.00	1	1	5	400x	8,100,000	15.6	78	43	46	4
		76	(ii)	1.00	0.125	0.125	0	1600x	405,000	312.6	0	0	0	0
	Fine	77		1.00	1	1	0	400x	8,100,000	15.6	0	0	0	0

Table DR4: ***continued***

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Rock Creek East (USA)	Ejecta Layer	124	(i)	1.00	1	1	6	400x	n/a*	-	-	29	7	6
			(ii)	1.00	1	1	5	400x	5,062,500	25.0	125	n/a	-	-
			(iii)	1.00	1	1	6	800x	10,125,000	12.5	75	19	15	6
			(iv)	1.00	1	1	1	1600x	1,518,750	83.4	83	40		1
	Lower Satiny (Fireball Layer)	126	(i)	1.00	0.1	0.1	5	400x	20,250,000	6.3	313	22	18	5
			(ii)	1.00	0.1	0.1	4	400x	12,150,000	10.4	417	45	30	4
			(iii)	1.00	0.1	0.1	1	400x	12,150,000	10.4	104	5		1
			(iv)	1.00	0.1	0.1	7	800x	10,125,000	12.5	875	22	24	7
	Upper Satiny	127	400x	1.00	0.1	0.1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.1	0.1	0	800x	5,062,500	25.0	0	0	0	0
Berwind Canyon (USA)	Ejecta Layer	112	400x	1.00	0.125	0.125	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.125	0.125	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.125	0.125	0	1600x	506,250	250.1	0	0	0	0
	Fireball Layer	113	400x	1.00	0.1	0.1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.1	0.1	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.1	0.1	0	1600x	506,250	250.1	0	0	0	0
	Re-worked Fireball Layer	114	400x	1.00	0.05	0.05	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.05	0.05	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.05	0.05	0	1600x	506,250	250.1	0	0	0	0

Table DR4: ***continued***

Table DR4: *continued*

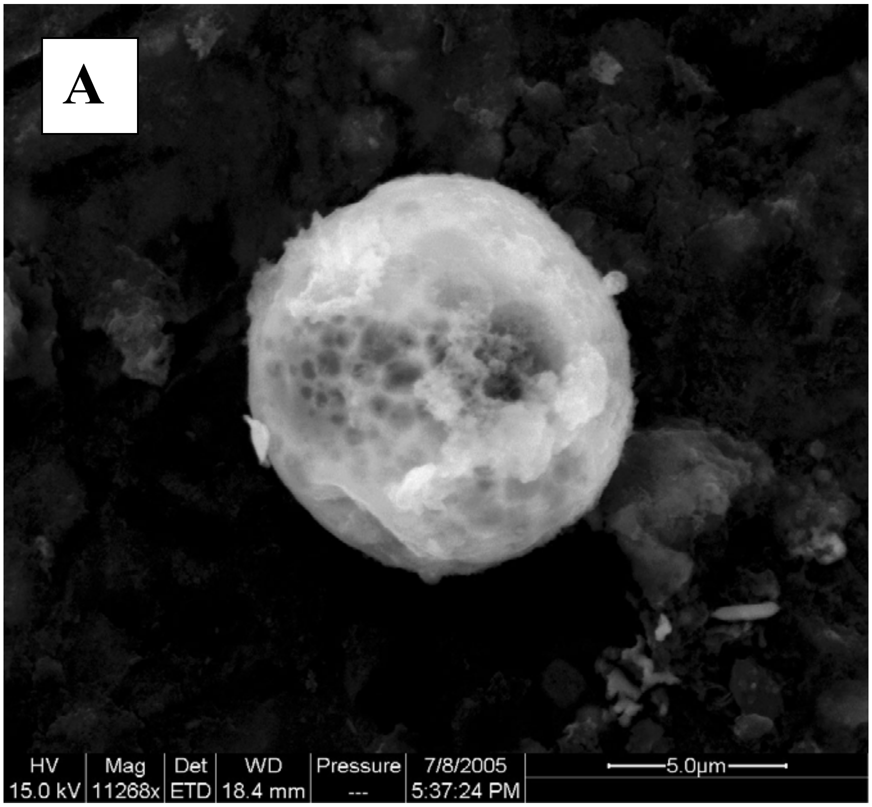
Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm²)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Clear Creek North (USA)	Ejecta Layer	115	400x	1.00	0.375	0.375	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.375	0.375	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.375	0.375	0	1600x	506,250	250.1	0	0	0	0
	Fireball Layer	116	400x	1.00	0.1	0.1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.1	0.1	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.1	0.1	0	1600x	506,250	250.1	0	0	0	0
	Re-worked Fireball Layer	117	400x	1.00	0.02	0.02	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.02	0.02	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.02	0.02	0	1600x	506,250	250.1	0	0	0	0
Madrid East South (USA)	Ejecta Layer	118	400x	1.00	0.1	0.1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.1	0.1	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.1	0.1	0	1600x	506,250	250.1	0	0	0	0
	Fireball Layer	119	400x	1.00	0.067	0.067	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.067	0.067	0	400x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.067	0.067	0	400x	506,250	250.1	0	0	0	0
	Re-worked Fireball Layer	120	400x	1.00	0.02	0.02	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.02	0.02	0	400x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.02	0.02	0	400x	506,250	250.1	0	0	0	0

Section	Description	Tube #	Sample	DM (g)	Trans	DM Ex (g)	CC	Mag	Search Area (μm^2)	Areas/ Stub	CC / g DM	Mean Diam (μm)	+/- (2σ)	n
Mud Buttes (USA)	Lower Ejecta Layer	112	400x	1.00	1	1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	1	1	0	800x	2,025,000	62.5	0	0	0	0
			1600x	1.00	1	1	0	1600x	506,250	250.1	0	0	0	0
	Upper Ejecta Layer	113	400x	1.00	0.5	0.5	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.5	0.5	0	400x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.5	0.5	0	400x	506,250	250.1	0	0	0	0
	Fireball Layer	113	400x	1.00	0.1	0.1	0	400x	12,150,000	10.4	0	0	0	0
			800x	1.00	0.1	0.1	0	400x	2,025,000	62.5	0	0	0	0
			1600x	1.00	0.1	0.1	0	400x	506,250	250.1	0	0	0	0

Explanations of column headings:

Section	*Outcrop location*
Description	*Boundary sub-layer and/or starting grain size of sediment prior to addition of reagents*
Tube #	*Number identification of centrifuge tube used for chemical pre-treatment*
Sample	*Sample reference number or magnification used during grid search*
DM	*Starting mass of dried sediment (prior to addition of reagents)*
Trans	*Proportion of DM transferred to SEM stub for examination*
DM ex (g)	*DM * Trans*
CC	*Total CC counted after grid search completed*
Mag	*SEM magnification used in grid search*
Search Area (μm^2)	*Area of stub covered by grid search*
Areas/Stub	*Search area / total area of stub*
CC / g DM	*CC * (Areas/Stub) * (1/DM ex)*
Mean Diam	*Mean diameter of CC*
+/- (2σ)	*Two confidence intervals relating to mean diameter*
n	*Number of CC in sample set providing mean diameter*

