

Paleontologia 2020 (Aula 6):

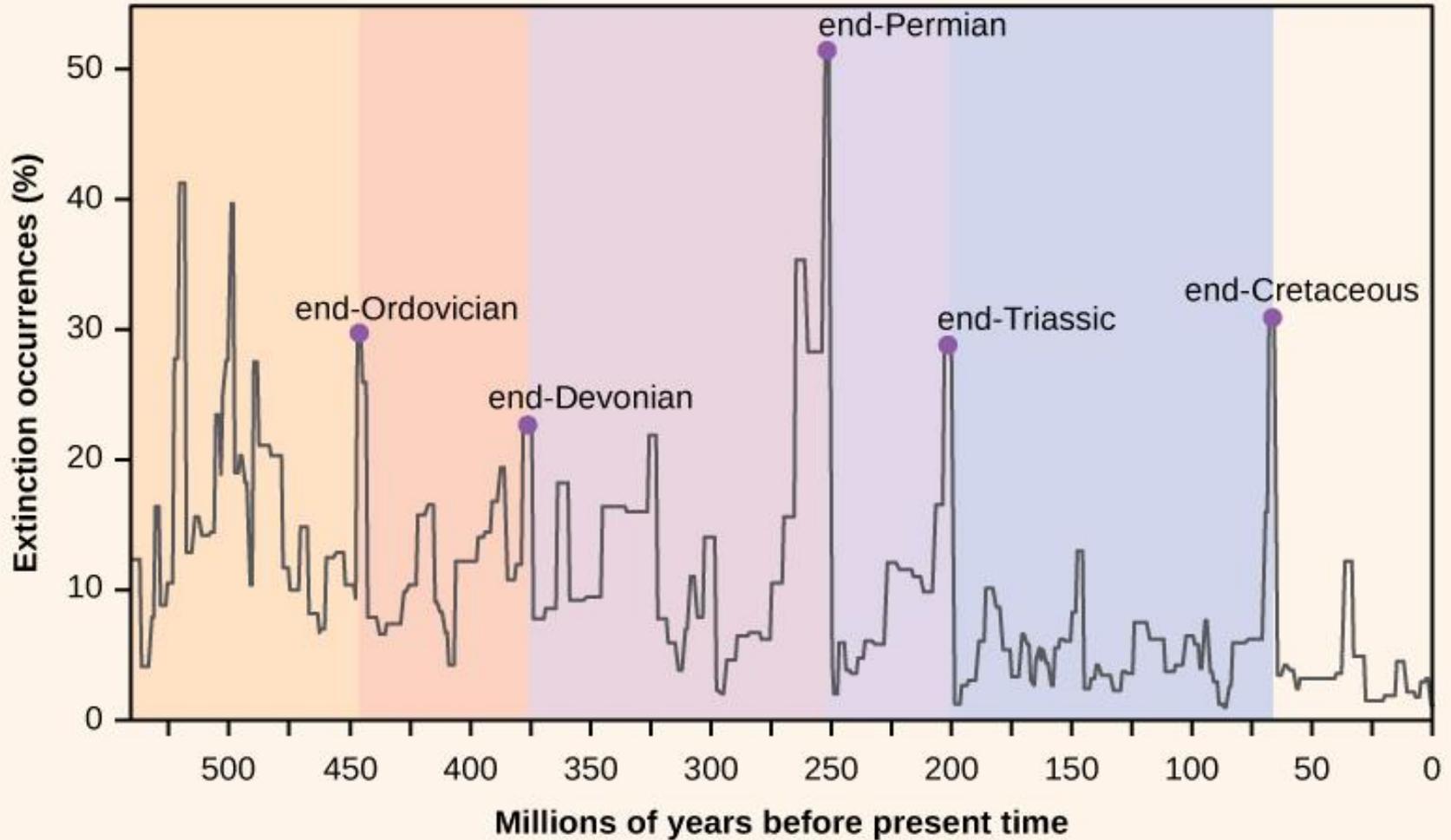
Extinções



Extinções e Registro fóssil

Os padrões de diversidade mudam ao longo do tempo

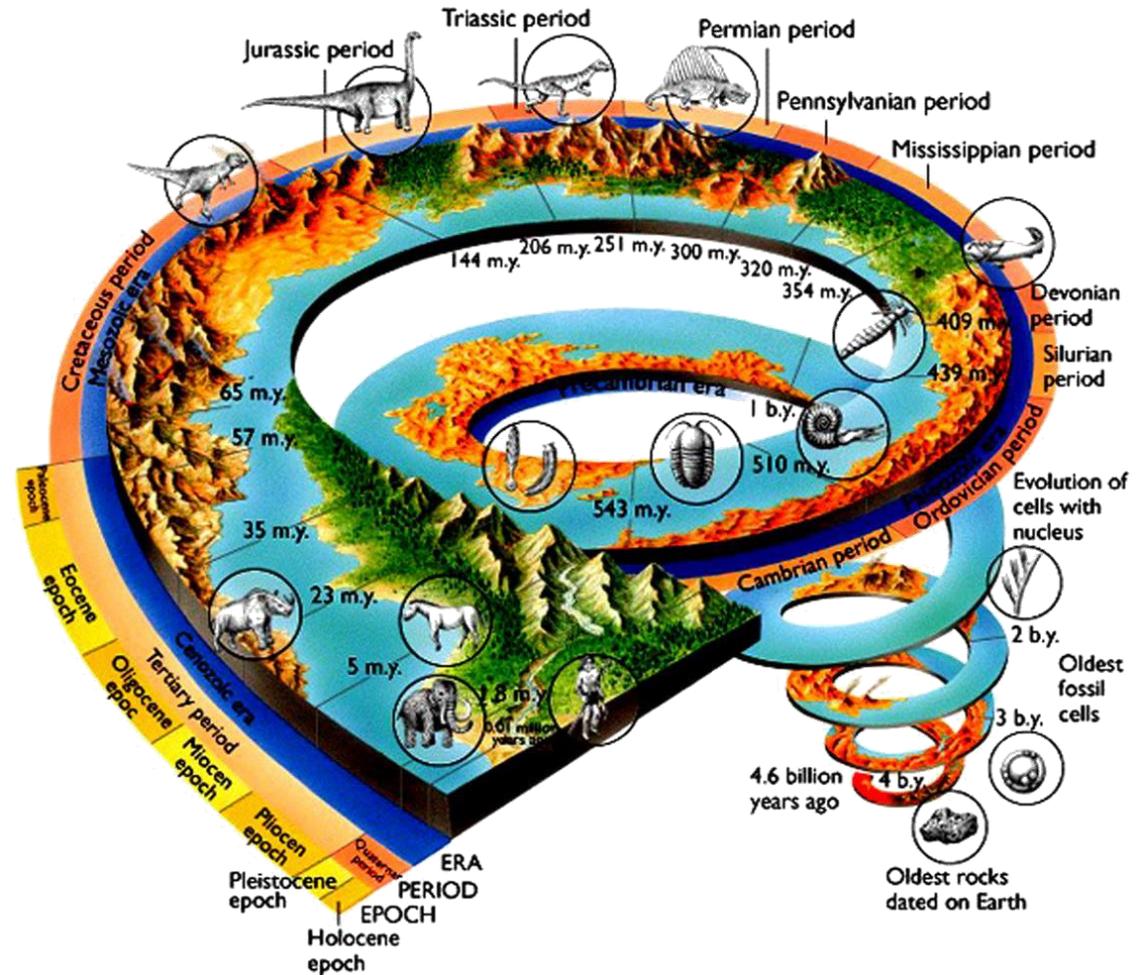
Desaparecimento de formas é um processo recorrente na evolução das espécies



Extinções e Registro fóssil

Os padrões de diversidade mudam ao longo do tempo

Desaparecimento de formas é um processo recorrente na evolução das espécies



Extinções e Registro fóssil

Terminologia / Extinção “de fundo”

