

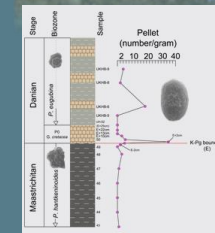
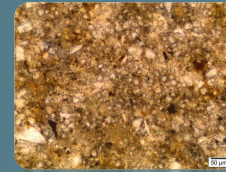
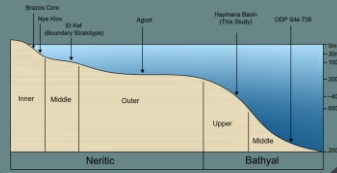
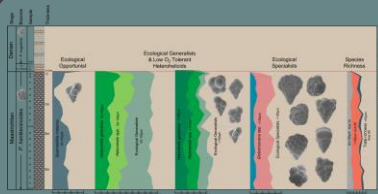


Faunal and environmental changes through the Cretaceous-Paleogene boundary (K-Pg) linked with Deccan Volcanism: evidence from the Neo-Tethys, Turkey

A. Uygur Karabeyoğlu, Sevinç Özkan Altıner, Demir Altıner, Thierry Adatte

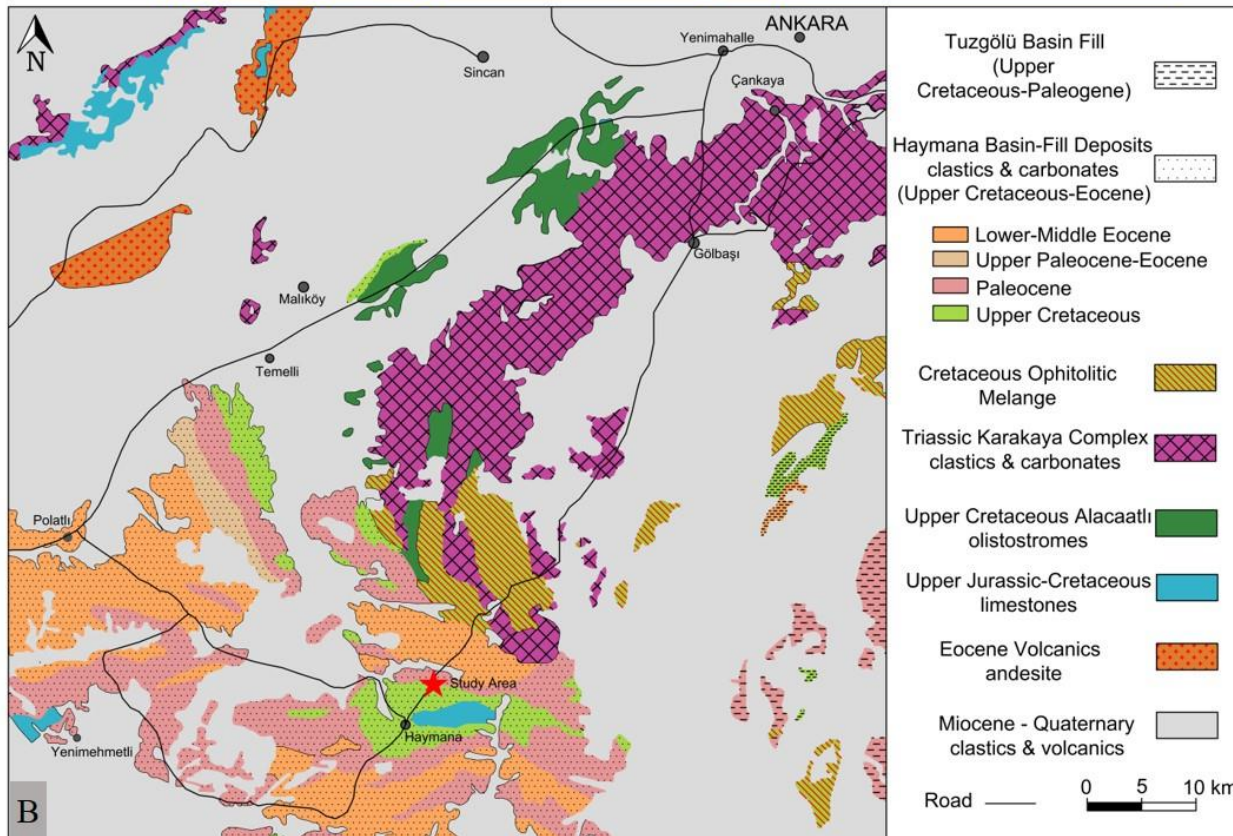


Outline



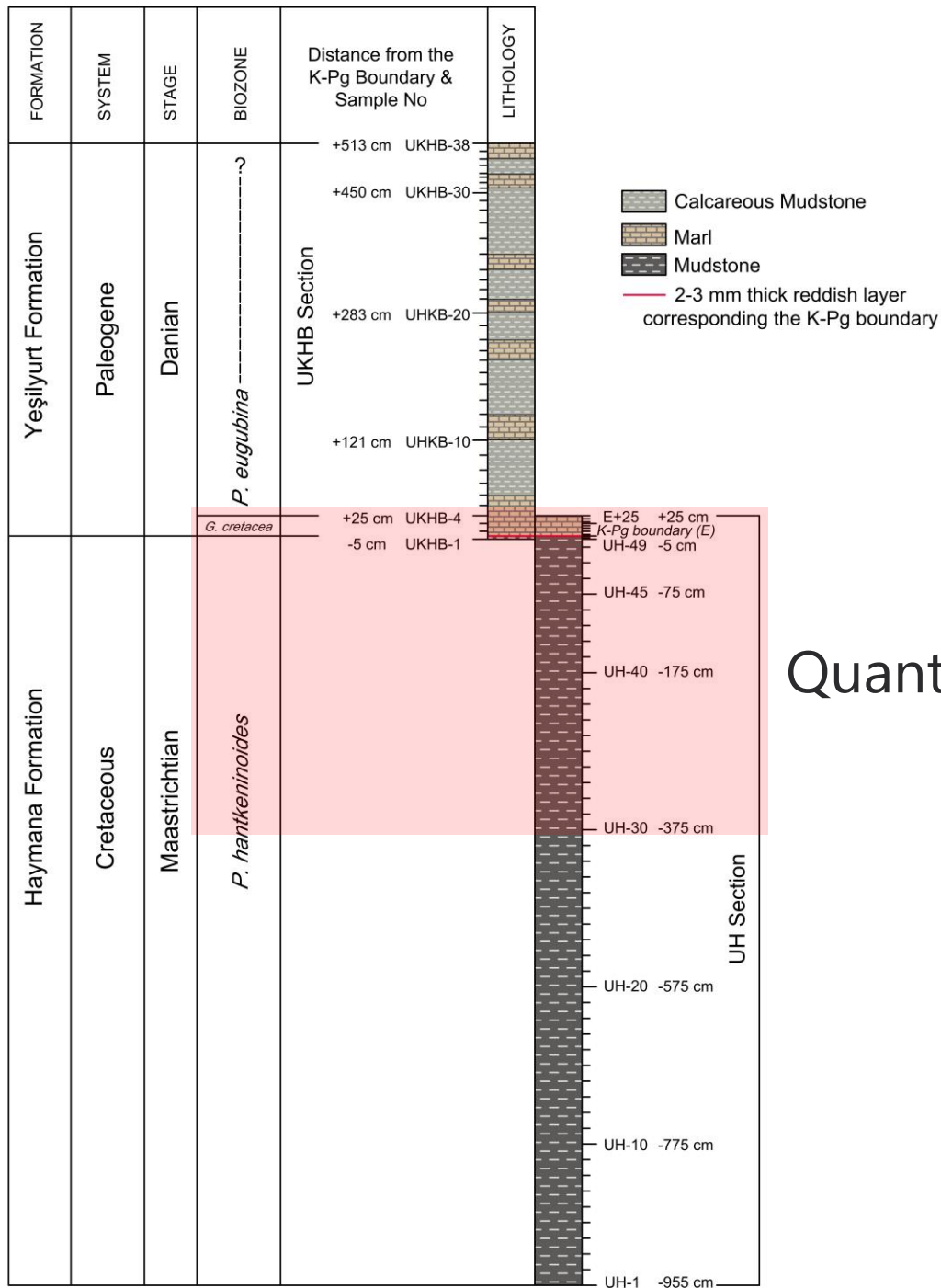
- Events across the K-Pg boundary

- Quantitative analysis:
63-150 μm & >150 μm
- Relative Abundances
and Species Richness
- Paleobathymetric
Analysis



ERATHM	SYSTEM	SERIES	STAGE	Thickness (m)	Lithology	Description
CENOZOIC	QUATERNARY					Alluvium
	NEOGENE	Mio-Pliocene		200		Conglomerate, marl, lacustrine limestone, volcanics
	PALEOGENE	EOCENE		a-1034, b-525, c-610		a-Yamak Formation: grey conglomerate, sandstone, marl b-Çayraz Formation: yellow-beige sandy clayey limestone and marl c-Beldede Formation: red conglomerate, sandstone, marl
				567		Eskipolatlı Formation: grey sandstone, shale, marl, limestone
				350		Ilgınlıkdere Formation: grey conglomerate, sandstone
				659		Kırkkavak Formation: algal limestone, grey marl
				b-1362, b-1187, c-342		a-Kartal Formation: red conglomerate, sandstone, marl b-Çaldağ Formation: reefal limestone c-Yeşilyurt Formation: marl with limestone blocks
	MESOZOIC	CRETACEOUS	Maastrichtian	125		a-Beyobası Formation: sandstone, conglomerate, pebbly limestone b-Haymana Formation: grey shale with turbiditic conglomerate and sandstone
			Campanian	1800		
			Santonian	100		Kocatepe Formation: limestone, shale
			Turonian	100		
			Cenomanian	500		Akkaya Formation: Limestone, breccia
			Albian	500		
			Berriasian	150		Soğukçam Limestone: pelagic limestone, breccia
TRIASSIC	JURASSIC		Tithonian	800		Bilecik Limestone: neritic limestone
			Kimmeridgian	800		
			Rhaetian	> 2000		Karakaya Complex: Greywacke, siltstone, shale with Carboniferous, Permian, Triassic limestone blocks

NOT TO SCALE



Quantitative analysis

UKHB
5.14 m

38 samples

K-Pg

9.70 m UH

50 samples

3.75 m Quantitative Analysis

Paleocene

K-Pg boundary

Cretaceous



Paleobathymetric Calculation

Planktic/Benthic
Ratio

$$\%P = \left(\frac{P}{P + B} \right) \times 100$$

Ave.
Depth

Van der Zwaan
et al. (1990)

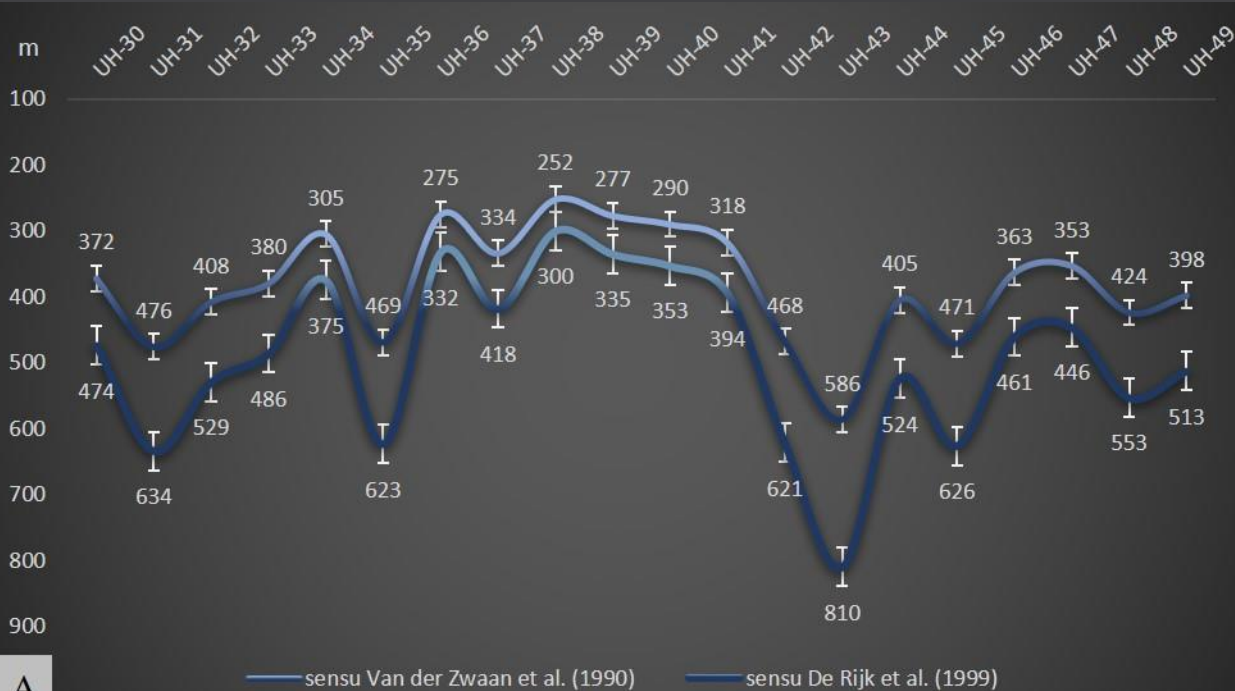
$$Depth(D) = e^{3.58718 + (0.03534 * \%P)}$$