Table DR4: ***continued***



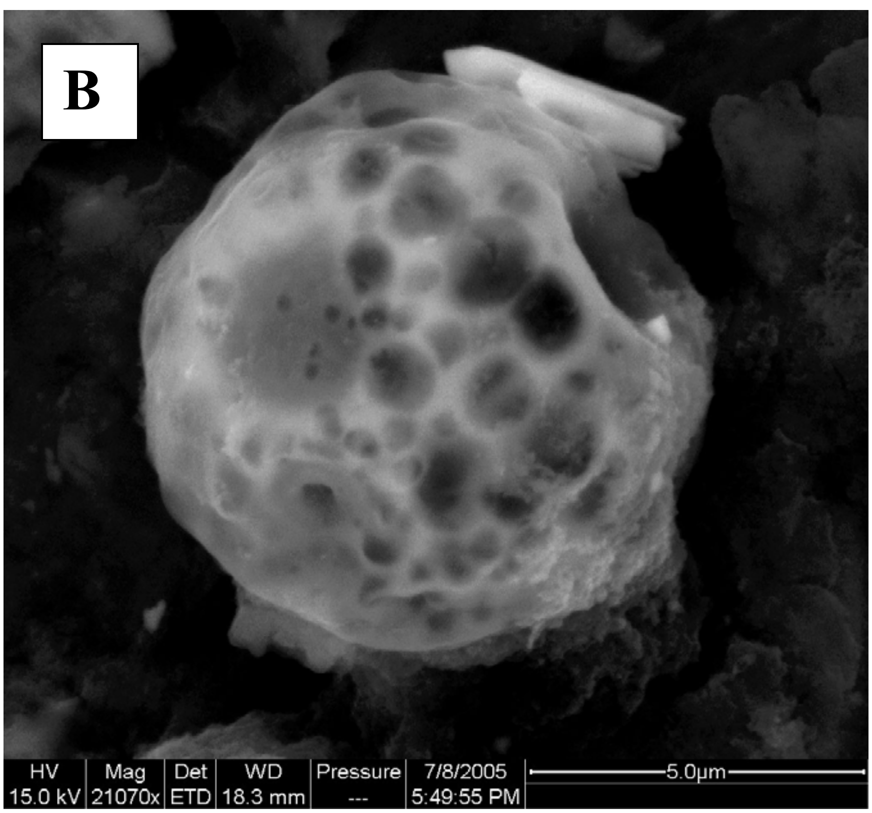


Figure DR1: Woodside Creek K/P boundary CC (see following page for EDS)

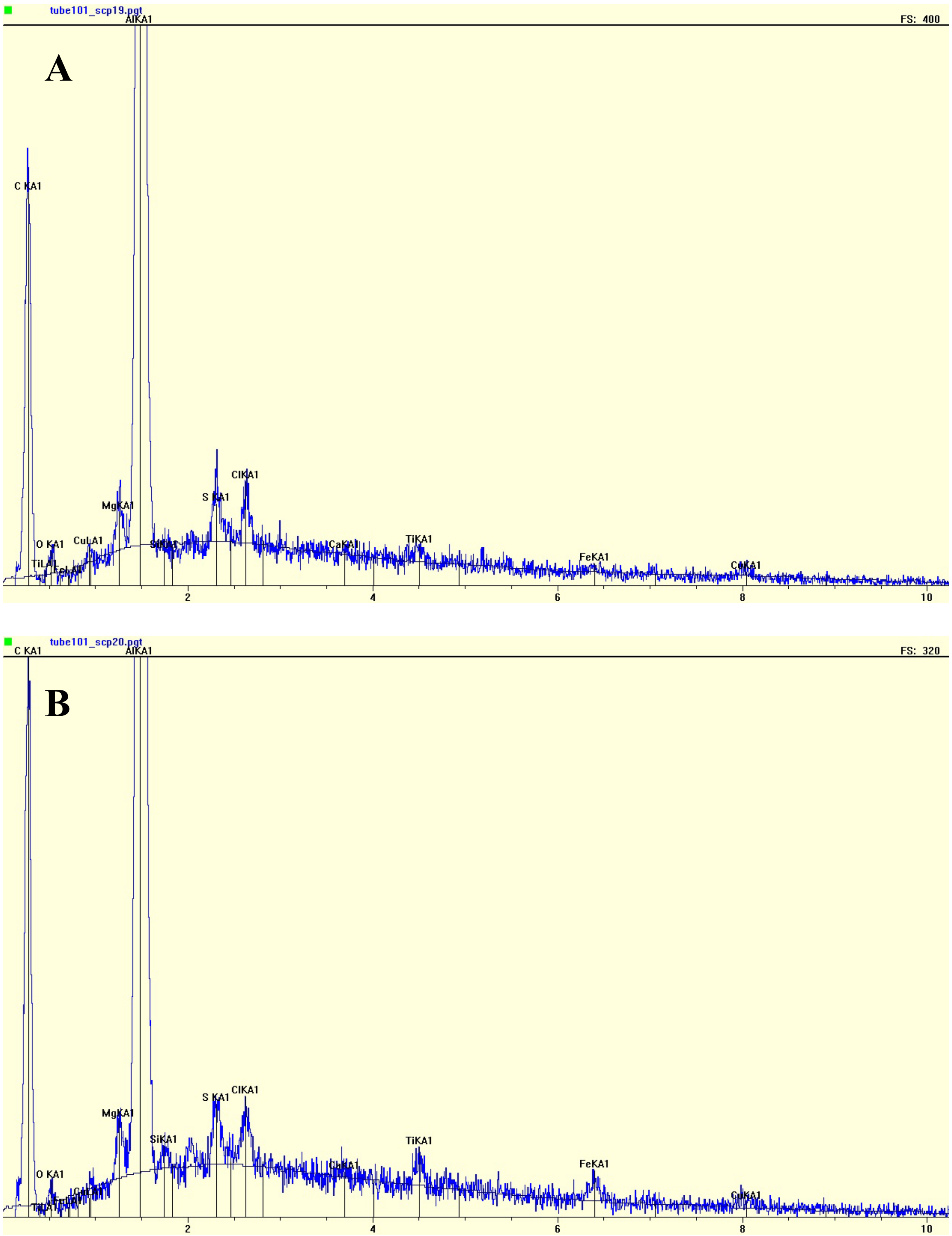
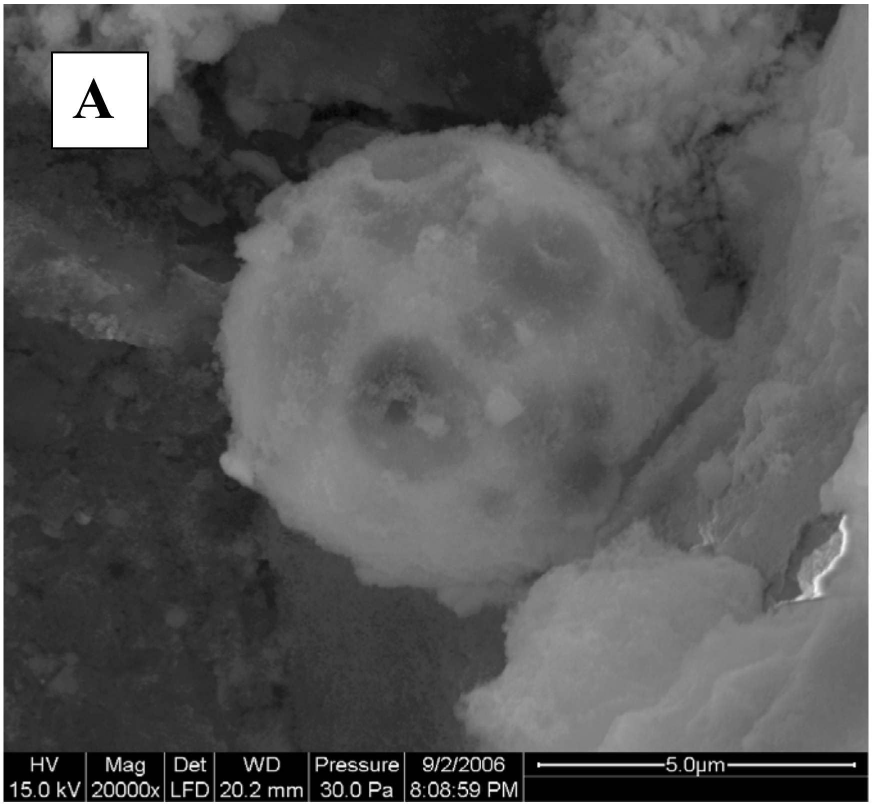