Tempo

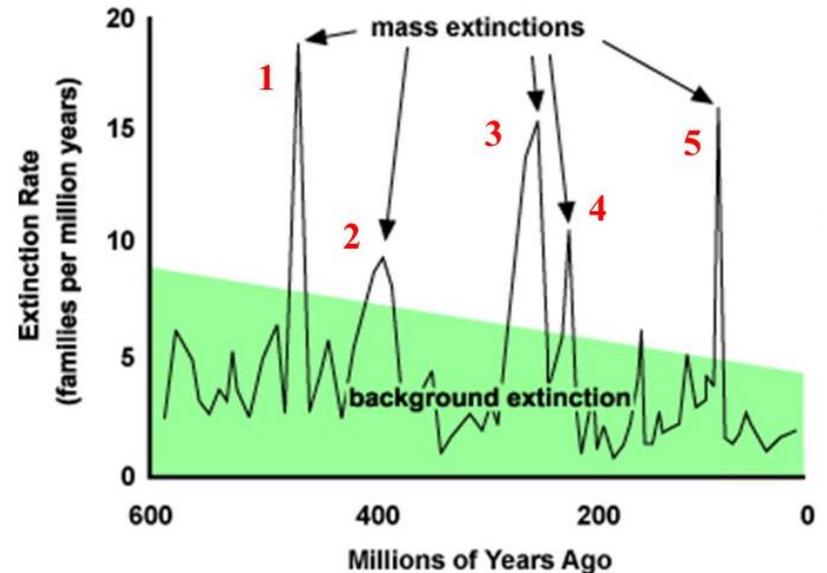
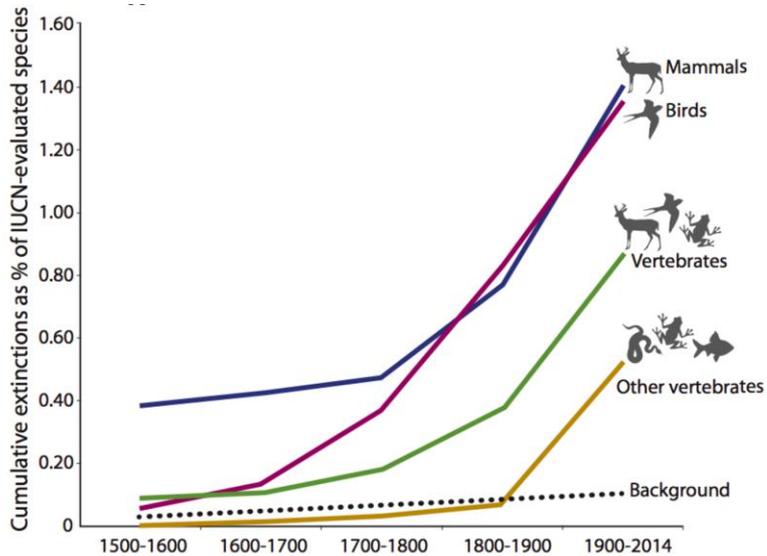
Lenta ou
Instantânea

Modo

Seletiva ou
Não-Seletiva

Intensidade

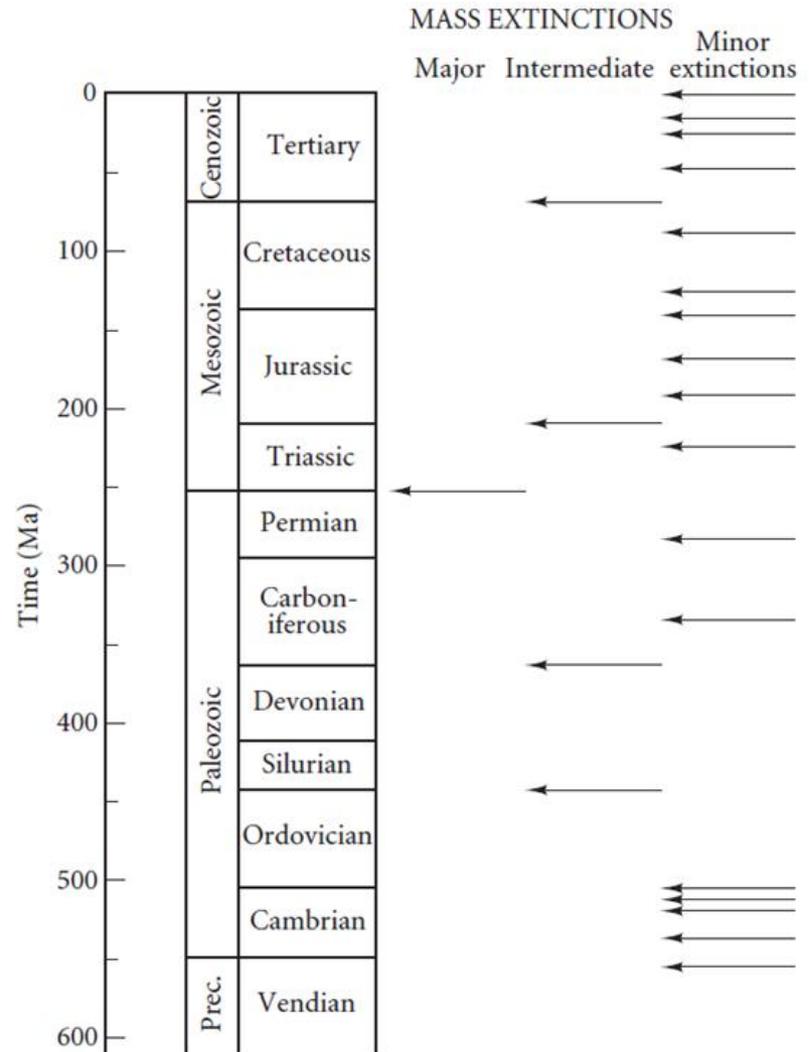
De fundo ou
Em Massa



Extinções e Registro fóssil

Grandes Extinções “em massa”

- 1 Many species became extinct, perhaps more than 30% of plants and animals of the time.
- 2 The extinct organisms spanned a broad range of ecologies, and typically include marine and non-marine forms, plants and animals, microscopic and large forms.
- 3 The extinctions were worldwide, covering most continents and ocean basins.
- 4 The extinctions all happened within a relatively short time, and hence relate to a single cause, or cluster of interlinked causes.
- 5 The level of extinction stands out as considerably higher than the background extinction level.