381m

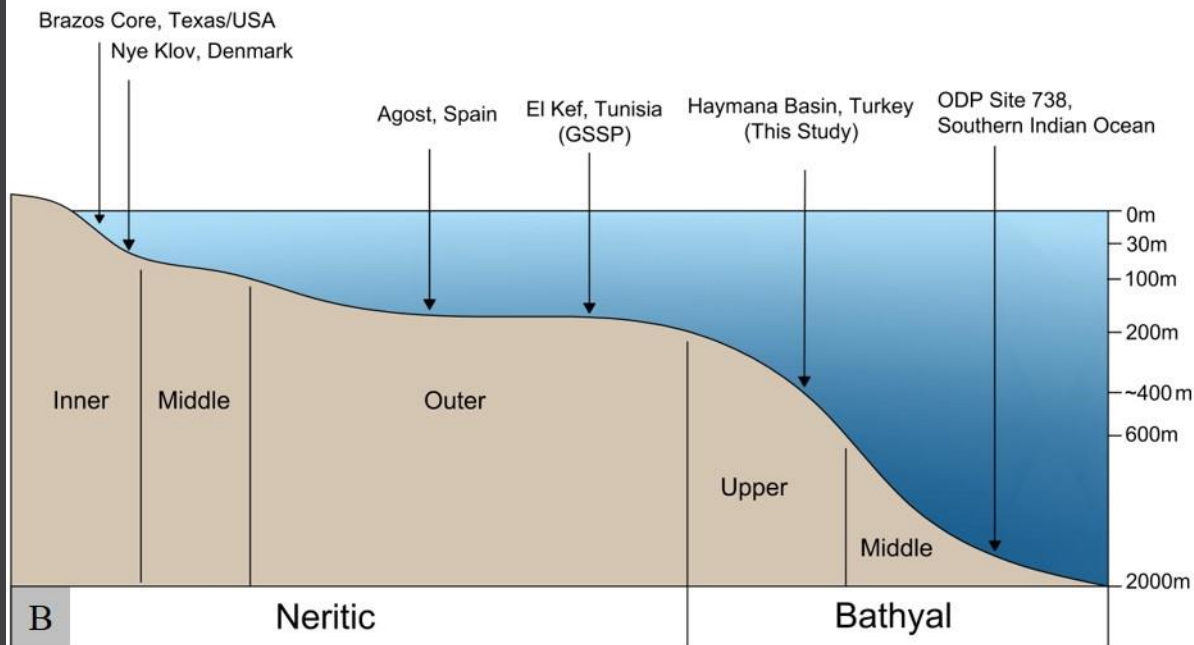
De Rijk *et al.*
(1999)

$$Depth(D) = e^{(\%P + 81.9) / 24}$$

490m



A) Paleobathymetric variations (depth in meters) through Maastrichtian are based on formulas of: Van der Zwaan et al. (1990) (upper graph), De Rijk et al. (1999) (lower graph). White bars represent standard errors. Paleobathymetric calculations revealed 400 m paleodepth for our study area corresponding upper bathyal zone.



B) Paleodepth of the study area in the Haymana Basin and its comparison with worldwide K-Pg boundary sections. Image modified after MacLeod and Keller (1994) and Molina et al. (2006 and references therein).



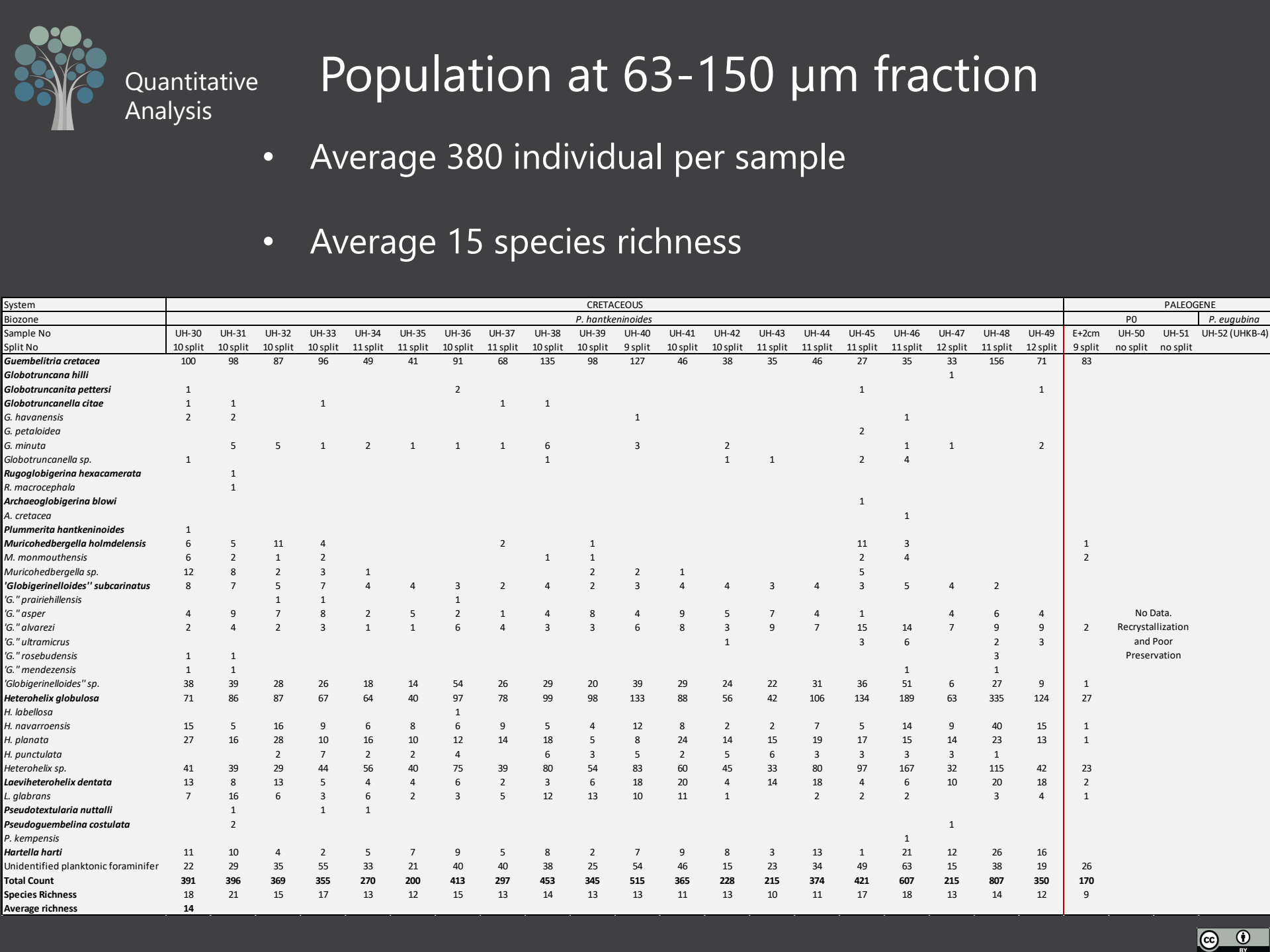
Quantitative Analysis

- 63-150 μm & $>150 \mu\text{m}$ size fractions
- Relative abundance and species richness changes across the K-Pg boundary

Population at $>150 \mu\text{m}$ fraction

- 394 individual count per sample
- Average 40 species richness

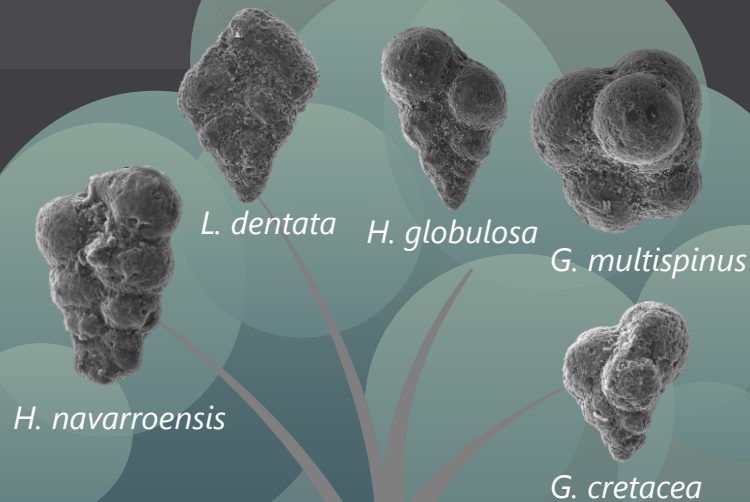
System	CRETACEOUS																				PALEOGENE			
Biozone	<i>P. harrisiensis</i>																				<i>P. eugubina</i>			
Sample No	UH-30	UH-31	UH-32	UH-33	UH-34	UH-35	UH-36	UH-37	UH-38	UH-39	UH-40	UH-41	UH-42	UH-43	UH-44	UH-45	UH-46	UH-47	UH-48	UH-49	EH-2cm	UH-50	UH-51	UH-52 (UH-48-49)
Split	5 split	5 split	5 split	5 split	5 split	5 split	6 split	5 split	5 split	5 split	5 split	6 split	5 split	6 split	5 split	6 split	6 split	6 split	6 split	6 split	2 split	no split	no split	no split
<i>Gublerella cretacea</i>	1	1	1	1	1	5	2	4	2	12														
<i>Globotruncana aegyptiaca</i>	4	4	3	6	7	4	1	4	1						2	5		2				3		
<i>G. arca</i>	3	5	6	8	2	3		1					3	7	1	4	7	7	4	2		1		
<i>G. bulloides</i>																								
<i>G. dupuilei</i>				1	2		1	1		1	1		2		1					1				
<i>G. exilis</i>	13	2	4	12	4	4	4	1	9	11	2	2	5	11	4	6	9	2				1		
<i>G. foliostuati</i>	1	3	3		4	4	3	1	4	1	3		2	2	2	1	3	1	1			1		
<i>G. lapparenti</i>				1																				
<i>G. lineolata</i>									3															
<i>G. hilli</i>	1	1		1					1	1	2	9	1	1	2	12	10	1	6					
<i>G. mariei</i>	8	6	14	6	6	4	1	3	7	1		1	1	1	2	12	10	1	6					
<i>G. orientalis</i>	5	1	3	5	8	4	2	4	3	1	1	1	1	1	8	1	2	2					1	
<i>G. rosata</i>			2	1			2	2	3	2		1	1	1	3	1		4	1			2		
<i>G. ventricosa</i>							2	1				2	1											
<i>Globotruncana sp.</i>	7	5	12	7	3	7	5	3	5	7	9	7	6	5	13	10	9	8	4	3		3		
<i>Globotruncanella angulata</i>	3	1		1	5	1	1	1	5	2						2								
<i>G. conica</i>			1			1		1	1															
<i>G. insignis</i>	4						3	4	4	9	2	9	6	1	8	1		1	1			3		
<i>G. pattersoni</i>	7	9	7	11	10	15	6	6	5	8	3	3	2	5	4	4	15	5	5	2				
<i>G. stuarti</i>		1		1						4		1						3	1			1		
<i>G. stuartiformis</i>	4	1	2	1	2		1	1	3	3	1	3	3	1	2	1	3	2						
<i>Globotruncanella sp.</i>	1			4	5	7	4	6	4	5	1	3	2	3		1	2	1			2			
<i>Contusotruncana contusa</i>																								
<i>C. patelliformis</i>	1	3		1	1											3					1			
<i>C. plummerae</i>																								
<i>C. fornicata</i>																								
<i>C. pilcata</i>																2								
<i>C. woffschensis</i>																								
<i>Contusotruncana sp.</i>								2					2	2		2		5			1			
<i>Globotruncanella pschodae</i>	2	2	2	2	2	6			2	2			2	2		2								
<i>G. havensis</i>	15	7	6	18	9	1	5	4	5	4	3	1	2	2	2	4	5	1				1		
<i>G. petaloides</i>	3	9	6	7	4	1	2	1	1	5	1	2	2	3	1	2	1	2	2			1		
<i>G. minuta</i>	1	3	1		2	1		1	1	2	3				1									
<i>Globotruncana sp.</i>	2		2	1	4	1	3	1	1	4	3	1	1				1	1						
<i>Gansserina gansseri</i>		1		1																				
<i>G. wiedenmayeri</i>		2																2						
<i>Rugoglobigerina rugosa</i>	11	5	6	3	7	11	2	1	9	3	4	10	3		1	1	1		4	3	1			
<i>R. hexacamerata</i>		2						3		1	4													
<i>R. macrocephala</i>				1				1	3	1		1							1					
<i>R. milamensis</i>	3	1	1	1	1	2		1																
<i>R. pennyi</i>	2	1	1	3	2	3		2					1					1	1					
<i>Rugoglobigerina sp.</i>	1		3	2		1	1	2	1	1	1													
<i>Trinitella scotti</i>	4	1	1	1			3	1	2	4	5	2										2		
<i>Kuglerina rotundata</i>		1																				1		
<i>Archeoglobigerina blowi</i>	6		1	2	5	3	6	10	7	2	11	1	4	1	2	13	16	8	4	1				
<i>A. cretacea</i>									1															
<i>A. australis</i>	1								3	2	1	2				2	2	5						
<i>Archeoglobigerina sp.</i>					2	1										3	4	2						
<i>Plummerita reichli</i>	3		1		1			1				1			1									
<i>Plummerita hantkenioides</i>	1																							
<i>Plummerita sp.</i>					1	3		2	1	3		3	1											
<i>Muricohedbergella holmdensis</i>	2	1		3	3	1		3					2	1		1								
<i>M. monmouthensis</i>	4	1	3	5	2	2	2	1	1	2	2		2				2	1	2	2				
<i>M. sileri</i>				1							1													
<i>Muricohedbergella sp.</i>	1		1					1	1															
<i>Globigerinellides"multispinus</i>	4	18	23	21	7	5	1	2	1	4		4	5		4	1		3	4					
<i>G. "subcarinatus</i>	10	14	7	6	3	12	1	4	3		4	3	6	2	5	3	2	4	2	4		2	1	
<i>G. "prairiehillensis</i>								1	3	4		5	1		1			2	3			1		
<i>G. "asper</i>	9	9	5	4	2	6		1	6		5	4	5	4	5		3	1	3			5	1	3
<i>G. "alvarezi</i>			1				2	2	1	1	1	1	2	1	3	1	1	1						
<i>G. "rosebudenis</i>	3	3	3	1	1							2	1		1									
<i>G. "mendicensis</i>								1																
<i>Globigerinellides"sp.</i>	19	30	12	28	19	24	23	10	16	12	7	10	16	10	16		4		4			1		1
<i>Heterohelix globulosa</i>	111	120	92	113	62	77	37	28	50	85	67	93	126	58	95	65	95	54	75	77	4	11	2	
<i>H. labellosa</i>	16	11	10	17	7	20	4	1	2	9	12	20	5	5	1	4	6	6	4					
<i>H. navarroensis</i>	1		2	1		3		1				9	1	2		2	1	4	3	2		1		2
<i>H. planata</i>	12	12	15	22	6	31	21	18	10	11	8	15	9	9	16	10	8	10	8	5		2		1
<i>H. punctulata</i>	31	24	26	16	16	25	10	16	6	2	12	13	8	12	12	7	3	4	10	1		1		1
<i>Heterohelix sp.</i>	39	49	44	34	45	53	20	23	31	68	23	51	41	34	38	37	35	36	27	28		34	8	
<i>Laeviheterohelix dentata</i>	1	5	4	2	7	6	5	3	1	2	1		2	3	2	2	1	4	1	3		1		
<i>L. globans</i>	6	10	1	3	4	17	5	2	1	2	1					1	1	1	1	3		1		
<i>Pseudotextularia elegans</i>	12	12	21	9	4	8	10	4	6	11	7	15	6	1	1	13	3	3	6	3		1		4
<i>P. nuttalli</i>	41	69	31	50	18	19	11	4	14	11	17	38	24	24	29	17	37	14	23	13		2		8
<i>P. intermedia</i>	10	4	5	8	3	3		3	2	7	5	6	3	1	3	7	7	1	4			1		2
<i>Pseudoglobulina sp.</i>	6	6	5	8	7	7	3	3	7	3	3	1	2	8	4									1
<i>Planoglobulina acervulinodes</i>	11	8	11	1	6	1	1	2	3	3	3	1	2	3	6	3	5	5	5			2		
<i>P. brazeensis</i>	2	3	3	2		1	2	3	5	4	1	5	5	6	5	3	3	3	5	3		3	1	
<i>P. carseyae</i>	28	24	30	20	12	6	6	8	6	3	11	10	12	11	5	16	13	12	3	11	6		2	
<i>P. multicamerata</i>																1								
<i>Planoglobulina sp.</i>	2	14	9	4	2	3	3	3	5	4	4	5	5	3	12	8	9	6	7	4		9		
<i>Pseudoglobulina costulata</i>				2		1			1	1	1	1	1	1	2									
<i>P. excolata</i>																								
<i>P. harrisiensis</i>	2	1	3	5	8		2	1	3	4	1	1	4		2	1	2	1	6	2				
<i>P. kempensis</i>																								
<i>P. palpebra</i>	1		1	3	2			5	4				1	2	4	1		2	2	1		1		
<i>Gublerina acuta</i>																								