Figure DR2: Energy Dispersive Spectroscopy of Woodside Creek K/P boundary CC (spectra correspond to images (A) and (B) on previous page, respectively). Note: Carbon peak is dominant. Aluminum peak is an artifact of the sample mounting stub.



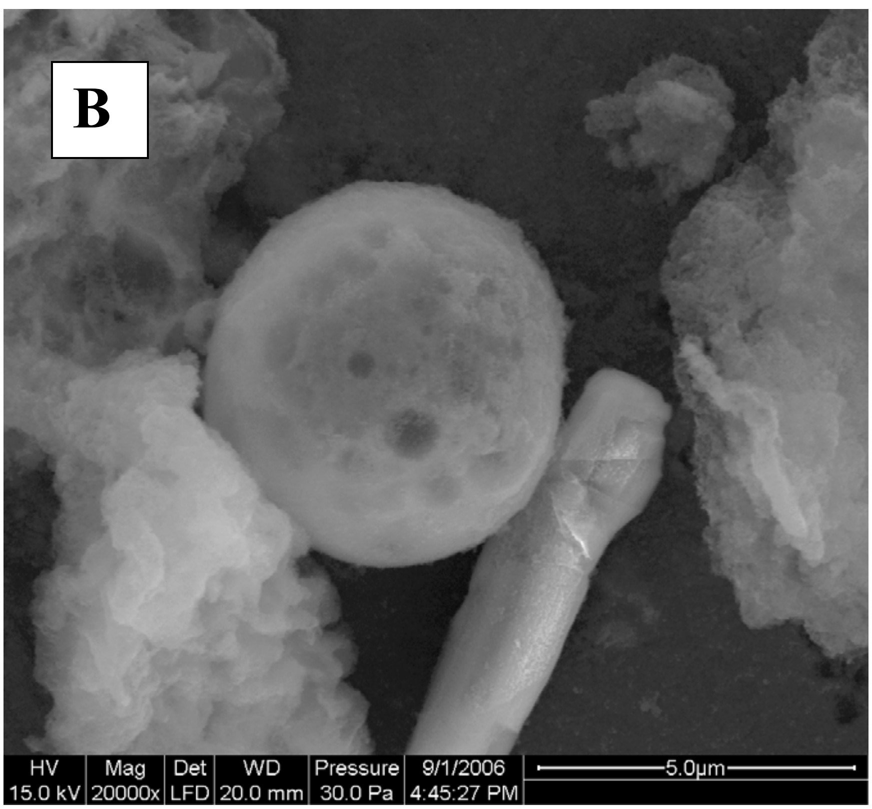
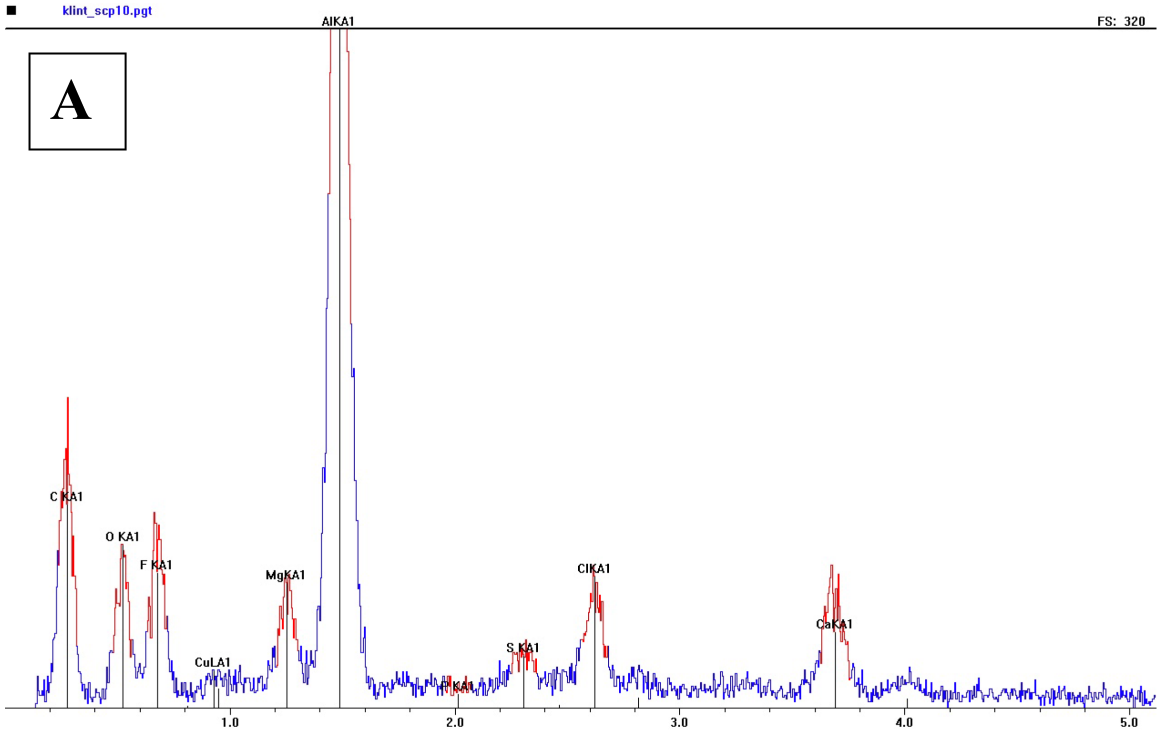