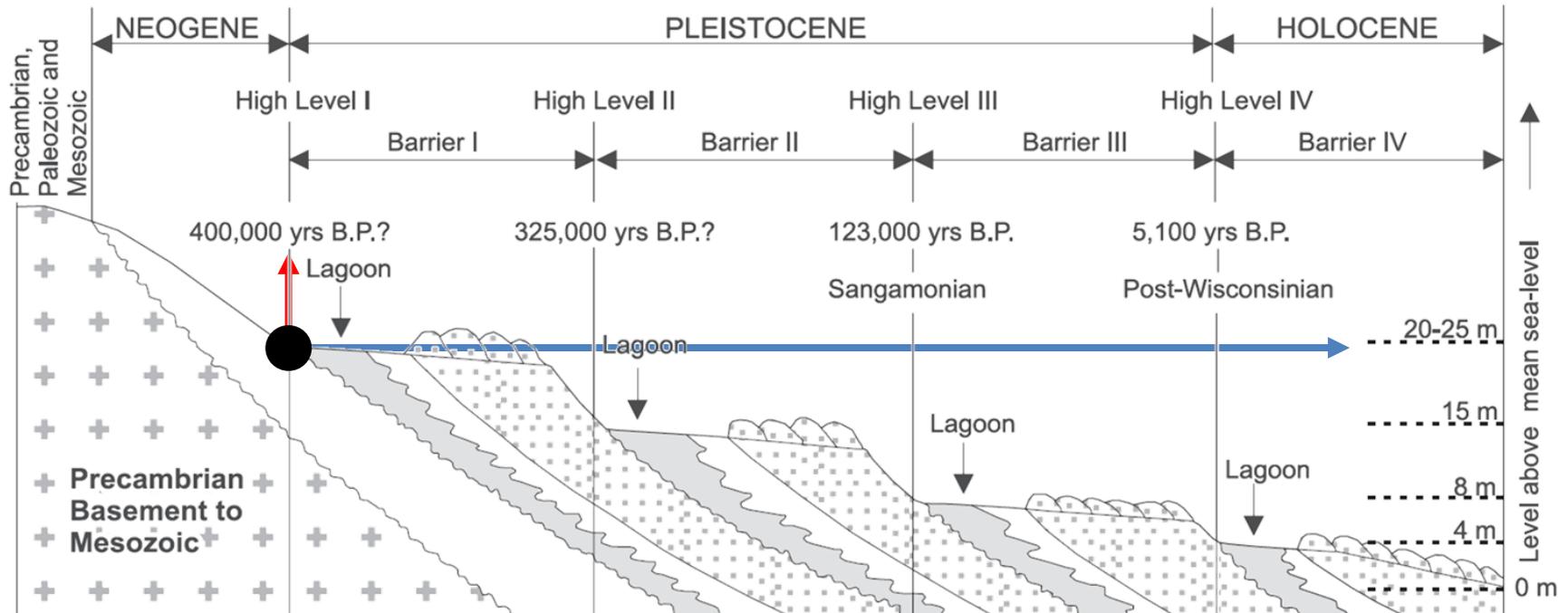


Extinções e Registro fóssil

Grandes Extinções – Causas: **Regressão/Transgressão Marinha**

- Soerguimento/subsidência dos continentes
- Variação da temperatura (níveis de CO₂)

Planície costeira do Rio Grande do Sul

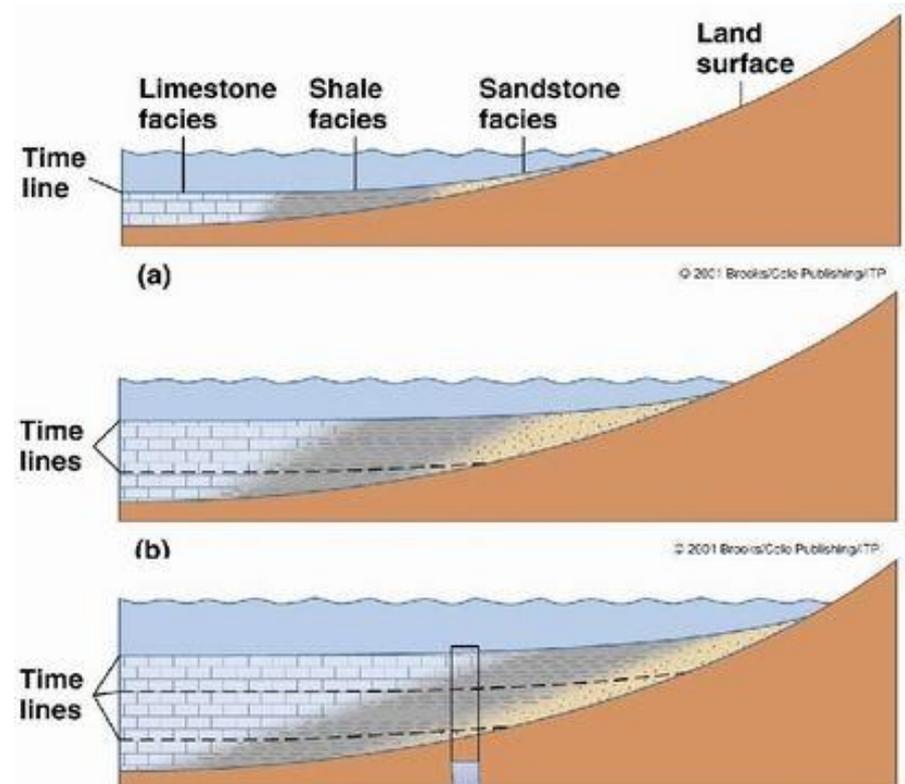


Extinções e Registro fóssil

Grandes Extinções – Causas: **Regressão/Transgressão Marinha**

Possíveis conseqüências que afetariam as biotas

- Envenenamento por elementos-traço (R/T)
- Acúmulo e oxidação de matéria orgânica (R)
- Redução e fragmentação de áreas de ocorrência (R/T)
- Aumento da continentalidade (R)
- Anoxia (R/T)
- Perda de biofácies (R/T)



Extinções e Registro fóssil

Grandes Extinções – Causas: **Vulcanismo**

- Extermínio direto
- Redução de hábitat
- Resfriamento global (inicial)
- Efeito estufa (desdobramento)
- Chuva ácida (diminui pH oceânico)