Relative Abundance Analysis



r-Strategists (Generalists)



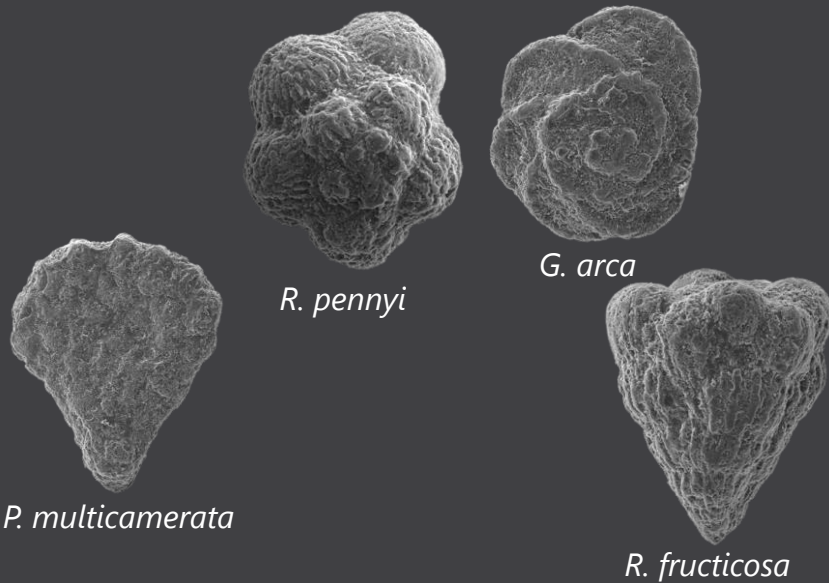
r strategists



- Small, unornamented, tolerant to nutrient, temperature, acidity fluctuations in environment



Some K-Strategists (Specialists)

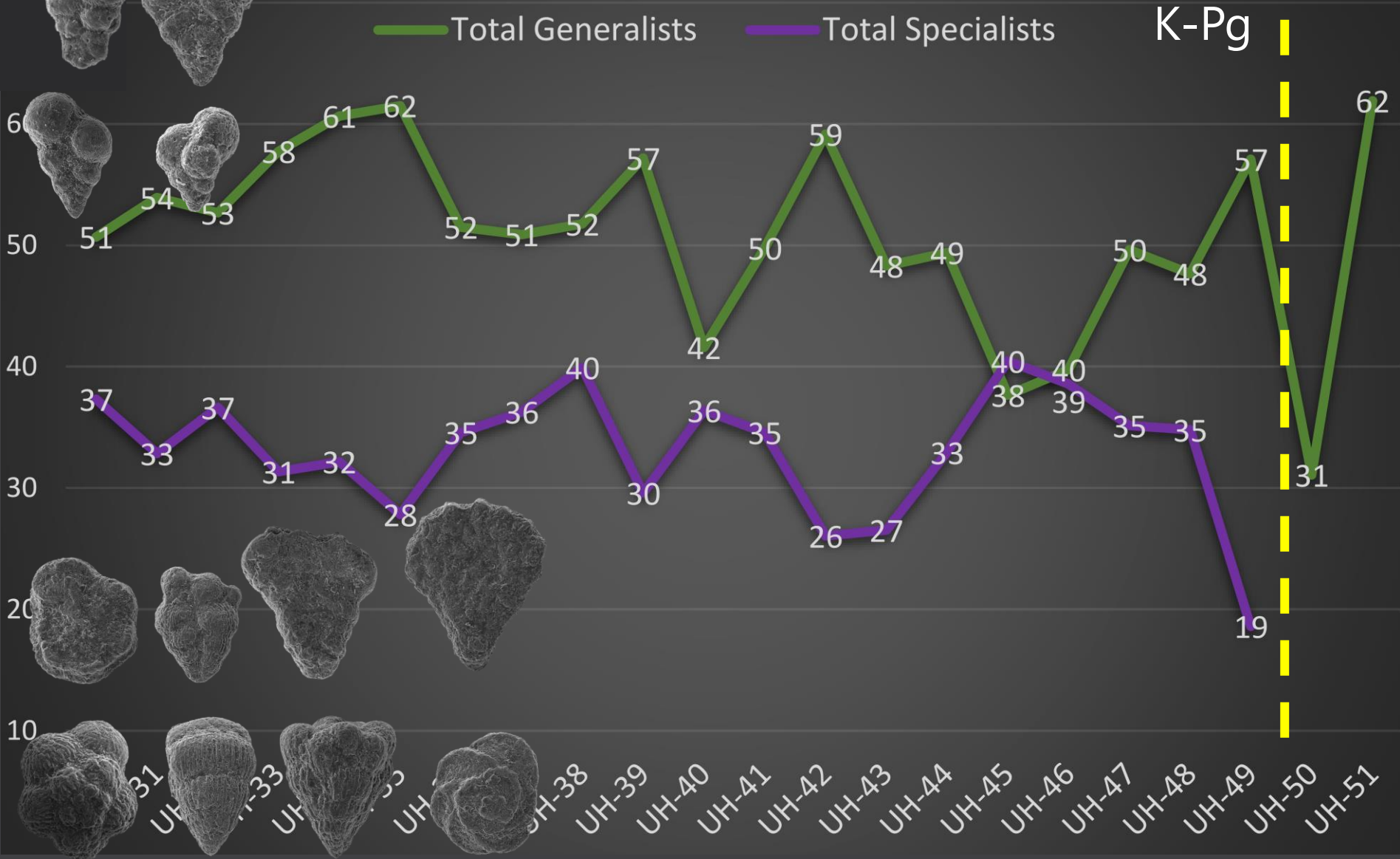


K strategists

- Large, ornamented, diversified but occupy certain niches and intolerant to environmental fluctuations!

r-Strategists (Generalists)

Relative abundance of population > 150 μm



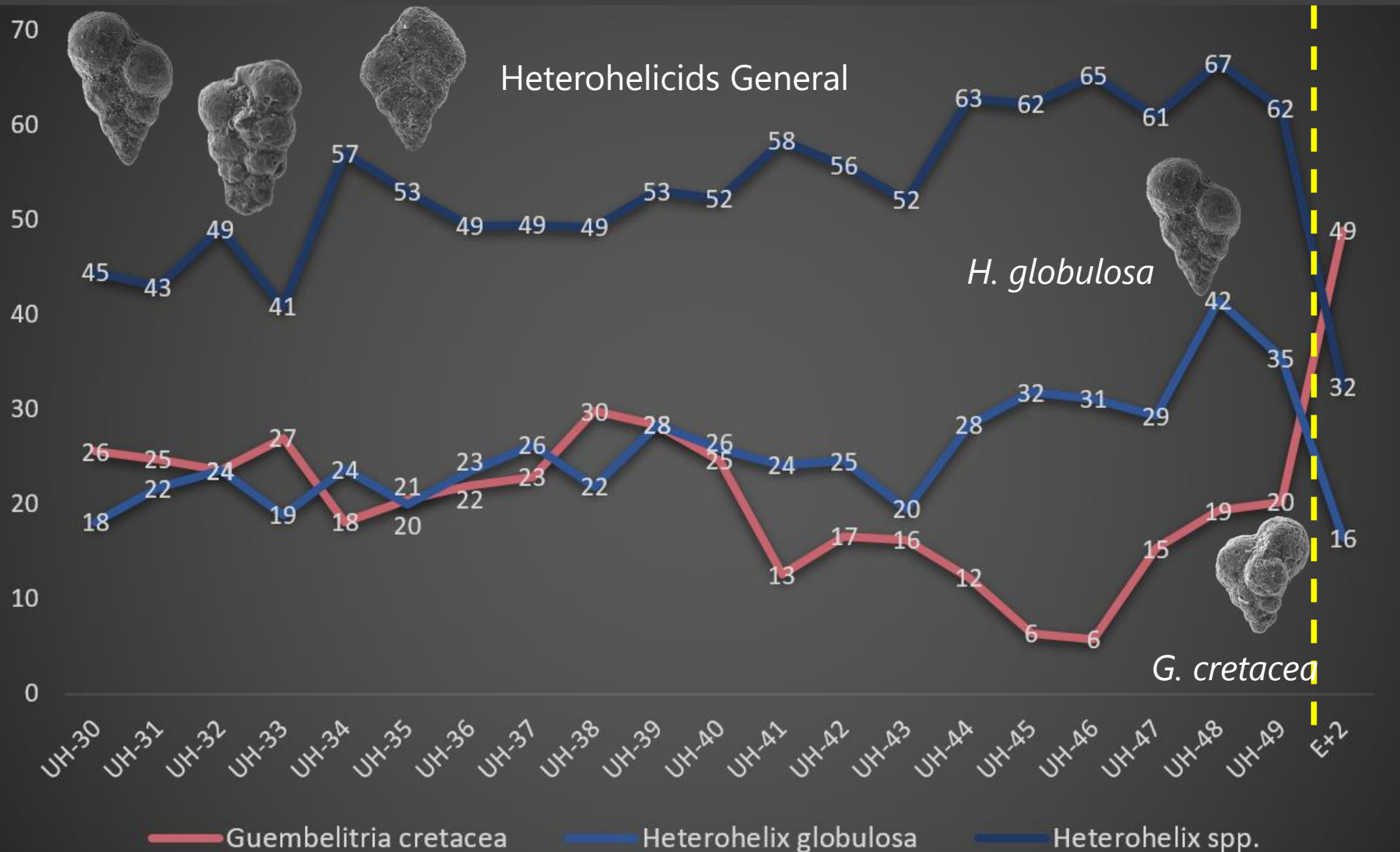
K-Strategists (Specialists)