Figure DR3: Stevns Klint K/P boundary CC : Layers 3&4 (A) and Layer 4+ (B) (see following page for EDS)



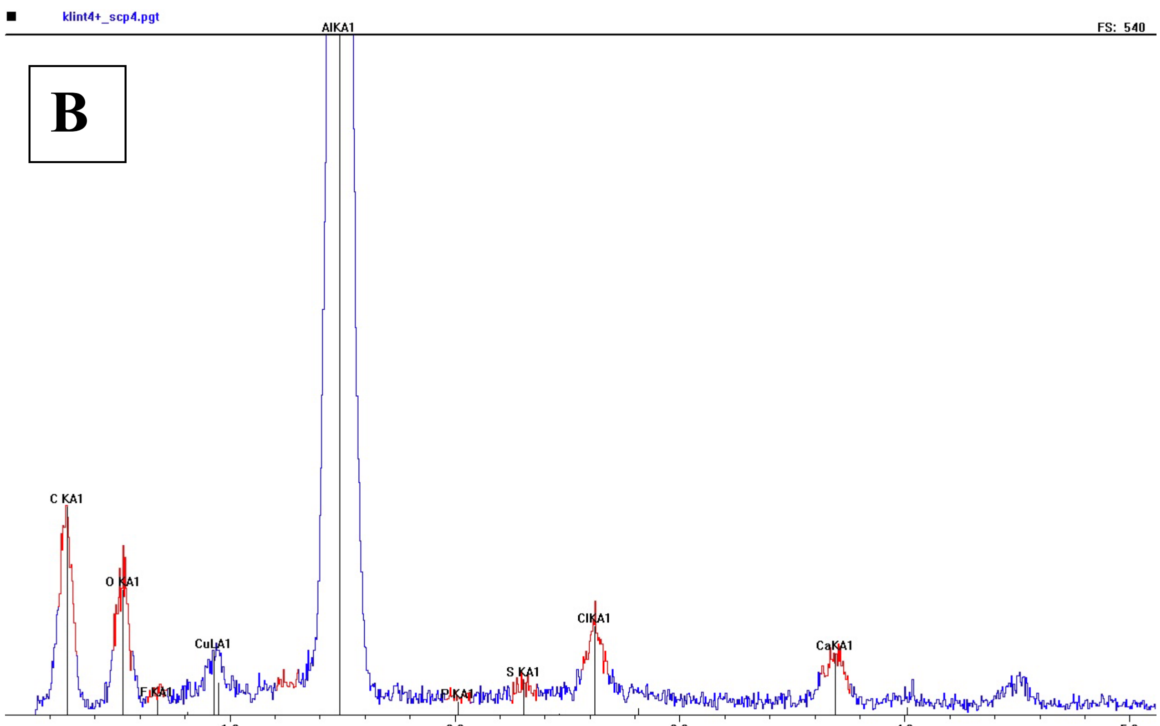


Figure DR4: Energy Dispersive Spectroscopy of Stevns Klint K/P boundary CC (spectra correspond to images (A) and (B) on previous page, respectively). Note: Carbon peak is dominant. Aluminum peak is an artifact of the sample mounting stub.

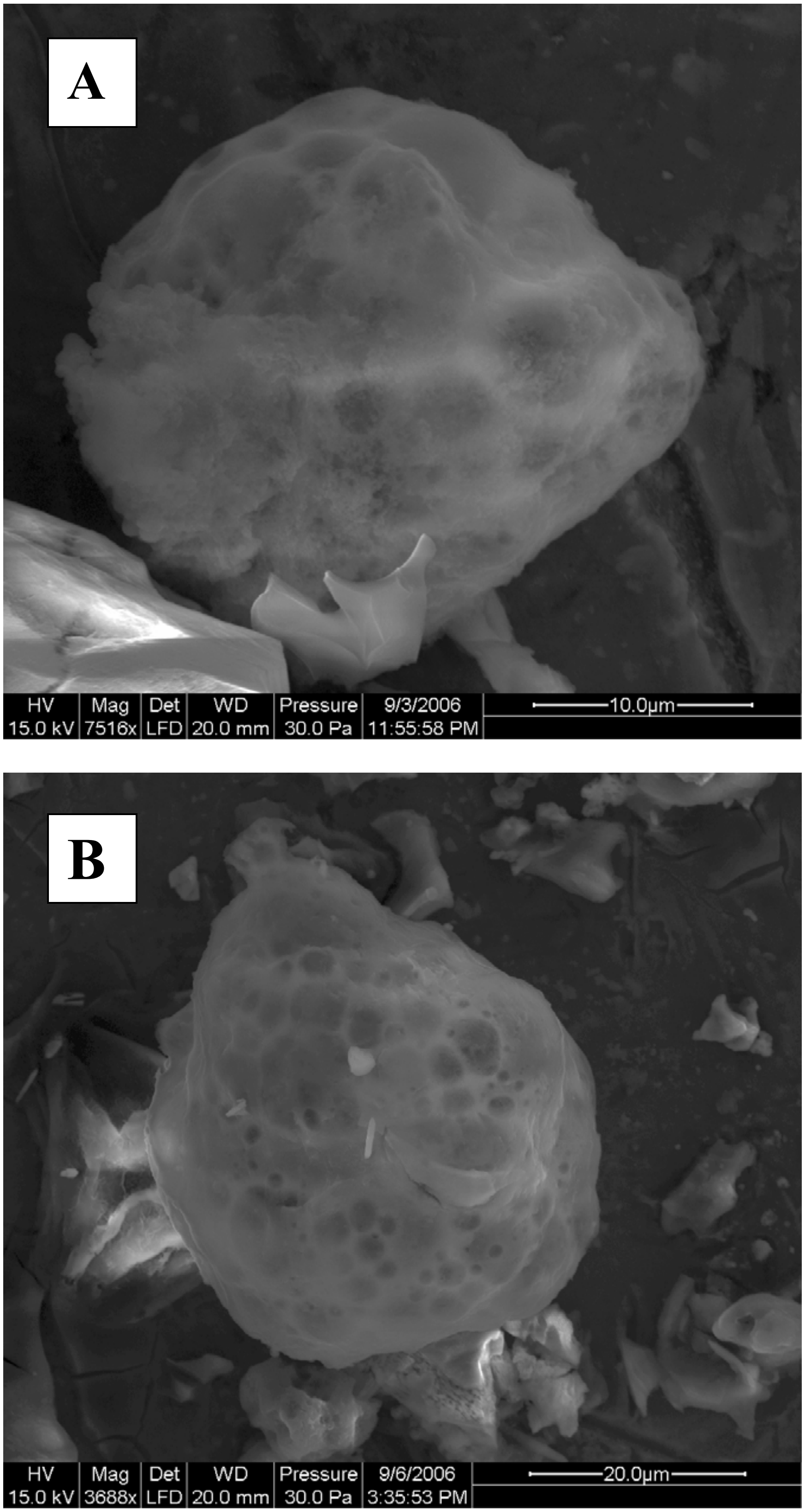
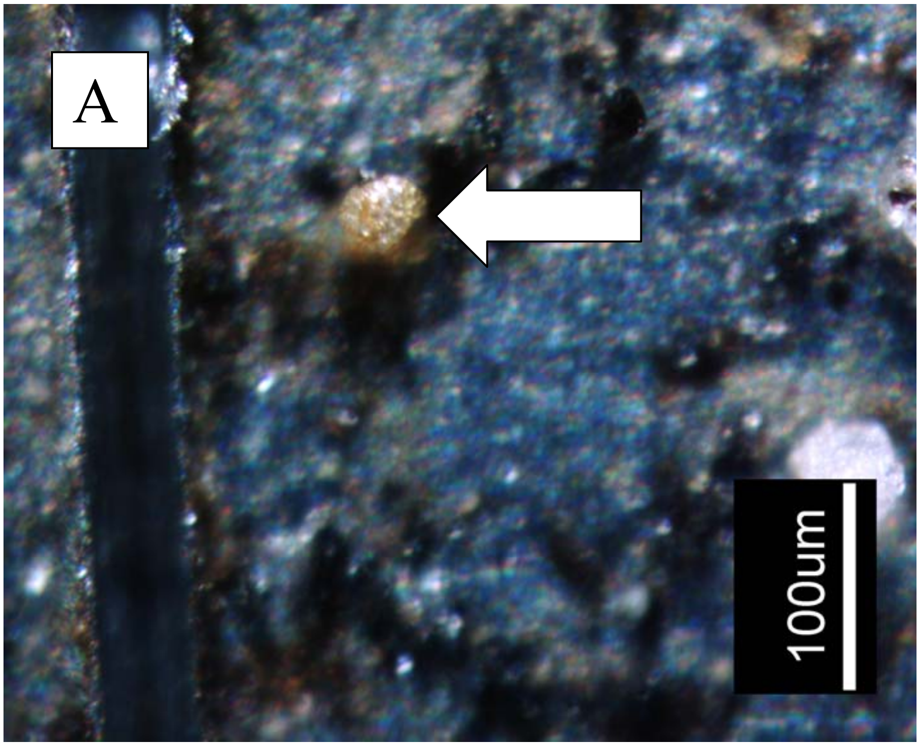