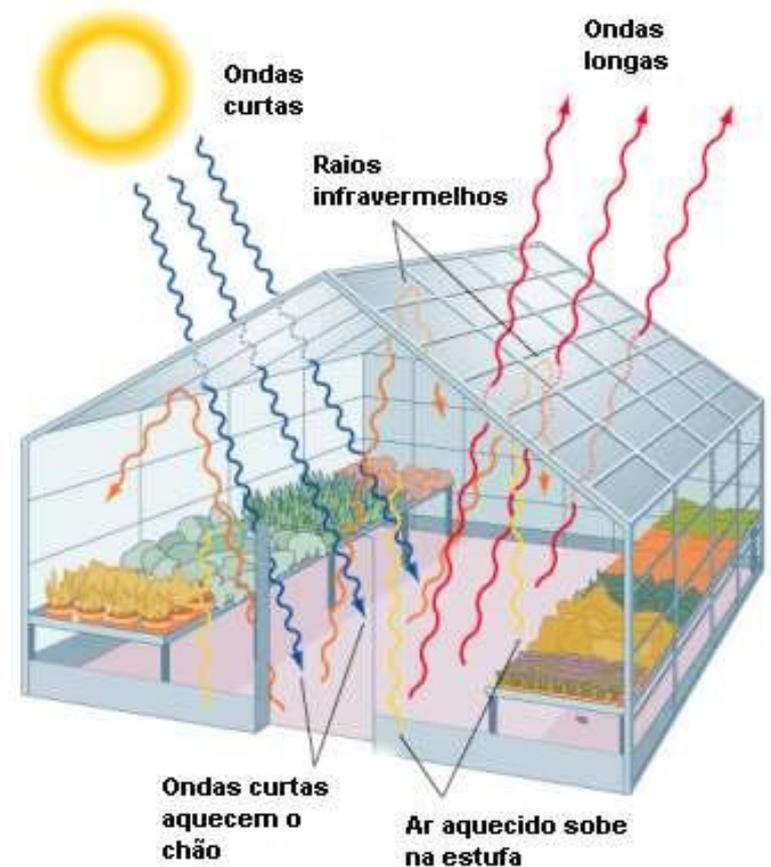


Extinções e Registro fóssil

Grandes Extinções – Causas: **Mudanças Climáticas Globais**

Causas da variação de temperatura

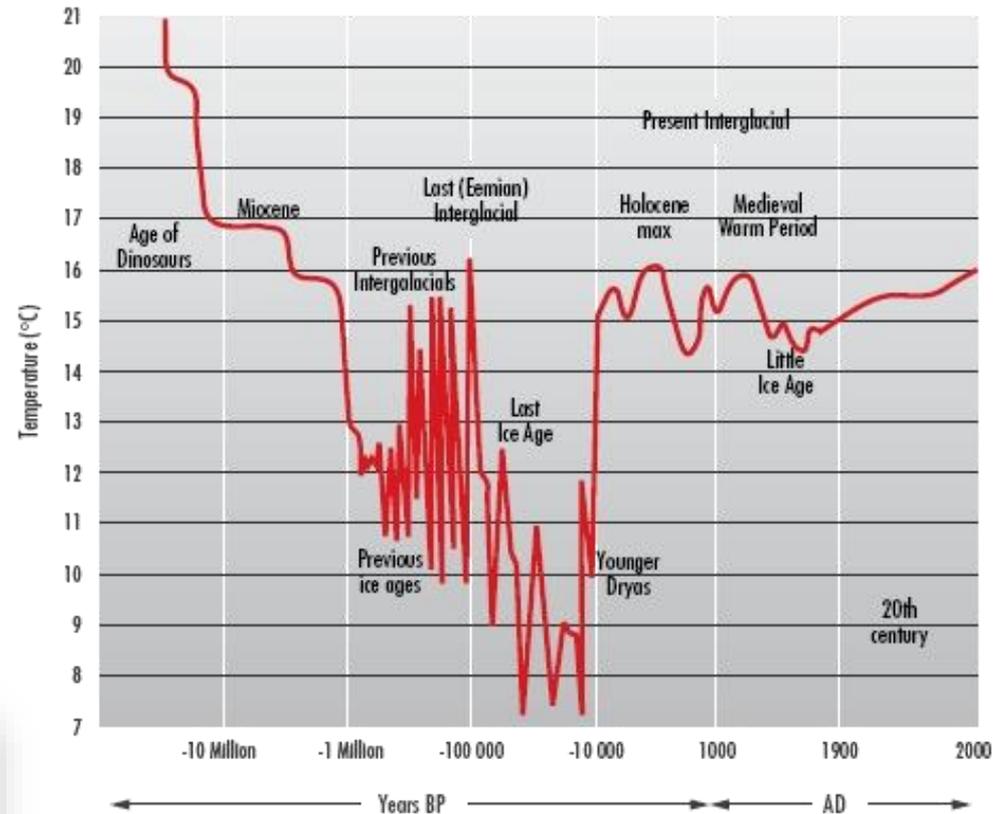
Efeito estufa causado por concentração de gases e aerossóis atmosféricos



Extinções e Registro fóssil

Grandes Extinções – Causas: Mudanças Climáticas Globais

- Alteração da produtividade primária
- Impacto nas cadeia tróficas
- Seleção sobre as adaptações fisiológicas
- Alteração da concentração oceânica de oxigênio



Extinções e Registro fóssil

Grandes Extinções – Causas: **Impactos de corpos extra-terrenos**

- Extermínio direto
- Resfriamento global (inicial)
- Efeito estufa (desdobramento)
- Chuva ácida (diminui pH oceânico)
- Incêndios globais
- Tsunamis



Extinções e Registro fóssil

As grandes extinções – Regimes de seleção



Extinções e Registro fóssil

As grandes extinções – “Big five”

Identificação de cinco picos de extinção

Outros eventos menores

Ordem de intensidade
(% de famílias marinhas extintas)

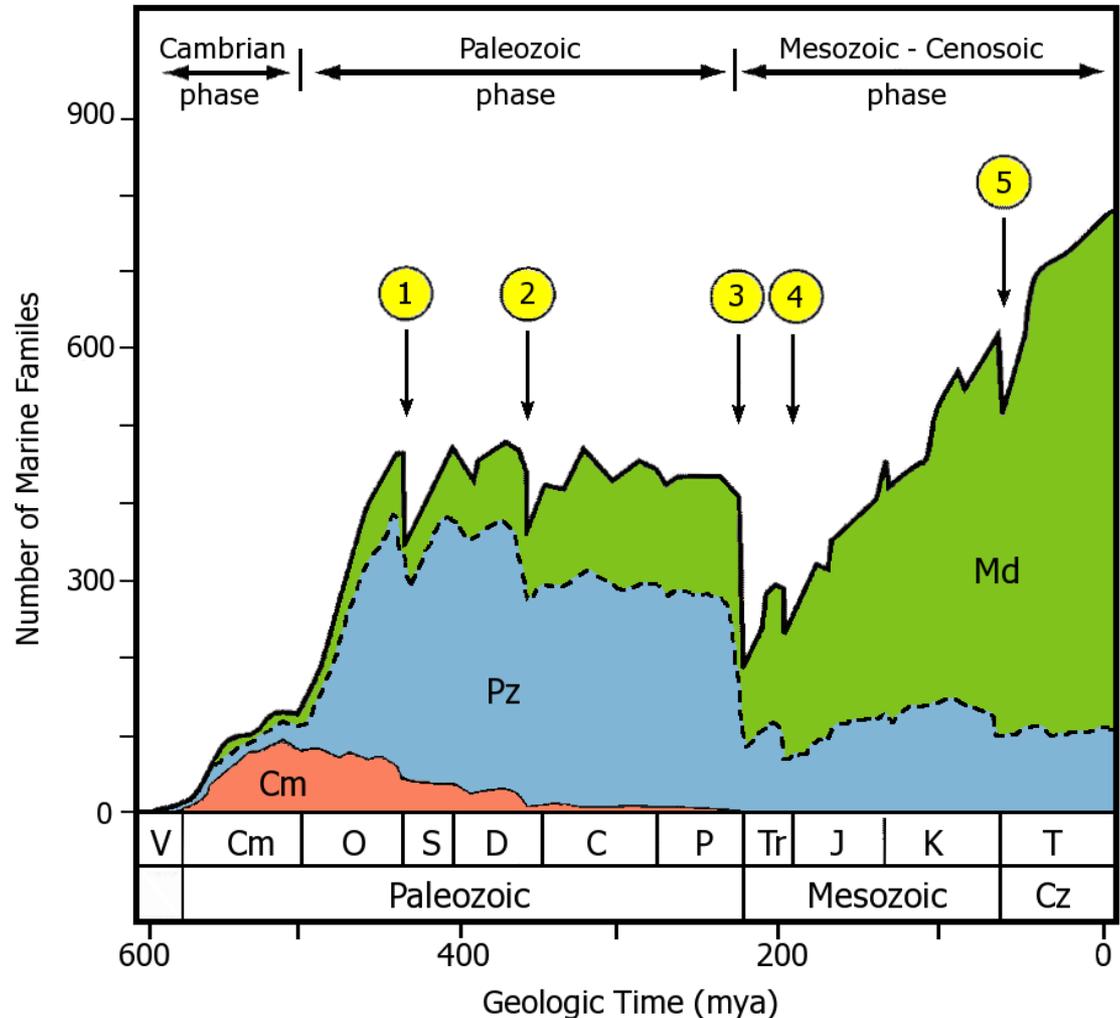
Permo-Triássico (50%)

Fim do Ordoviciano (22%)

Fim do Devoniano (21%)