Quantitative
Analysis

Population above 63-150 μm fraction

K-Pg





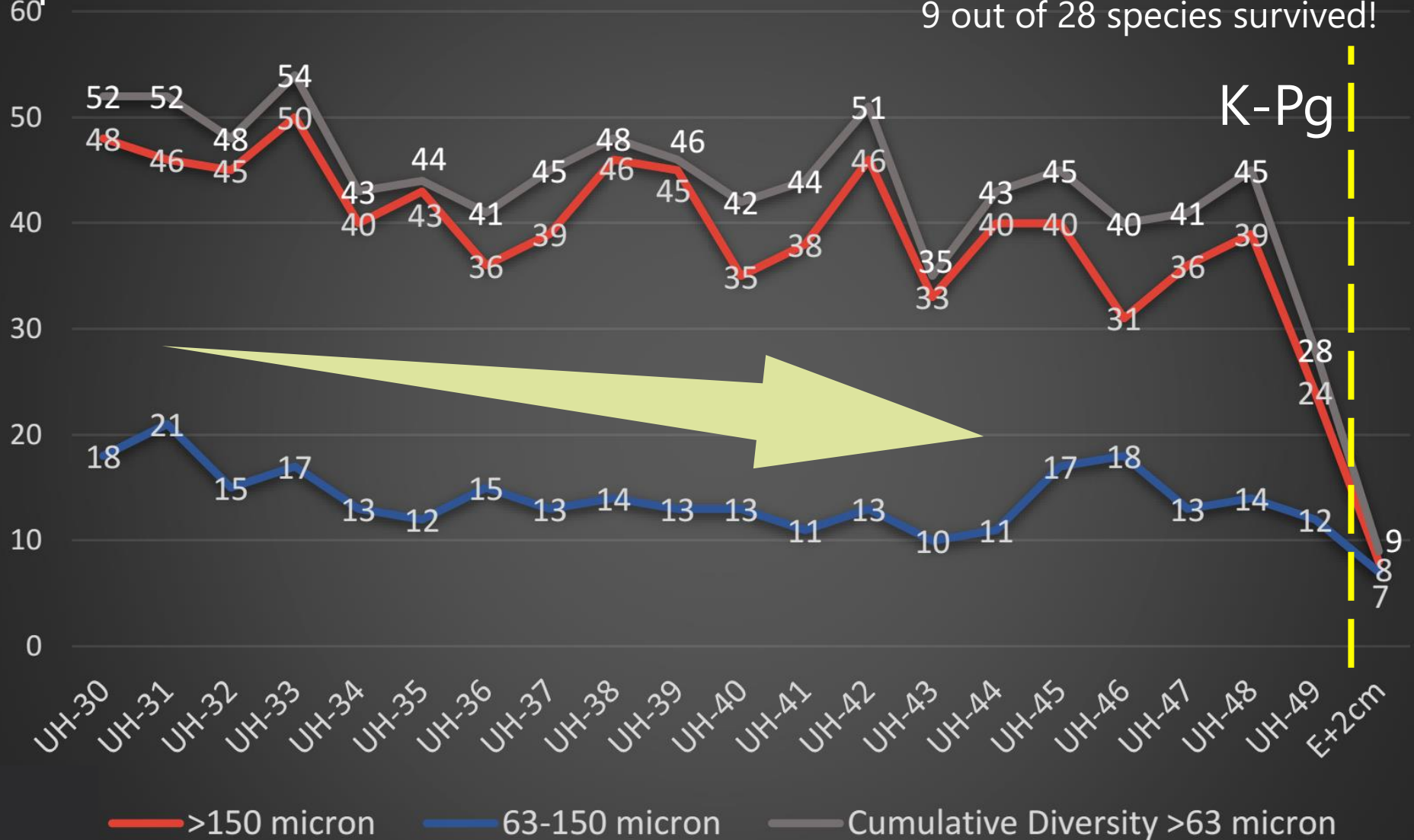
Quantitative
Analysis

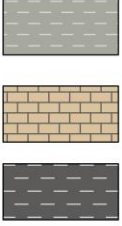
- 50% drop in the species richness before the KPB
- Environmental stress prior to KPB!

Species Richness

9 out of 28 species survived!

K-Pg





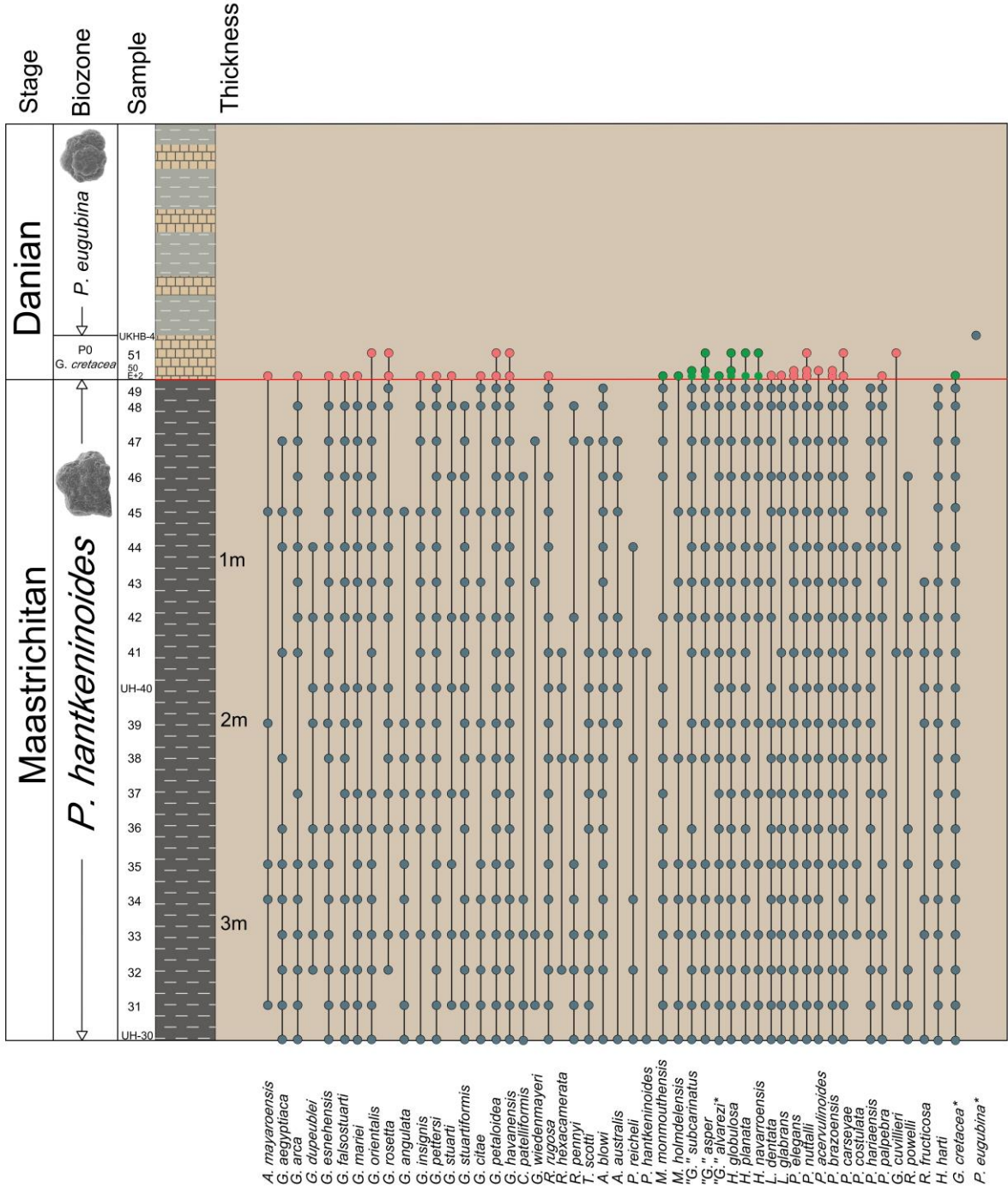
Calcareous
mudstone

Marl

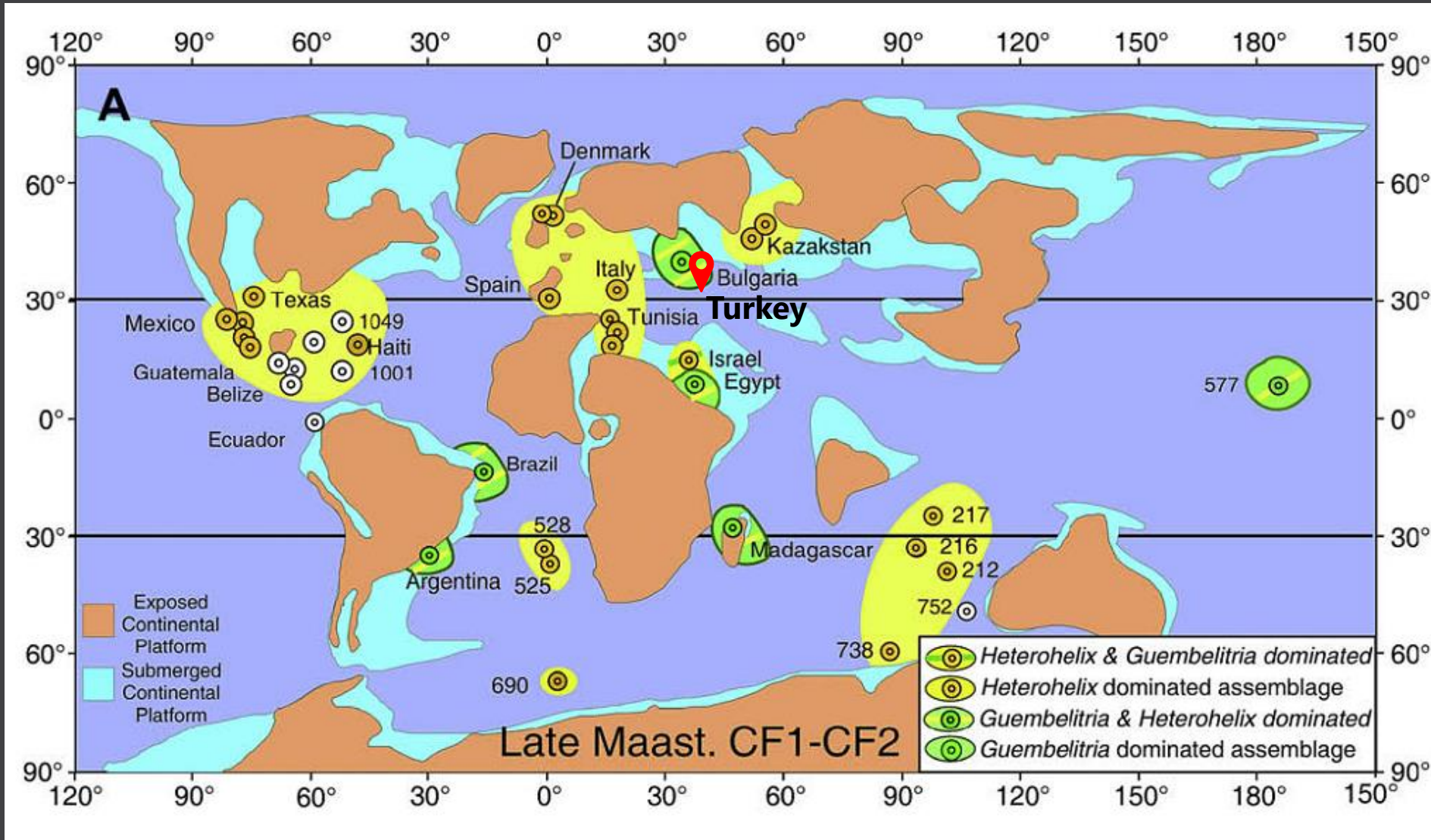
Mudstone

● Reworked Forms

● Survivors



Maastrichtian CF1-CF2



Pardo & Keller 2008

> 150 μm



63-150 μm



Nature of the K-Pg boundary layer

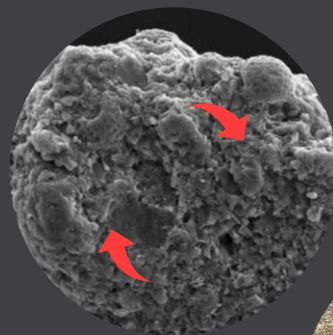
- 2-3 mm thick reddish oxidized layer
- Sharp extinction horizon!
- >63 μm Almost no planktonic foraminifera (only some heterohelicids, guembelitrids, globigerinellids & hedbergellids) & very rare benthics





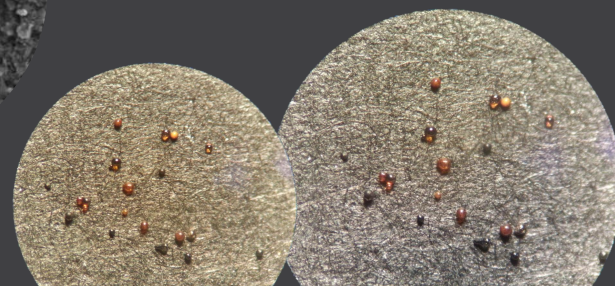
Findings across the K-Pg boundary

- Thoracosphaera acme



- Black and Brown spherules

Only found within the 2-3mm thick reddish layer



- Amorphous Grains

Only found within the 2-3mm thick reddish layer!