Figure DR5: Rock Creek East K/P boundary CC (see following page for corresponding light microscope images)



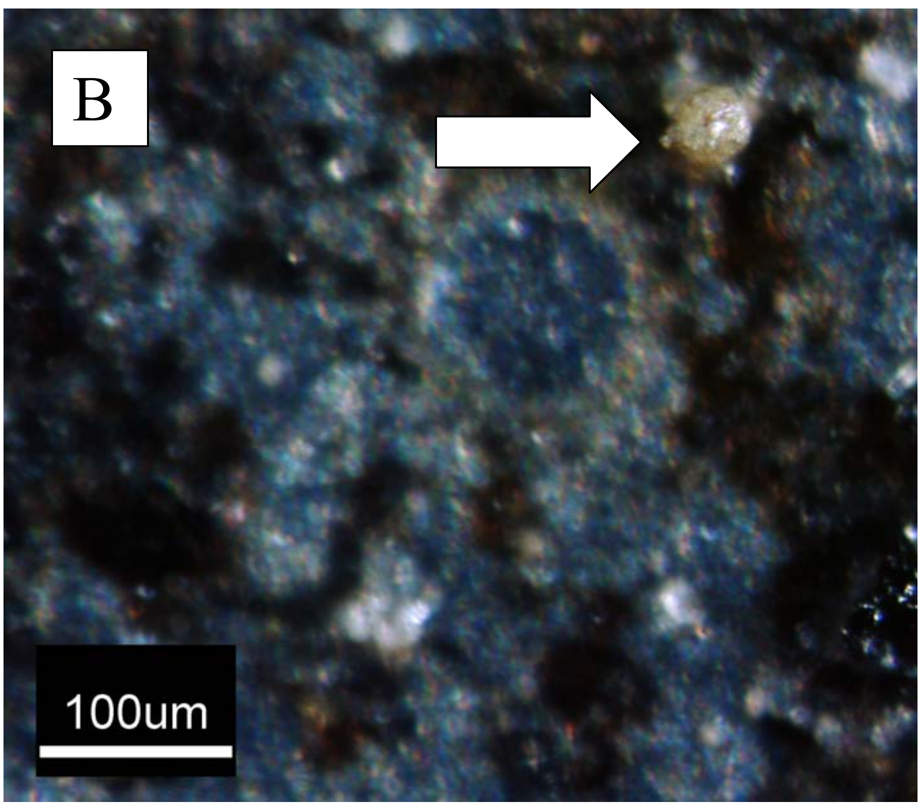


Figure DR6: Light microscope images of Rock Creek East K/P boundary CC (images correspond to (A) and (B) on previous page, respectively). Note: Light brown coloration of CC.