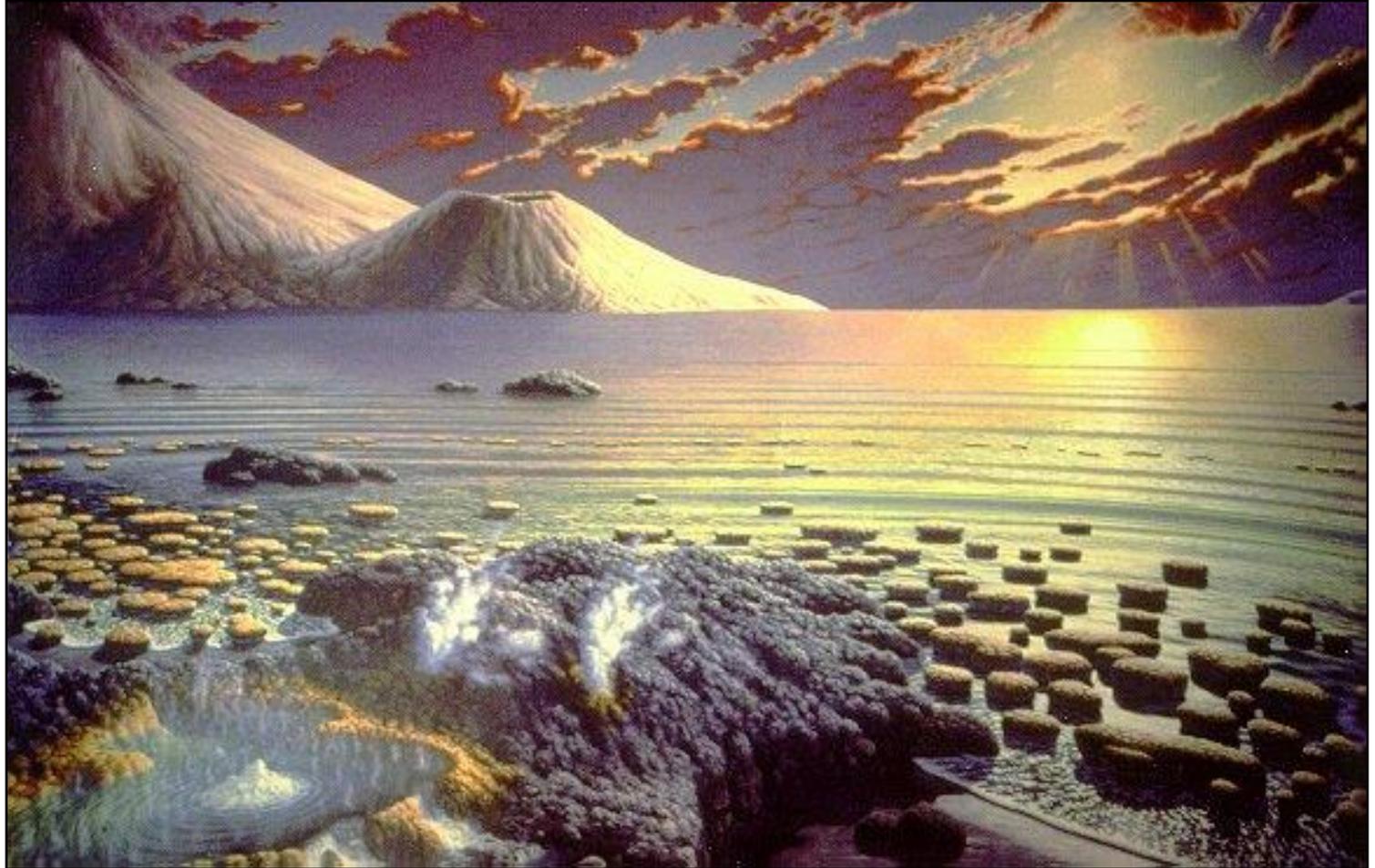
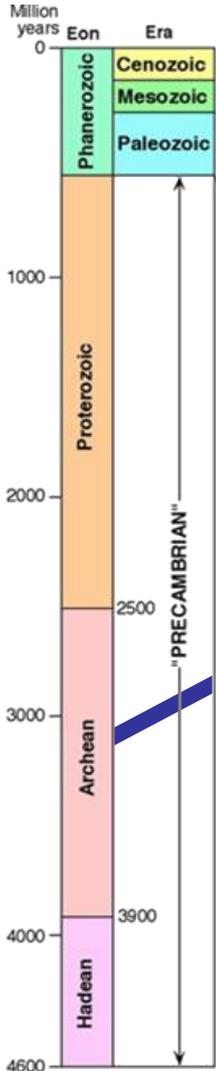
Fim do Triássico (20%)

Cretáceo-Terciário (15%)



Antes das “Big five” (“Big-Seven”)

O surgimento e irradiação da vida fotossintetizante

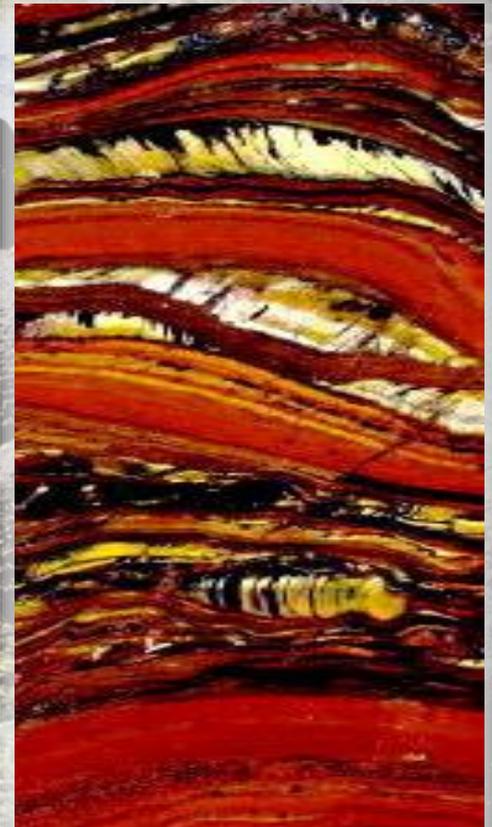


Impressão artística do Arqueno (atmosfera sem oxigênio)

Antes das “Big five” (“Big-Seven”)

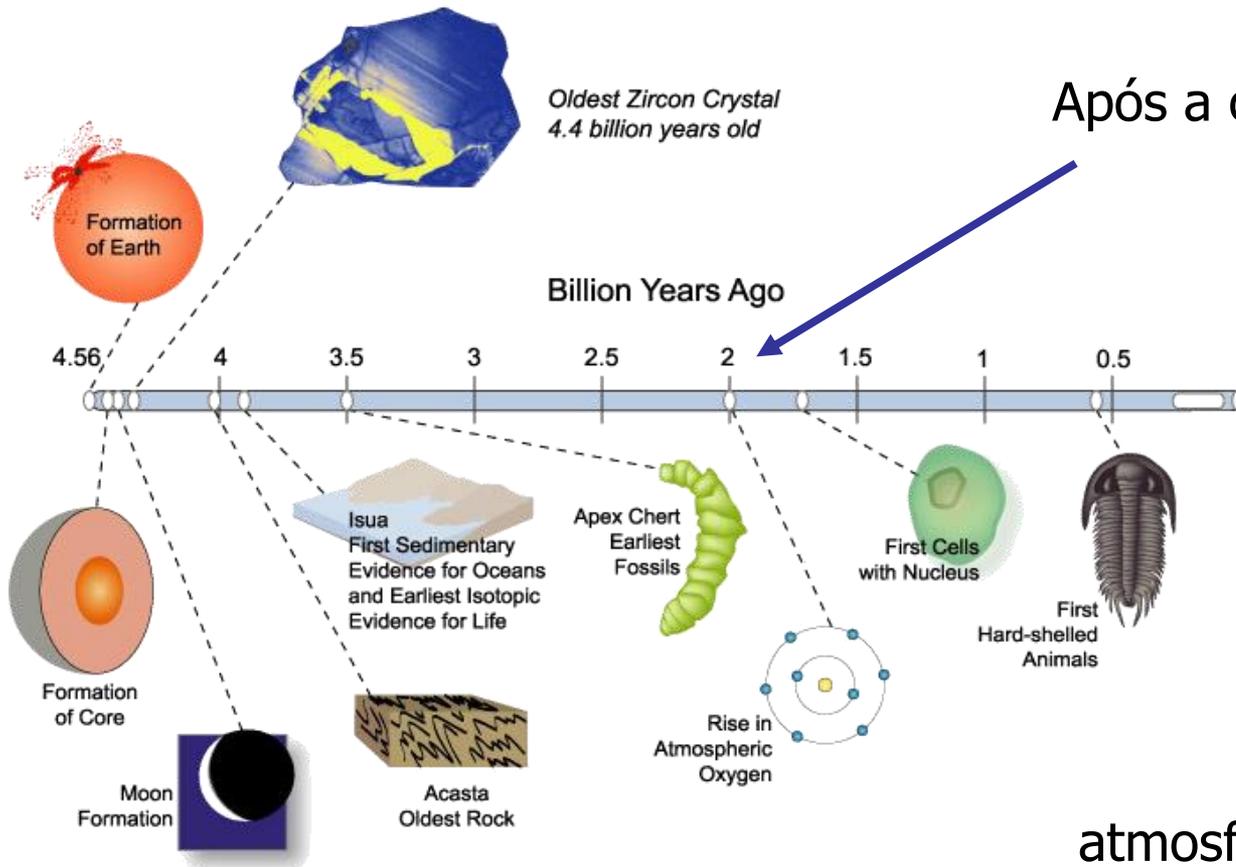
O surgimento e irradiação da vida fotossintetizante