- Abrupt increase in pellets



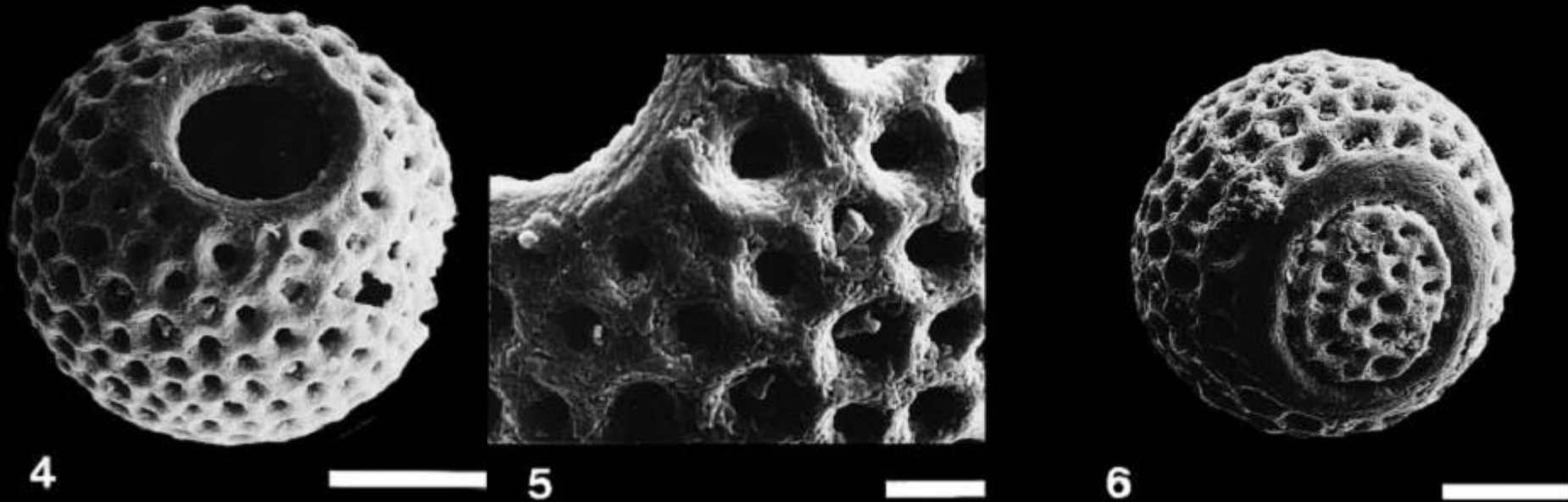
- Euhedral Grains

Found -2cm & at the K-Pg boundary layer.
Not above!



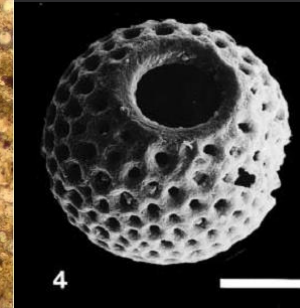
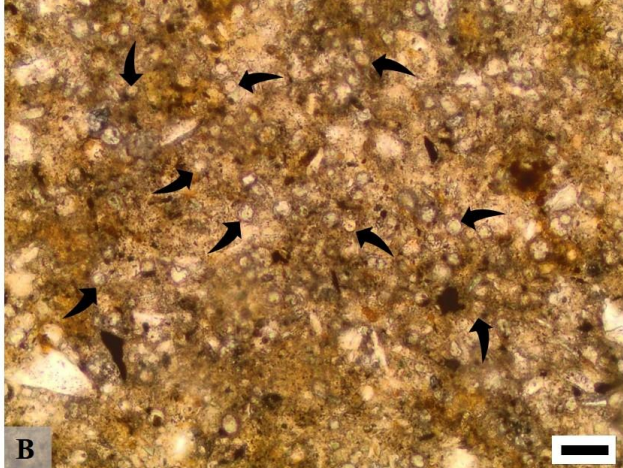
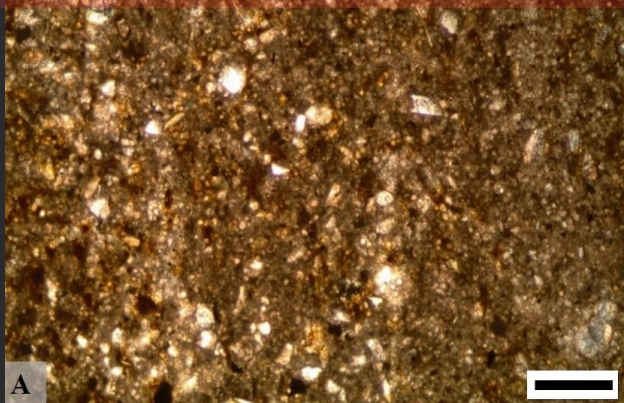
Thoracosphaera spp. increase

- Calcareous dinoflagellate-Phytoplankton
- Environmental Stress Marker (Lamolda *et al.*, 2005)

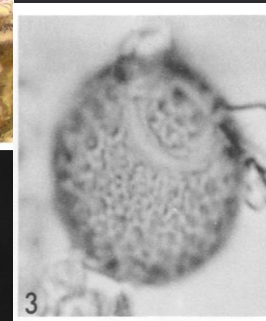


Hildebrand-Habel et al., 1999

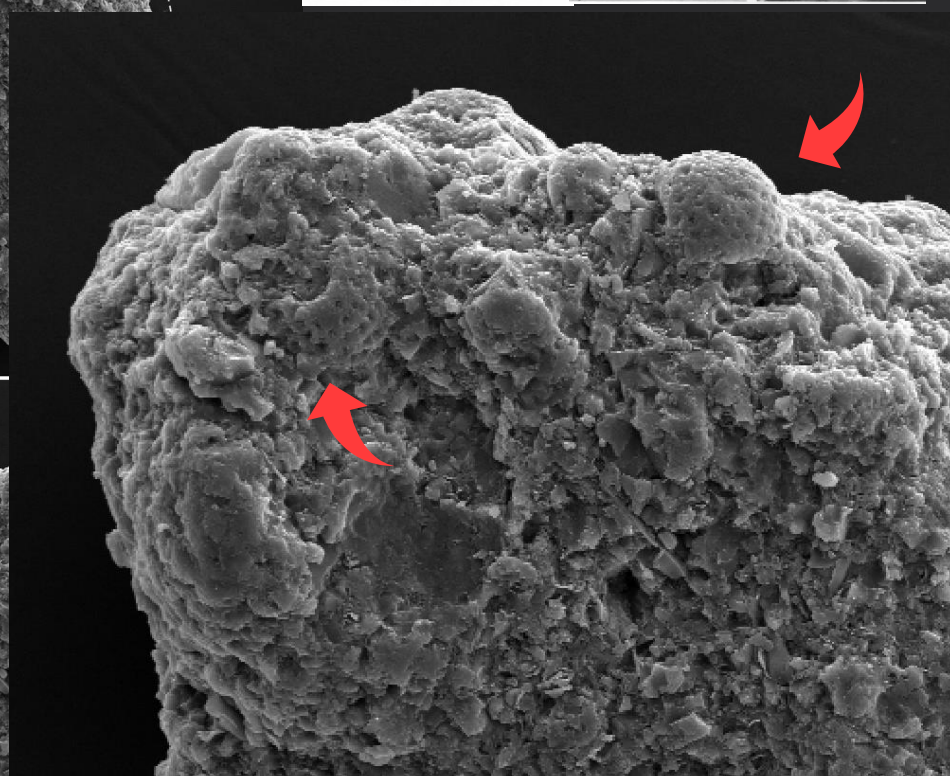
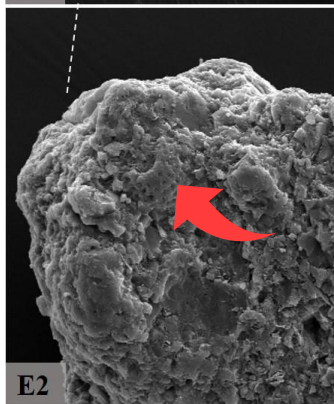
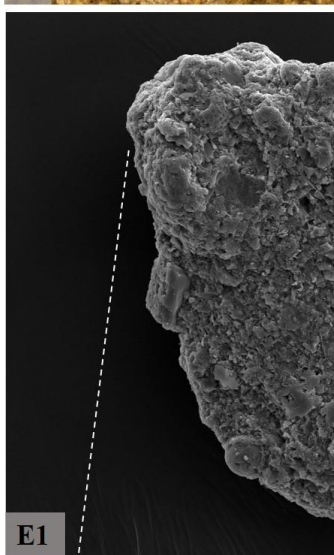
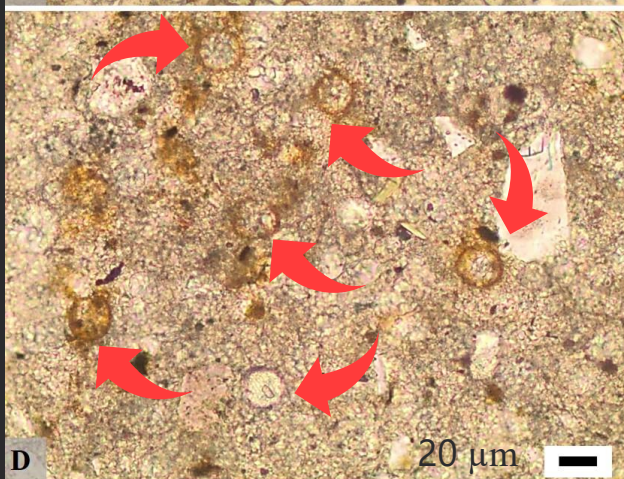
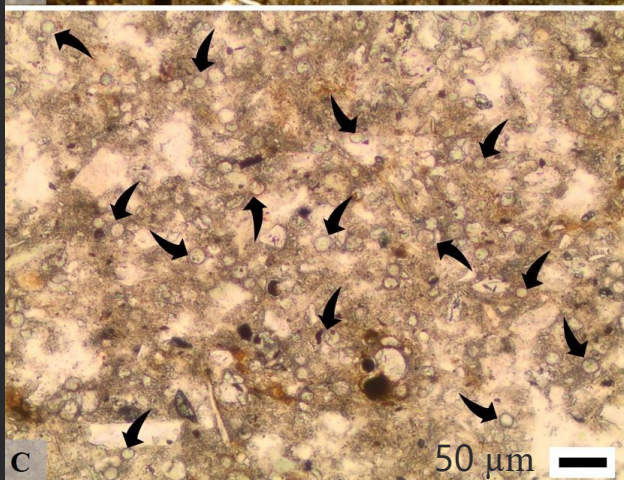
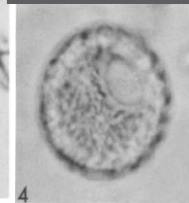
Our Findings in Haymana Basin