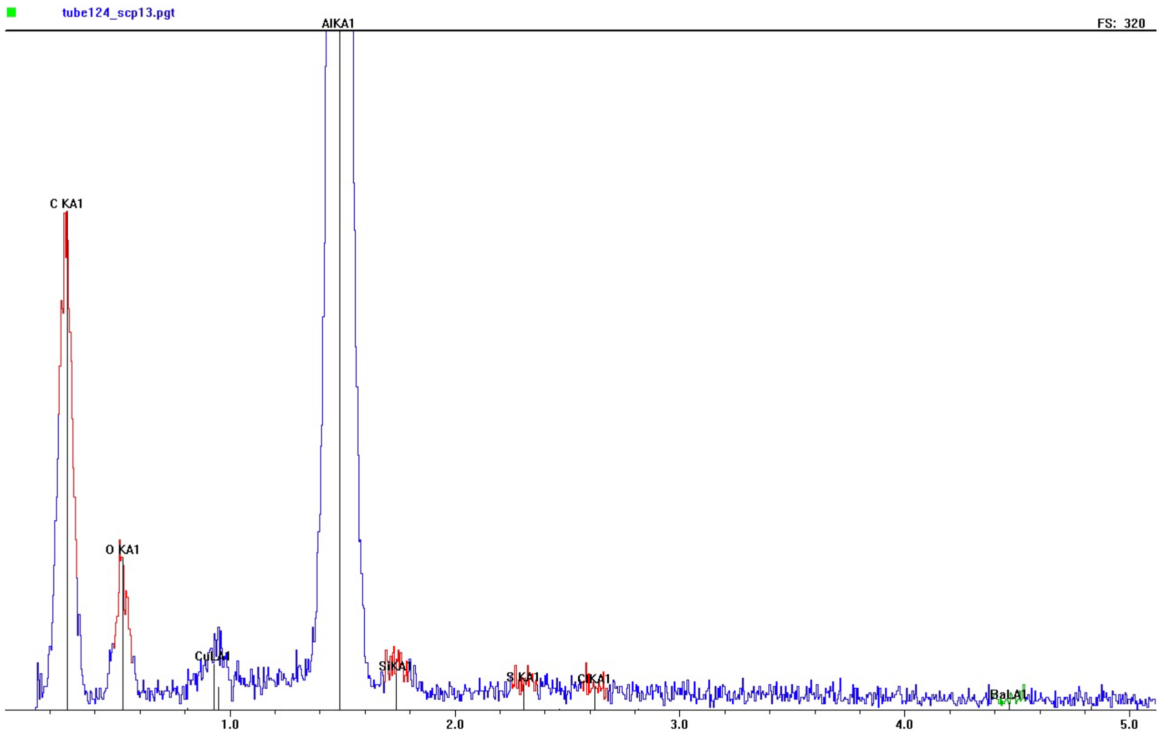


Figure DR7: Energy Dispersive Spectroscopy of Rock Creek East K/P boundary CC (spectra corresponds to image (A) on previous page). Note: Carbon peak is dominant. Aluminum peak is an artifact of the sample mounting stub.

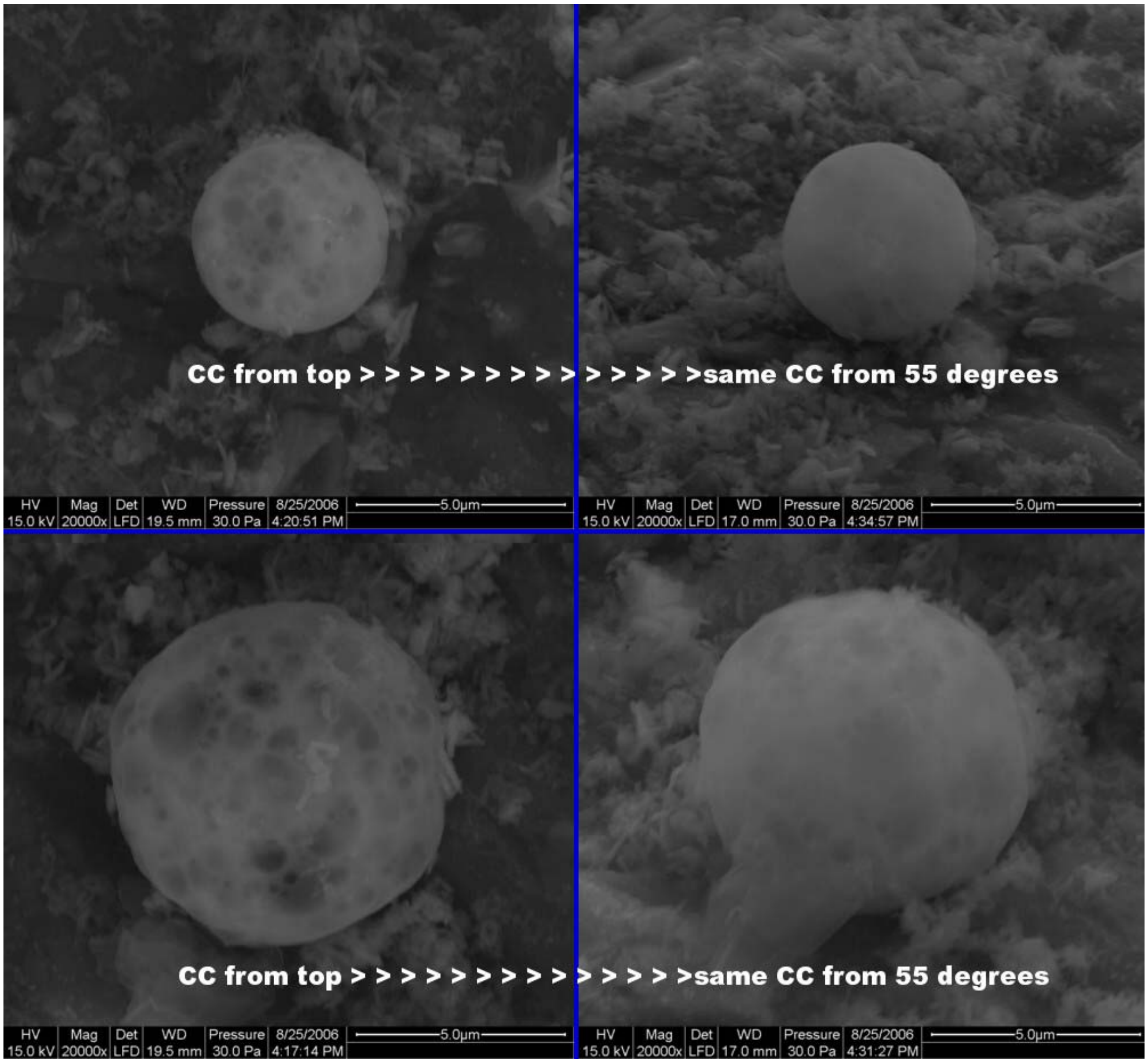


Figure DR8: Woodside Creek K/P Boundary Carbon Cenospheres examined from above (left) and then, from an angle of 55 degrees (right). Note: These images reveal spheroidal morphology. Images at 55 degrees were obtained by tilting the SEM stage.

Quantification of CC by Grid Search

Initial Sample Survey

Sample material was first examined at 1600x magnification. This level of magnification was found to be capable of efficiently identifying small (> 2 μm diameter) CC. Approximately 20 non-overlapping locations were examined at this magnification.
If no CC were found, the magnification was lowered to 800x and 20 non-overlapping locations were examined. This level of magnification was found to be capable of efficiently identifying medium size (> 10 μm) CC. If no CC were identified then the magnification was lowered to 400x and 20 non-overlapping locations checked. This level of magnification was found to be capable of efficiently identifying large size (> 20 μm) CC. EDS data were collected for some CC, and all CC diameters were noted.

Note: At 1600x, 800x and 400x magnification, only a small fraction of the SEM stub surface was examined (~0.4%, 1.6% and 6.4% respectively) in a 20-location search. To allow for possible clumped distribution of CC on the stub surface, the 20 search areas selected for examination were distributed over different parts of the stub. For example, rather than just searching the center of the stub, areas closer to the perimeter were also examined.

Secondary Survey

If any CC were discovered in initial survey, further grids were examined in a secondary survey, in order to increase sample size.

Equation for conversion of CC tallies to sediment concentration values:

$$\text{CC / gram Dry Sediment Mass (CC / g DM)} = \frac{\text{CC tally} * \text{total area of SEM stub } (\mu m^2) \text{ / total area searched } (\mu m^2)}{\text{starting dry sediment mass (g)} * \text{proportion of dry sediment mass examined}}$$

Where starting dry sediment mass, the proportion of dry sediment mass examined, the total area searched, and the total area of stub is known. This calculation assumes an even distribution of CC on the SEM stub. Where several tallies are available for one sample (E.g. grid search at 1600x, 800x or 400x provided different tallies – see Quantification of CC by Grid Search on previous page), the highest magnification tally was used. To allow for possible uneven distribution, the search area was divided into sub-search areas (see *Note* previous page).