Shark Bay, Austrália



Antes das “Big five” (“Big-Seven”)

O surgimento e irradiação da vida fotossintetizante

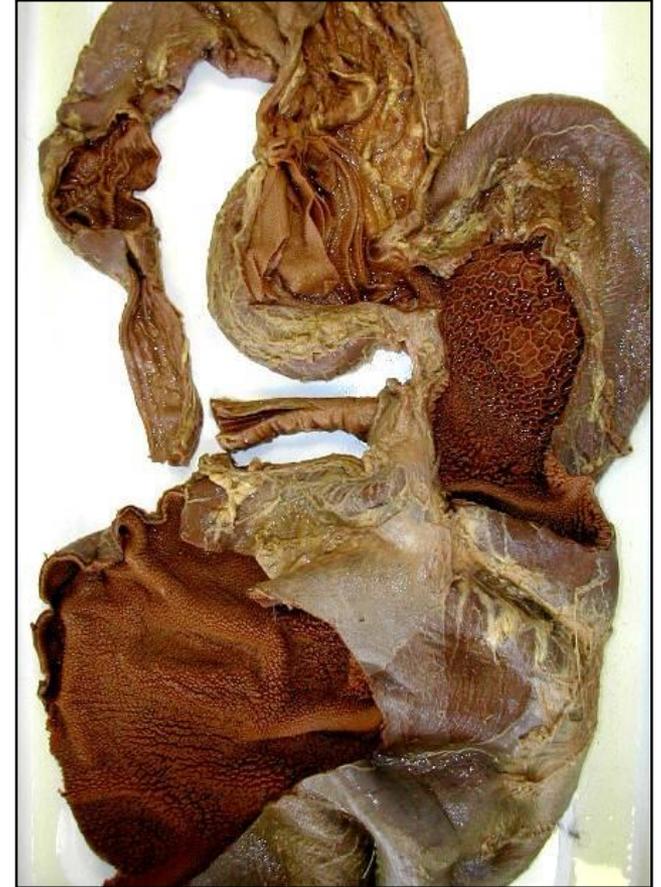


Após a origem destes depósitos,
O₂ se acumula na
atmosfera e oceanos

níveis de O₂ na
atmosfera do Arqueano = 1%
níveis de O₂ na
atmosfera do Proterozoico = 15%

Antes das “Big five” (“Big-Seven”)

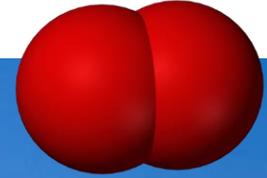
O surgimento e irradiação da vida fotossintetizante



Com o aumento do O_2 muitas formas se extinguíram ou restringiram-se a ambientes periféricos (anaeróbicos)

Antes das “Big five” (“Big-Seven”)

O surgimento e irradiação da vida fotossintetizante



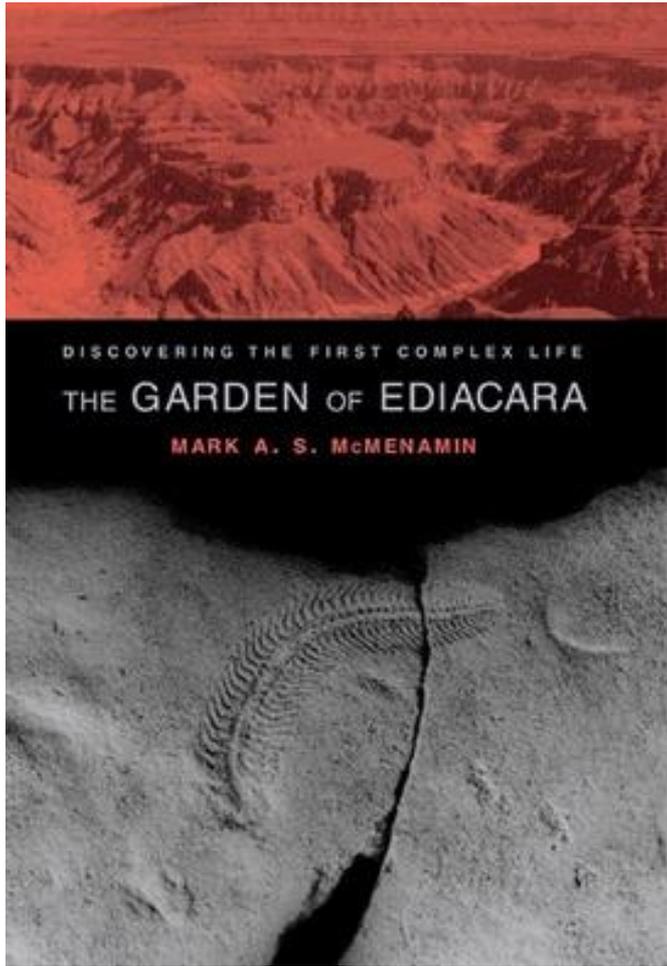
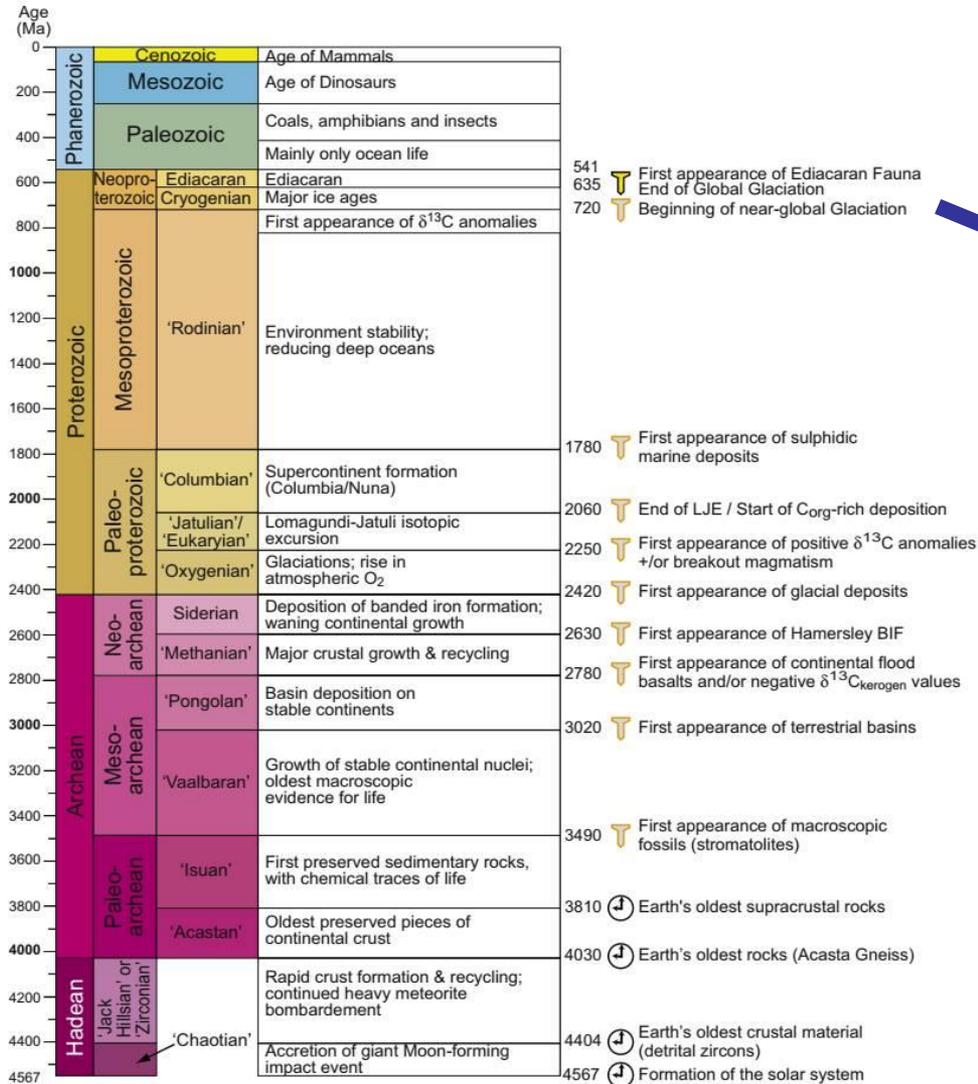
O₂