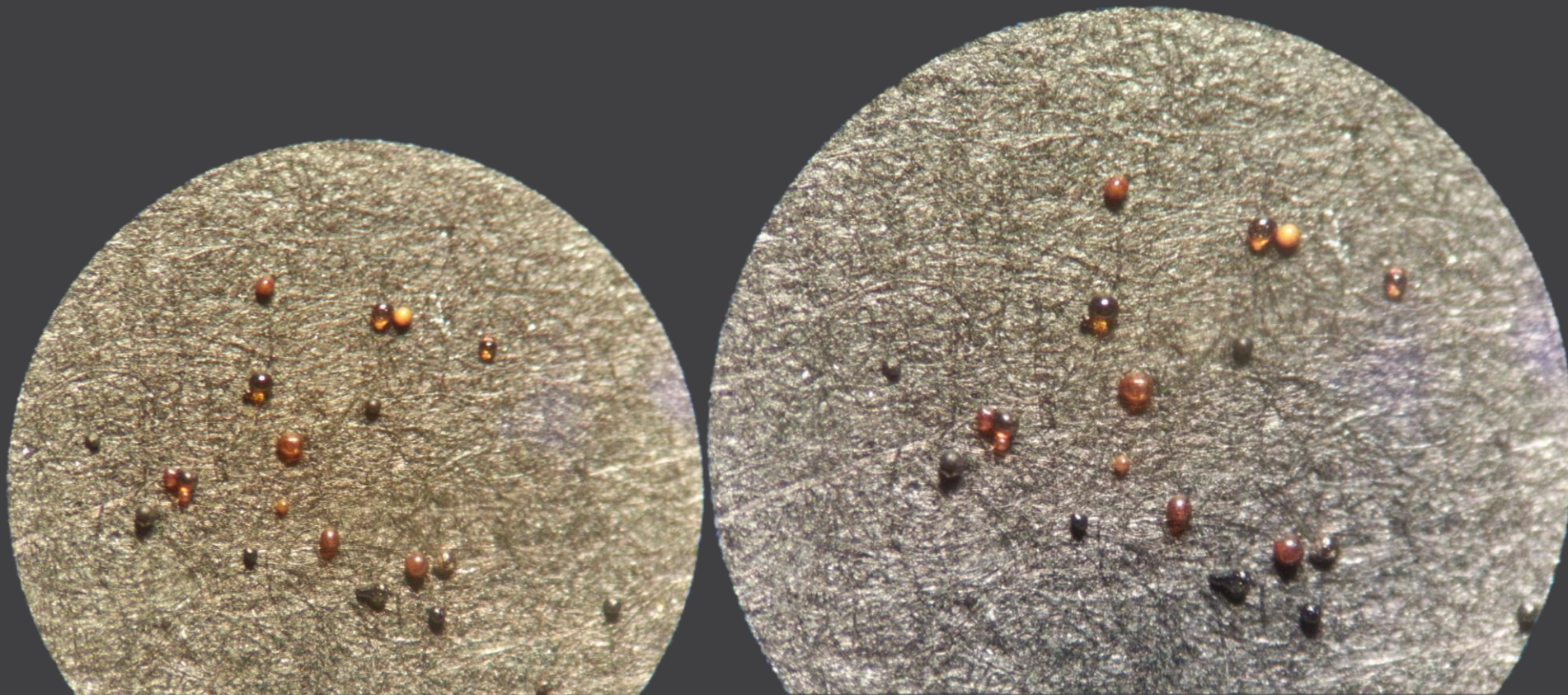
Hildebrand-
Habel et al. 1999



Bramlette & Martini 1964
Thoracosphaera opercula



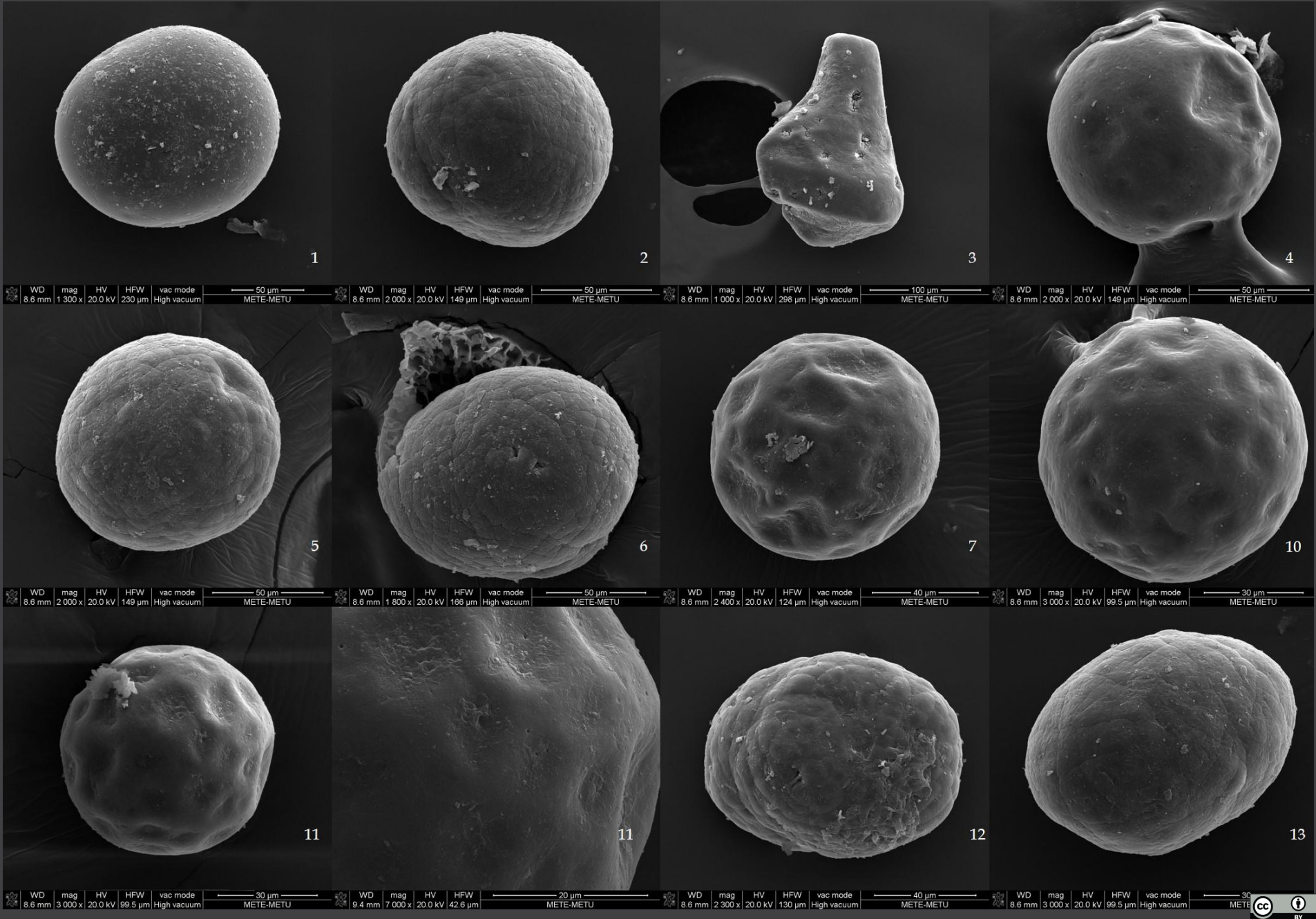
Black and Brown spherules



400 μm

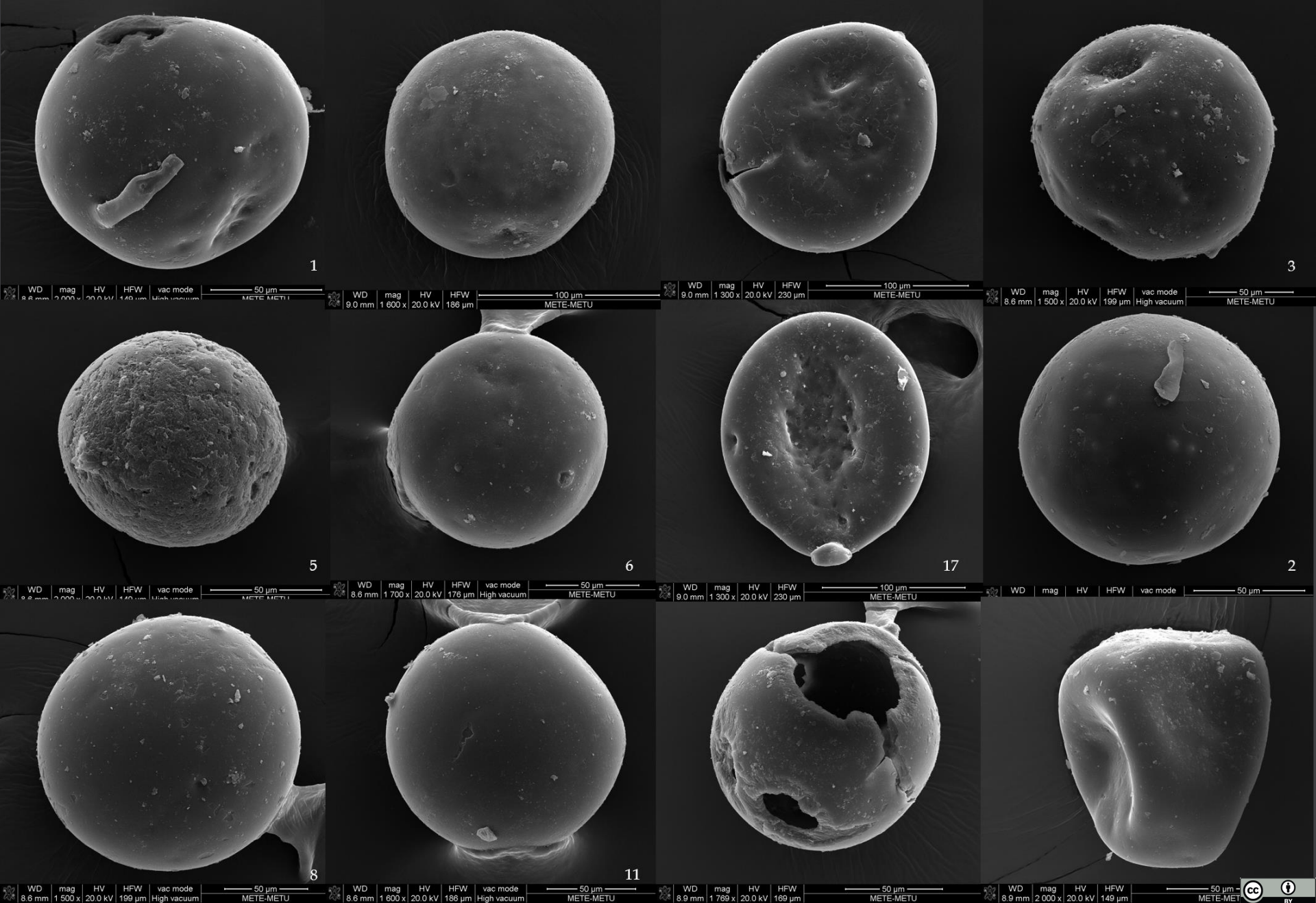
Series 1- Brownish, amber and yellow ones

Some specimens are pliable!

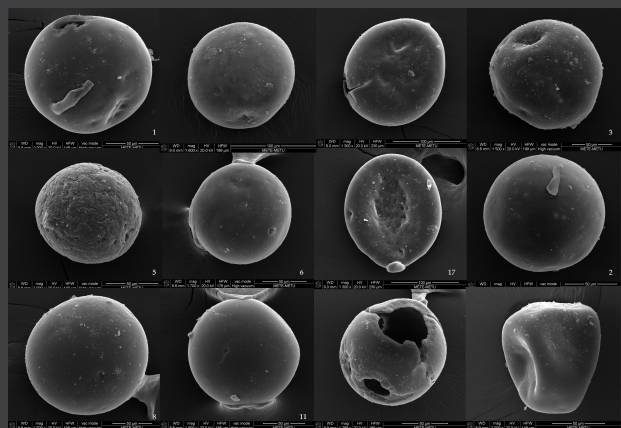
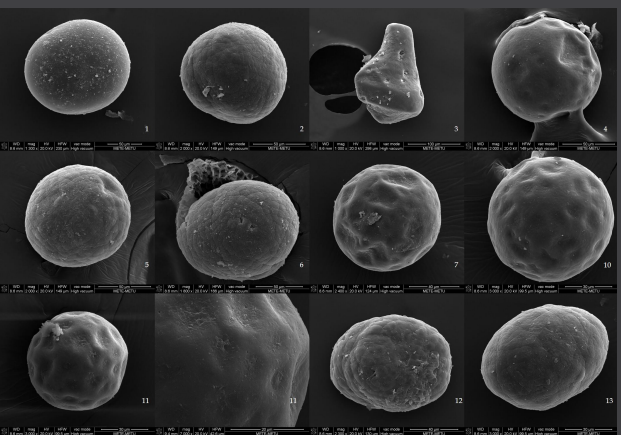
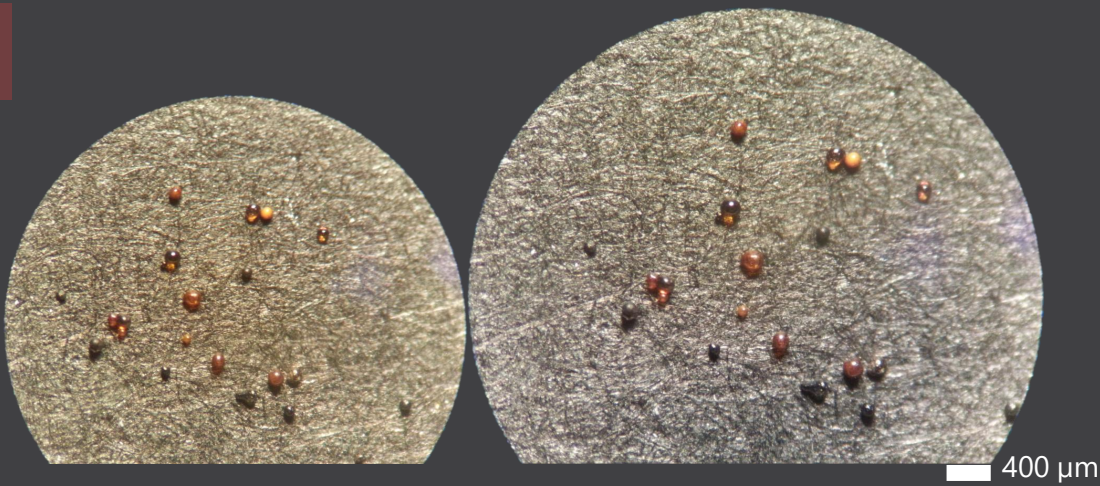


Series 1- Black ones

More smooth surface!