Location	Depositional Environment	Iridium (ppb)	Carbon Abundance (g/cm2)	PAH (ppb)	Shocked Quartz	Spherules
Woodside Creek (New Zealand)	Marine	70 [1]	4.8 ($^{+}$/- 0.5) [2]	33 [3]	Present [5]	-
Caravaca (Spain)	Marine	40 [6]	10 (+10 / -1) [2]	3 (Coronene) [7]	Present [5]	Present [8]
Stevns Klint (Denmark)	Marine	42 [9]	11 (+11 / -1) [2]	30 [3]	Present [5]	Present [5]
Monte Pietralata (Italy)	Marine	2 [10]	-	-	-	Present [10]
Petriccio (Italy)	Marine	8 [9]	-	-	Present [11]	Present [5]
Frontale (Italy)	Marine	5 [10]	-	-	-	Present [10]
Fonte d'Olio (Italy)	Marine	-	-	-	Present [10]	Present [10]
Fornaci East (Italy)	Marine	10 [10]	-	-	-	Present [10]
Berwind Canyon (USA)	Non-Marine	Fb – 23 [12, 13, 14, 15] Ej – low level	-	-	Present [15]	Present [15]
Clear Creek North (USA)	Non-Marine	Fb – 14.6 [12, 13, 14, 15] Ej – 0.22	-	-	Present [15]	Present [15]
Madrid East South (USA)	Non-Marine	Fb – 7.5 [12, 13, 14, 15] Ej – 0.32	-	-	Present [15]	Present [15]
Mud Buttes (USA)	Non-Marine	Not measured	-	-	Present [17]	Present [17]
Rock Creek East (Canada)	Non-Marine	Fb – 32.6 [16] Ej - -	-	-	Present [16]	Present [16]

Table DR5: GENERAL FEATURES OF SAMPLE LOCATIONS

[1] Strong et al. (1988)
[2] Wolbach et al. (1985)
[3] Venkatesan and Dahl (1989)
[5] Bohor and Modreski (1987)
[6] Smit and ten Kate (1982)
[7] Arinobu et al.(1999)
[8] Smit and Klaver (1981)
[9] Alvarez (1980)
[10] Montenari and Koeberl (2000)
[11] Montenari (1991)
[12] Orth et al. (1981)
[13] Pillmore et al. (1984)
[14] Tshudy et al. (1984)
[15] Izett (1990)
[16] Sweet et al. (1999)
[17] Nichols and Johnson (2002)

Fb = Fireball Layer
Ej = Ejecta Layer   Ref from terminology Hildebrand (1993), Belcher et al., (2003)

Outcrop	A	B	C	D	E	F	G	H	I	J	Global Mass (g)
Woodside Creek	4.19	28.4	1E-09	0.001	0.28	4994	4.5	0.6	5.1E+18	33333	7.62407E+16
Stevns Klint	4.19	25.7	1E-09	0.001	0.28	398	4.5	10	5.1E+18	33333	9.16298E+16
Rock Creek East	4.19	2197	1E-09	0.001	0.28	479	4.5	1	5.1E+18	33333	9.43742E+17

Table DR6: Mass of Carbon required to produce observed Carbon Cenosphere abundance

Explanation of column headings:

A: 4/3 π
B: mean CC radius cubed (μm^3) from tables DR1,2 &3
C: conversion μm^3 to mm^3
D: conversion mm^3 to cm^3
E: CC density (g/cm^3)(Baltrus et al., 2001)
F: mean CC abundance (CC/g) from Table DR4
G: K/P boundary sediment density (g/cm^3)
H: K/P boundary sediment thickness (cm)
(Smit and Ten Kate, 1982; Sweet et al., 1999)
I: surface area of Earth (cm^2)
J: % dispersed organic matter converted by combustion to CC (Rose et al., 1996)

Stratigraphy Woodside Creek, North-Eastern Marlborough, New Zealand

The stratigraphy of the Mead Hill K/P boundary section at Woodside Creek, New Zealand, has been described previously by Strong (1977) and Hollis et al. (2003). The following descriptive text outline aspects of the above papers relevant to this research.

The Mead Hill Formation, Marlborough, New Zealand

The pelagic lithofacies are composed of the late Cretaceous Haumurian, a thickly bedded pale siliceous limestone, the iridium rich boundary clay approximately (8 mm thick), and the basal Paleocene Teurian, a thin-bedded dark grey clay-rich calcareous chert. The Haumurian limestones were probably deposited at upper baythal depths of 200-600 m, where as the Teurian strata were probably deposited at 100-200 m depth.

The K/P boundary is well constrained at Woodside Creek, both from the perspective of biostratigraphy and chemostratigraphy. Biologically, the thickly bedded Late Cretaceous limestone is dominated by typical Late Cretaceous foraminifera, and the thin-bedded Paleocene chert is dominated by Early Paleocene fauna. Chemically, the boundary clay contains the highest iridium concentration in the southern hemisphere, and one of the highest in the world (70ng/g – Strong et al., 1988). In addition, it contains abundant energy-shocked quartz mineral grains (Bohor et al., 1987), and elevated concentrations of soot (Wolbach et al., 1985), the latter interpreted as evidence for global wildfires at the K/P boundary.

The redox conditions of the Woodside Creek K/P boundary depositional environment have been interpreted to be reducing due to the presence of pyrite in the boundary clay (Wolbach et al., 2003). Additionally, the overlying 32 cm of organic-rich laminated sediment also suggest reducing conditions (Hollis et al., 2003).

Stratigraphy Scaglia Rossa Formation, Umbria-Marche, Italy

The stratigraphy of the Scaglia Rossa K/P boundary sections at Petricio, Frontale, Fonte d'Olio, Fornaci East and Furlo - Monte Pietralata, have been described previously by Montanari and Koeberl (2000). As with Woodside Creek, all sites described below for the Umbria/Marche (U/M) region have significant iridium, as well as other trace element anomalies and impact related microspherules (Montanari and Koeberl, 2000). Paleodepths in the U/M region were probably upper baythal (200-600 m). The following descriptive text outline aspects of stratigraphy specific to each of the K/P boundary sites sampled within the U/M region.

Petriccio

The uppermost Cretaceous limestone is bleached white and contains abundant *Zoophycos* trace fossils. The K/P boundary is well constrained, the K/P clay layer being 20-30 mm thick and containing a thin green basal layer. The K/P layer underlies the overhanging Tertiary limestone containing characteristic basal tertiary *Parvularugoglobigerina eugubina* fossils. Chemically, the boundary clay at Petriccio contains Iridium at 8.3 ppb; abundant microspherules are present along with shocked quartz. The shocked quartz is concentrated in the basal 5mm thick green sole of the boundary clay (Montenari, 1991). Redox conditions of the Petriccio K/P boundary depositional environment occurred in two stages with an approximately 5 mm green basal layer of boundary clay underlying the top 20 mm of red boundary clay. According to Montanari and Koeberl (2000), the basal green layer was probably deposited during the low oxygen conditions of the mass plankton die-off, the red upper clay layer deposited after the return to normal oxidizing conditions.