Ao passo que outras passaram a usá-lo em seu metabolismo (respiração)

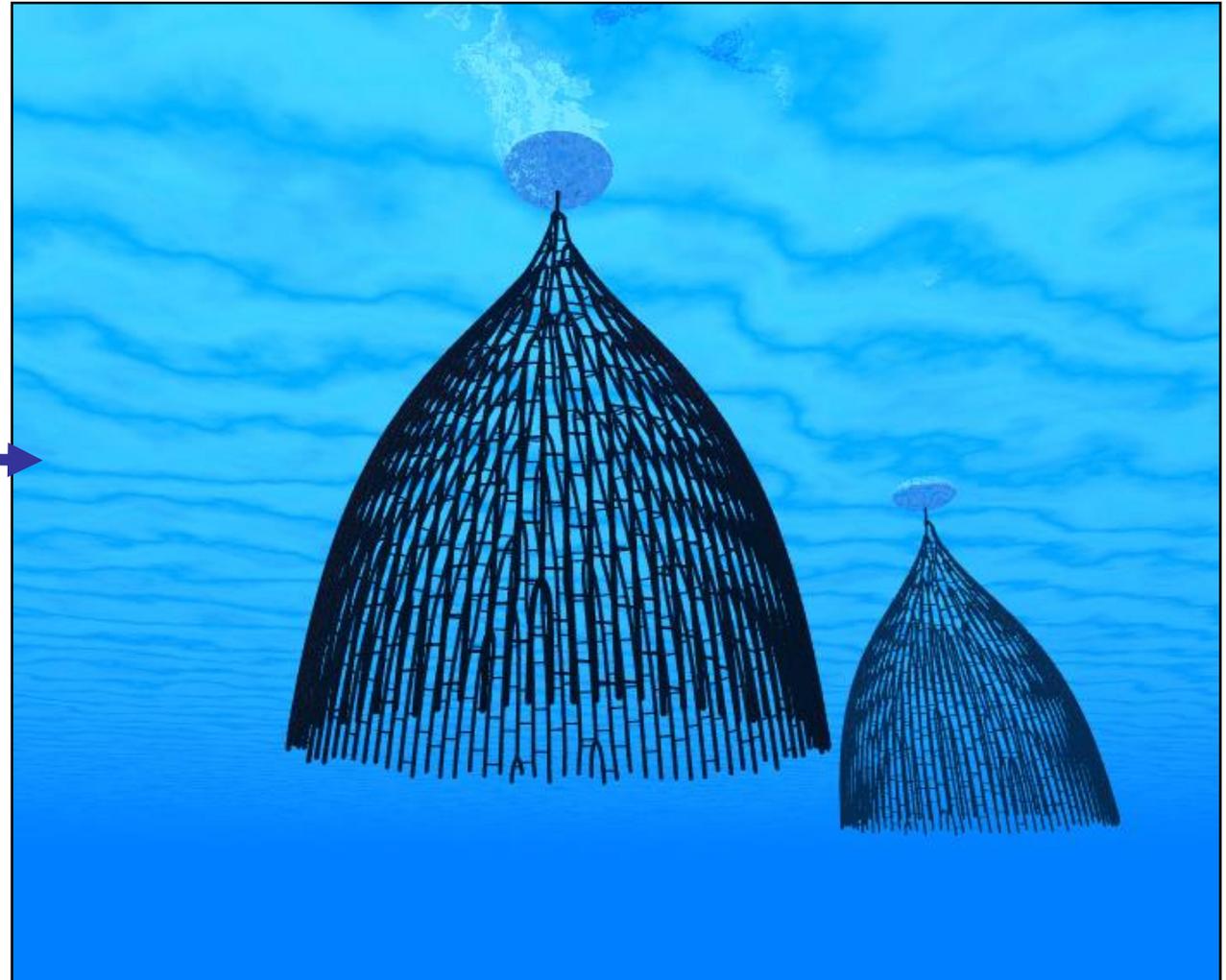
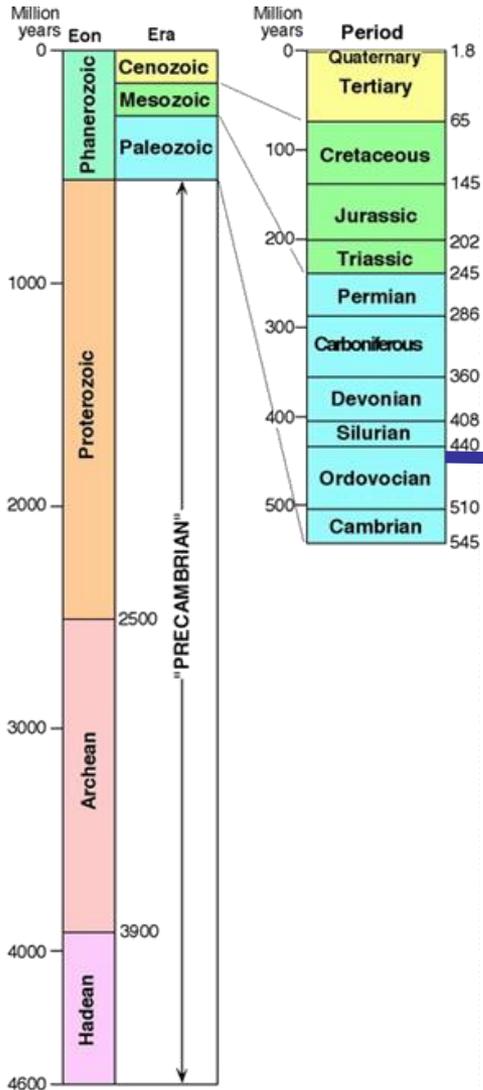
Antes das “Big five” (“Big-Seven”)

A queda do “Jardim de Ediacara”



Extinção do Ordoviciano

A primeira grande extinção do Paleozóico



Impressão artística do Ordoviciano (graptozoário)

Extinção do Ordoviciano

Grupos mais afetados

Conodontes (80%) →

Graptólitos (70%)

Equinodermas crinóides (45%)

Ostrácodos (30%)

Corais (2%)

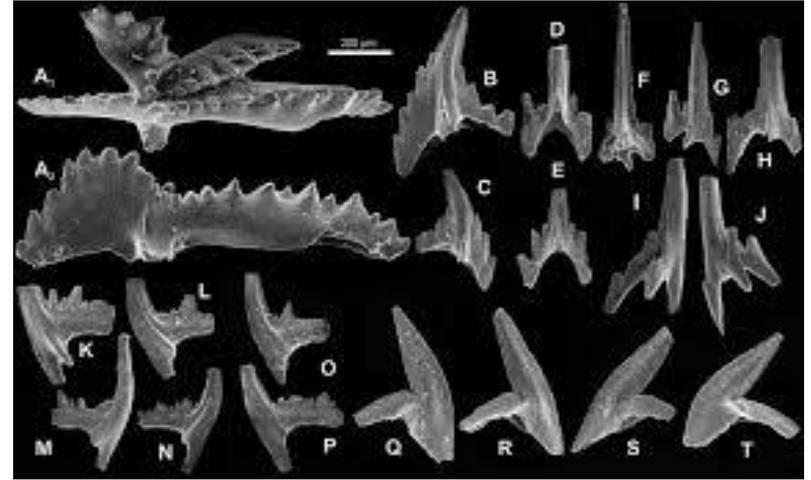
Brachiopoda (20%)

Bryozoa (13%)

Moluscos cefalópodes (12%)