Black and Brown Spherules



Brown-Yellow

Sample No:	Series 1-a	Series 1-b	Series 1-d	Series 1-e	Series 1-f	Series 1-h	Series 1-i	Average
Wt %								
SiO ₂	15,37	12,55	9,55	16,63	3,38	3,86	3,46	9,3
CaO	56,08	57,03	38,72	47,97	80,49	80	74,42	62,1
Na ₂ O	n.d.	3,13	10,91	4,42	n.d.	n.d.	2,44	5,2
MgO	12,94	13,53	15,92	16	9,88	8,9	15,47	13,2
Al ₂ O ₃	6,2	6,9	4,76	4,91	1,88	3	1,85	4,2
Fe ₂ O ₃	9,4	6,86	6,14	10,07	4,38	4,24	2,37	6,2
Cl ₂ O	n.d.	n.d.	13,99	n.d.	n.d.	n.d.	n.d.	

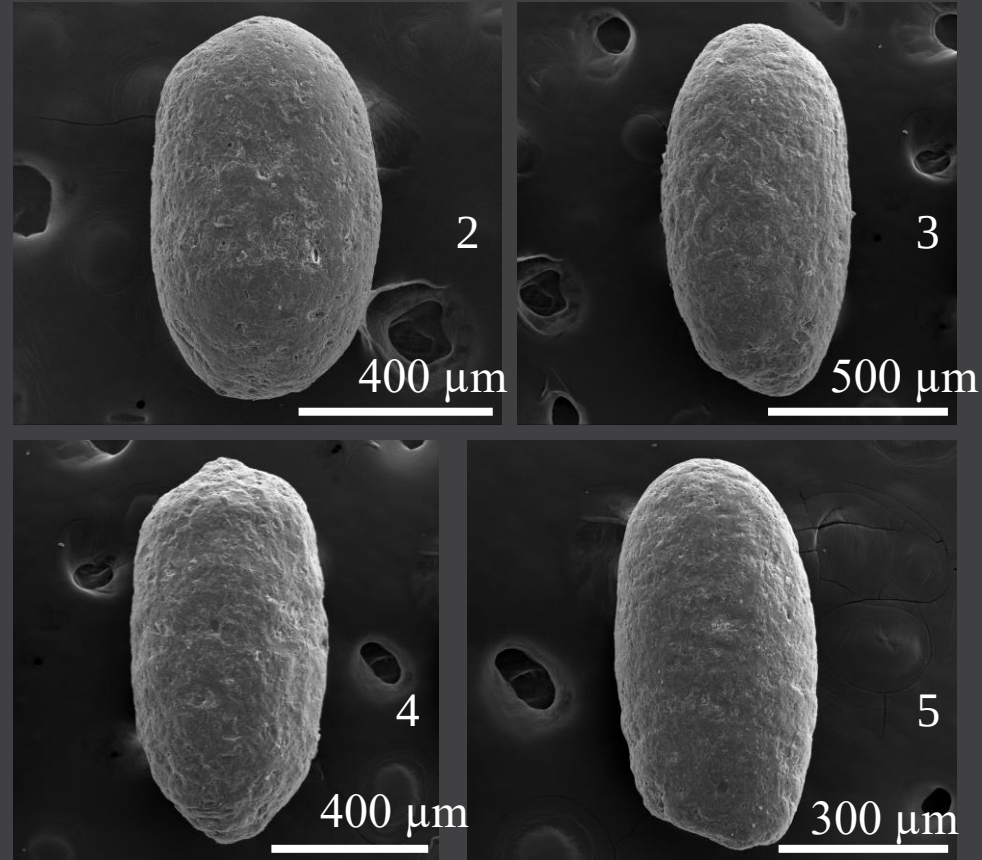
Black

Sample No:	Series 2-a	Series 2-d	Series 2-e	Series 2-f	Series 2-g	Series 2-h	Series 2-i	Average
Wt %								
SiO ₂	9,31	20,1	n.d.	6,58	n.d.	11,11	n.d.	11,8
CaO	73,01	46,98	73,01	76,78	81,92	66,39	91,01	72,7
Na ₂ O	4,65	n.d.	2,82	n.d.	n.d.	n.d.	n.d.	3,7
MgO	8,43	10,87	8,93	12,75	10,99	6,6	7,1	9,4
Al ₂ O ₃	4,59	9,4	4,14	3,89	3,98	4,61	1,89	4,6
Fe ₂ O ₃	n.d.	12,44	7,79	n.d.	n.d.	11,29	n.d.	10,5
Cl ₂ O	n.d.	n.d.	3,31	n.d.	3,11	n.d.	n.d.	3,2

Pellet Surge



A) View of the fecal pellets in reflected light. Samples from E+2, 2 cm above the K-Pg boundary, recovered from >150 mm sieve, X60 magnification

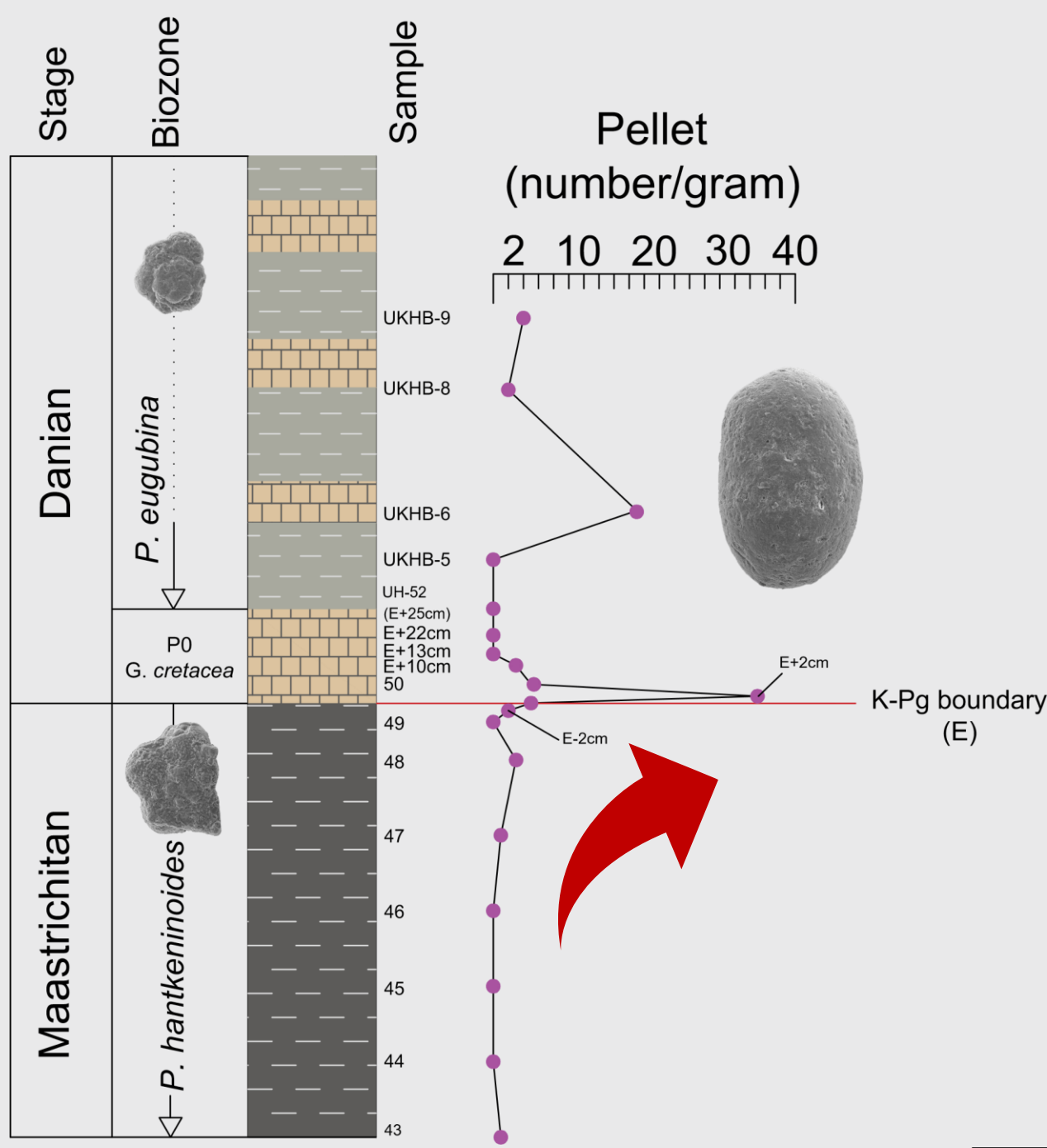


B) Scanning electron microscope (SEM) views of the fecal pellets peak at 2 cm above the K-Pg boundary

Pellet Surge

Sample No	Pellet Count per gram
UKHB-9	4
UKHB-8	2
UKHB-6	19
UKHB-5	0
E+25 UKHB-4	0
E+22	0
E+13	0
E+10	3
UH-50	5
E+2	35
K-Pg boundary	5
E-2	2
UH-49	0
UH-48	3
UH-47	1
UH-46	0
UH-45	0
UH-44	0
UH-43	1

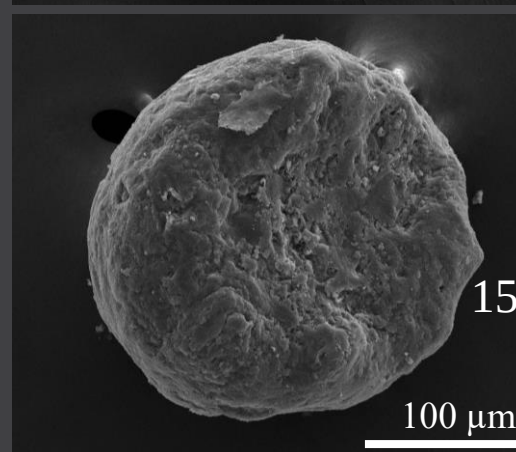
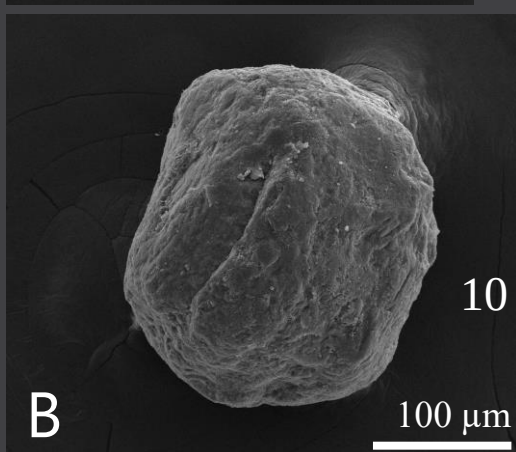
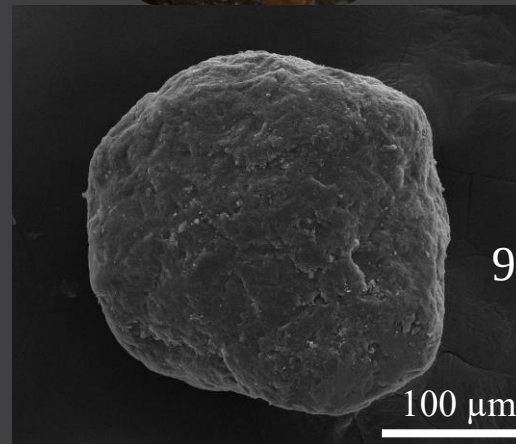
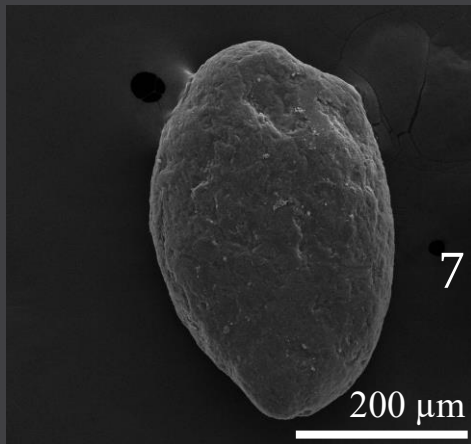
Number of fecal pellets rapidly increases right after the K-Pg boundary in the Danian P0 Zone. Notice the abrupt increase right after the K-Pg boundary. Another but much minor increase was detected in the lower Pα Zone



Amorphous Grains



Sample No:	7	9	10	15	Average
Wt %					
SiO ₂	44,65	42,91	36,35	44,92	42,2
CaO	1,87	2,13	1,92	1,92	2,0
K ₂ O	1,76	0,77	0,29	1,17	1,0
MgO	8,19	8,95	9,21	8,53	8,7
Al ₂ O ₃	15,32	16,19	14,29	17,27	15,8
Fe ₂ O ₃	28,21	29,05	37,95	26,19	30,4



A) Brown grains were found in washed residues of the 2-3 mm thick reddish layer corresponding the K-Pg boundary. Displayed grains were recovered from >150 mm sieve.
Left view x40 magnification, right view x60 magnification.