Frontale

The late Cretaceous limestone grades gradually from pink (30 cm below boundary) to white (15 cm below boundary). Abundant *Zoophycos* and *Planolites* trace fossils with diameters of a few millimeters are filled with reddish brown basal Tertiary sediment. The 15-20 mm thick boundary clay is well constrained, having a thin green basal layer, as at Petriccio, and is well preserved, free of secondary calcite and tectonic shearing. However, the boundary clay does contain frequent and moderately well preserved Cretaceous and lowermost Tertiary planktonic foraminifers, presumably introduced by post K/P boundary bioturbation. The K/P layer underlies the overhanging Tertiary limestone, pink grading upwards into whitish color 3-4 cm above the base, and containing characteristic basal tertiary *Eugubina* fossils. The redox conditions of the Frontale K/P boundary depositional environment were very similar to those at Petriccio (described above), with a thin green basal clay layer representing a pulse of low oxygen conditions, underlying the remainder (~ 15mm) of red clay deposited after a return to more oxidizing conditions (Montanari and Koeberl, 2000).

Monte Conero - Fonte d'Olio

The whitish top Cretaceous limestone has fewer fossils than other locations in the Umbria-Marche basin. The lowermost Tertiary limestone has a light ochre color and is thoroughly homogenized by bioturbation. The boundary clay is entirely ochre-green in color, and quite different from the dual red/green coloration of the K/P layer anywhere else in the Umbria-Marche basin. Chemically, the boundary clay at Fonte d'Olio contains Iridium of 10 ppb, the largest in the U-M basin. Altered microkrystites made of slightly evolved, pale-green glaucony, and shocked quartz are present but there are no goethite microspherules. This pale coloration of the boundary clay indicates an extended period of reducing conditions at the seafloor. Indeed, the lack of goethite spherules in the boundary layer also supports reducing conditions (Montanari and Koeberl, 2000).

Monte Conero – Fornaci East

This section has much in common with the nearby Fonte d'Olio outcrop, the topmost Cretaceous and basal tertiary pelagic limestones are light in color suggesting reducing conditions at the paleo-seafloor, but have the normal texture and microfacies of other locations in the Umbria-Marche basin. The 18mm thick boundary clay is a pale green color and impact related spherules are present.

Furlo – Monte Pietralata

The light pink top Cretaceous limestone is bioturbated, and the lowermost 2-m-thick interval of Tertiary limestone consists of thin bedded, dark pink platy limestones. The boundary layer here is 8mm thick and lacks the green sole typical of the K/P boundary in the U-M region. Chemically, the boundary clay at Furlo contains only a low concentration of Ir (1-2 ppb) compared to other sites in this region. The strong bioturbation and vertical mixing present at this site may indicate relatively oxygenic conditions

Stratigraphy of the Maastrichtian/Danian section, Stevns Klint, Denmark

The stratigraphy of the Maastrichtian/Danian section at Stevns Klint was described previously by Christensen et al. (1973). The Maastrichtian is represented by the lower 35 m of white chalk with large content of bryozoans, *Zoophycos* and flint nodules. The latest Maastrichtian is represented by a thick layer of grey chalk, and is abruptly overlain by a dark grey marl band, the so-called fish clay and the basal Danian bed. The K/P boundary, or fish clay is well described, having been sub-divided by Christensen et al. (1973) into 4 layers (from bottom to top): (i) A grey laminated marl, (ii) black marl with pyrite concretions, (iii) black laminated marl with pyrite considered to be the 'fireball' or 'impact' layer, (iv) light grey marl with flattened lenses of white chalk which grades into indurated *Cerithium* limestone. The depositional environment was shallow water marine, approximately 40 meters in depth. Chemically, the boundary clay at Stevns Klint contains Iridium of 42 ppb (Alvarez et al., 1980), impact glasses and shocked quartz (Bauluz et al., 2000). The fine laminations in layer (iv) and pyrite concretions in layer (iii) noted by Christensen et al. (1973) suggest euxinic redox conditions for the depositional environment.

Stratigraphy of Caravaca, Spain

The stratigraphy of the Barranco del Gredero section is described in detail by Smit and Klaver (1981), Smit and ten Kate (1982) and Smit (2005). The following descriptive text outline aspects of the Caravaca K/P boundary section relevant to this research.

The Barranco del Gredero section is Milankovitch in style, well bedded from early Maastrichtian through to Lower Eocene and over 225m thick. By comparison, the well known section at Gubbio in Italy represents the same interval, but is only 10.5m thick (Smit, 2005). The lithologies of the uppermost Cretaceous and lowermost Tertiary are similar with alternations of hemi-pelagic marls and marly limestones inter-dispersed with minor amounts of hard pelagic limestones and calciturbidites (Smit and ten Kate, 1982). A 10-12 cm thick dark clayey marl bed forms the boundary at Barranco del Gredero, with a basal red layer (0.5 cm) and a green-gray upper layer (8-12 cm) gradually growing lighter towards the top and underlying the classic basal Barranco del Gredero Tertiary *P.eugabina* zone (Smit and ten Kate, 1982). In addition the boundary layer contains abundant tiny sanidine spherules, interpreted as the remains of impactor melt droplets (Smit and Klaver, 1981). The depth of deposition at Barranco del Gredero was approximately 1000 m as suggested by the presence of mesopelagic fish teeth (Smit, 2005). Geochemically, the boundary clay at Barranco del Gredero contains anomalously high concentrations of Cr, Ni, As, Sb, Zn and platinum group elements including iridium (40 ppb) (Smit and ten Kate, 1982). In addition the boundary layer contains abundant shocked quartz (Bohor and Modreski, 1987).

Stratigraphy of North American Sites

In contrast to other sites in this study, all North American sections are non-marine. North American sections contain two distinctive claystone layers. The lower well-lithified creamy colored claystone layer (the "ejecta layer" of Hildebrand [1993]); "hackly layer" of Sweet et al. [1999]) is 7-27 mm thick and composed of kaolinite with some melt spherules. The kaolinite darkens upward and texture becomes finer toward a sharp contact with the overlying layer. The upper layer ("impact layer" of Izett [1990]; "fireball layer" of Hildebrand [1993], "satiny layer" of Sweet et al. [1999]) is less lithified than the lower layer, is 2-10 mm thick, and is composed of beige to brown claystone. The upper layer contains numerous cream oval-shaped pellets or graupen with long axis aligned parallel to bedding, and thin vitrinite laminae. An iridium anomaly and shocked minerals occur in this layer (Hildebrand, 1993).

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