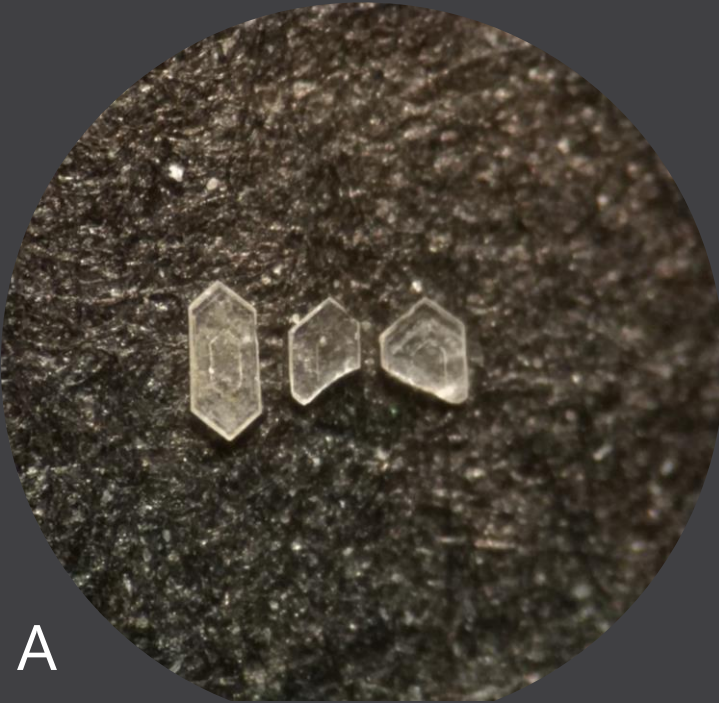
B) SEM images of the brown grains

No solid interpretation is pronounced at this stage about their genesis.

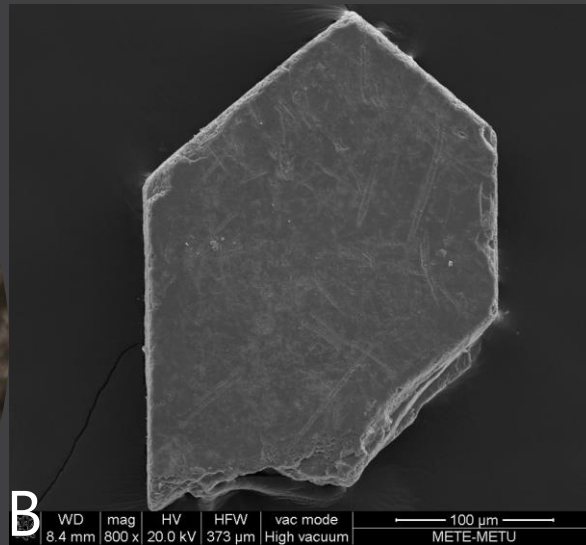
Yet, **being present only in the 2-3 mm thick layer** corresponding the K-Pg boundary may infer the impact origin.

Euhedral Grains

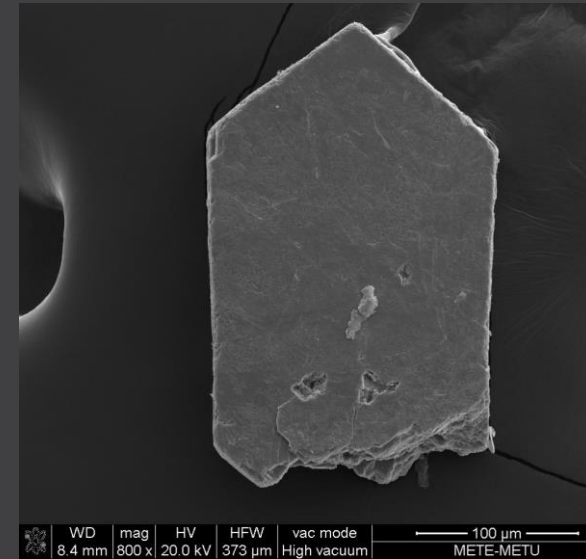
Found -2cm & at the K-Pg
boundary layer.
Not above!



A



B



Sample No:	19	20	
Wt %			Average
Ba	74,5	61,03	67,8
S	19,85	34	26,9
Sr	5,65	4,97	5,3

A) Barite crystals were found only from 2 cm below and right at the K-Pg boundary level (2e3 mm thick reddish layer). View in reflected light. Sample E-2 from >150 mm screen, x100 magnification. B) SEM images of Barite grains.

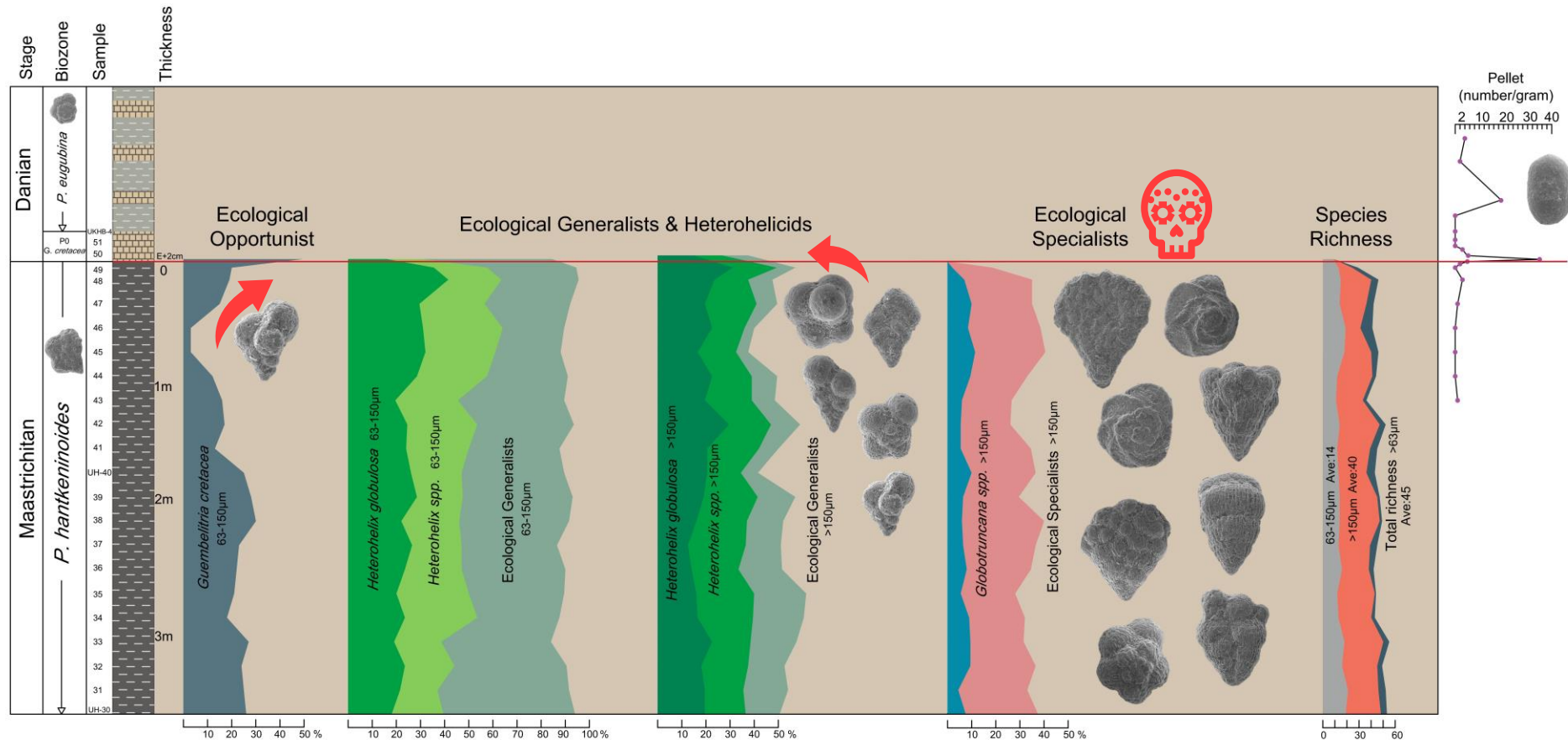
The increase in the barite grains below and at the K-Pg boundary layer may be a record of paleoproductivity enhancement across the K-Pg interval and/or increase in atmospheric sulphur oxides caused by the Chicxulub impact

63-150 μm

>150 μm

Almost complete dominance of *r-Strategists*
Heterohelix vs *Guembelitra* domination

- *r-Strategists* (Generalists) > *K-Strategists* (Specialists)
- *Heterohelix* domination
- More species richness (Average 40 species)

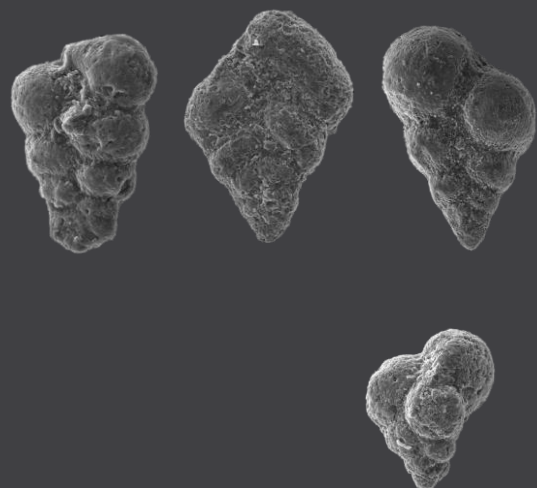




Events *before* the K-Pg boundary



Interpretation:



Dominance of *Heterohelix* species

Guembelitra blooms



Decreasing species richness

- Expanded Oxygen Minimum Zone (OMZ)
- High terrigenous influx directing augmented nutrient levels/ *eutrophication*. This might have caused by Deccan-induced climate change and enhanced weathering.

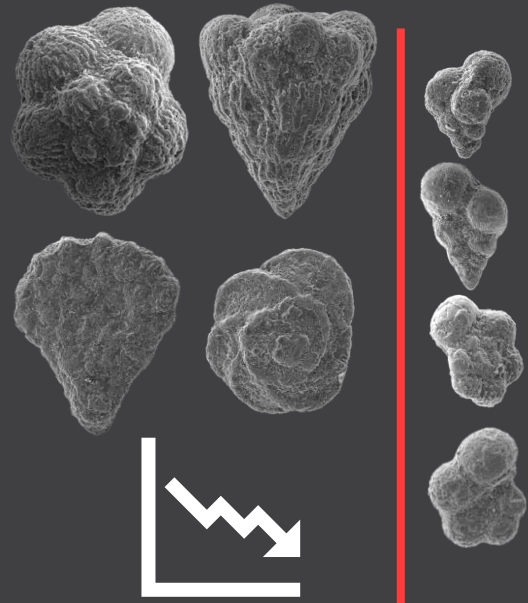


- Environmental stress

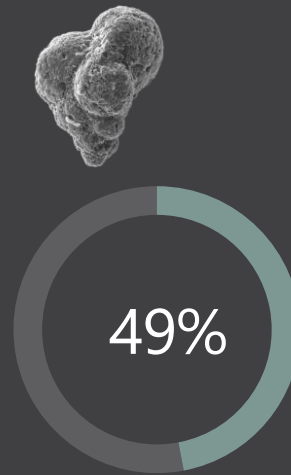
Deccan Volcanism



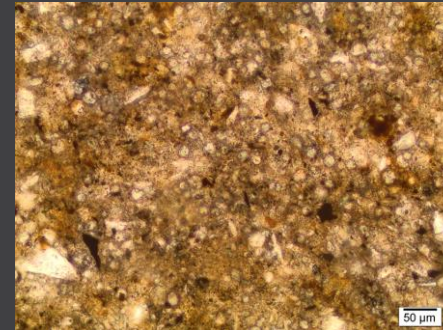
Events **at** & **after** the K-Pg boundary



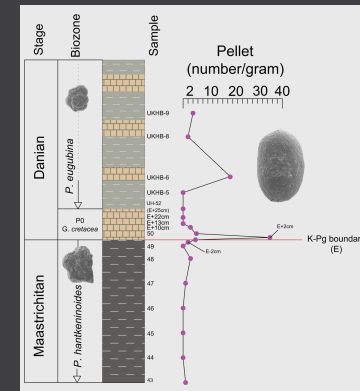
68% of planktonic foraminifera underwent extinction at the K-Pg boundary



Guembelitra cretacea bloom after the KPB



Thoracosphaera acme



Abrupt increase in echinoid pellets

Environmental crisis after the KPB

Thank you...