22% das famílias

49% dos gêneros



Extinção do Ordoviciano

Grupos mais afetados

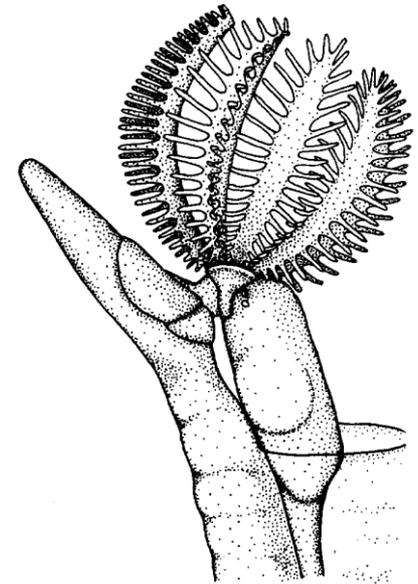
Conodontes (80%)

Graptólitos (70%) →

Equinodermas crinóides (45%)

Ostrácodos (30%)

Corais (2%)



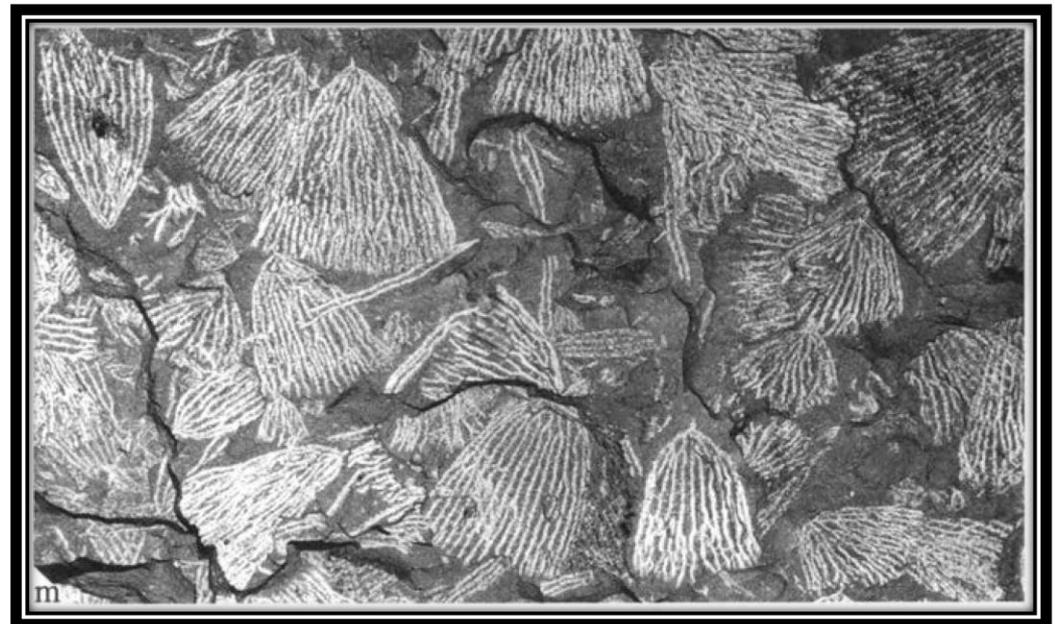
Brachiopoda (20%)

Bryozoa (13%)

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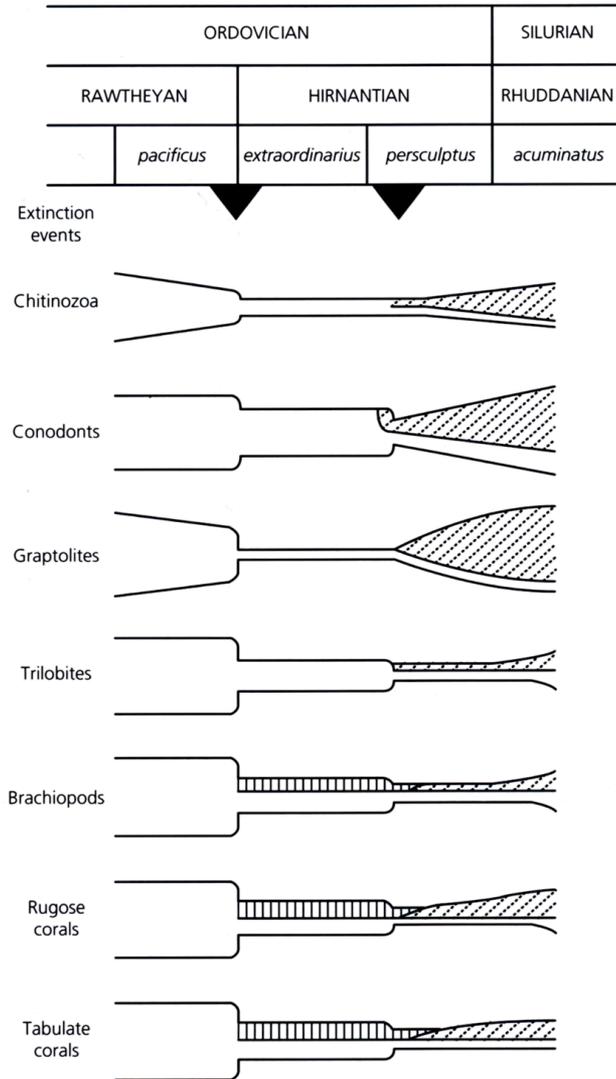
22% das famílias

49% dos gêneros

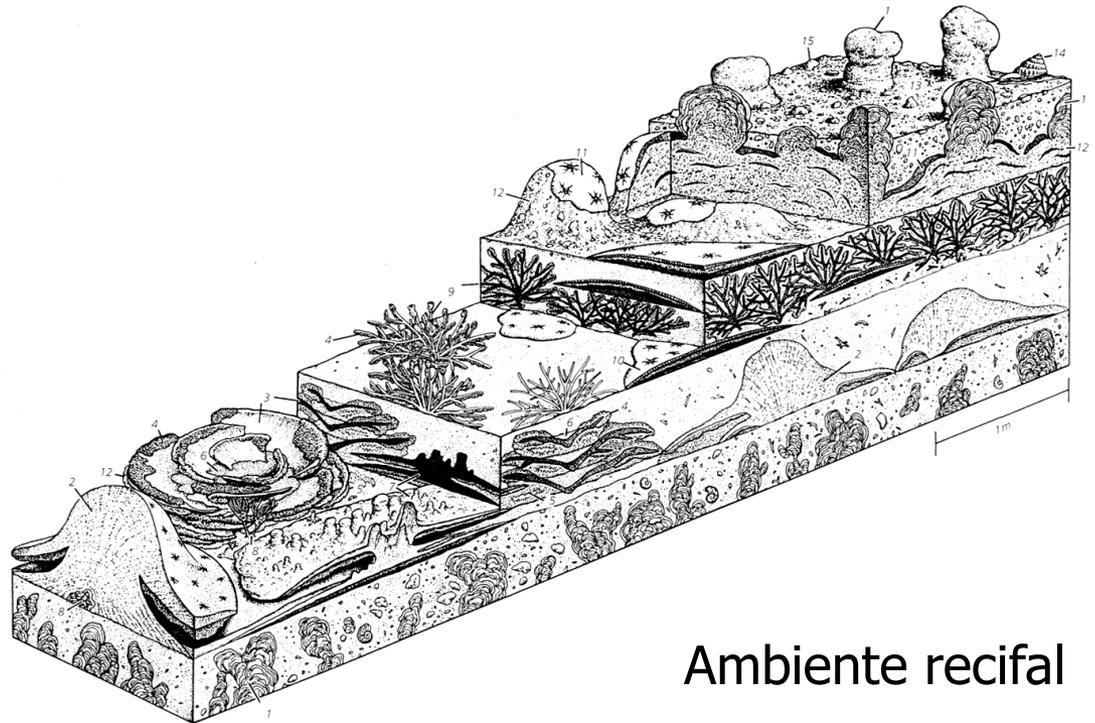


Extinção do Ordoviciano

A primeira grande extinção do Paleozóico



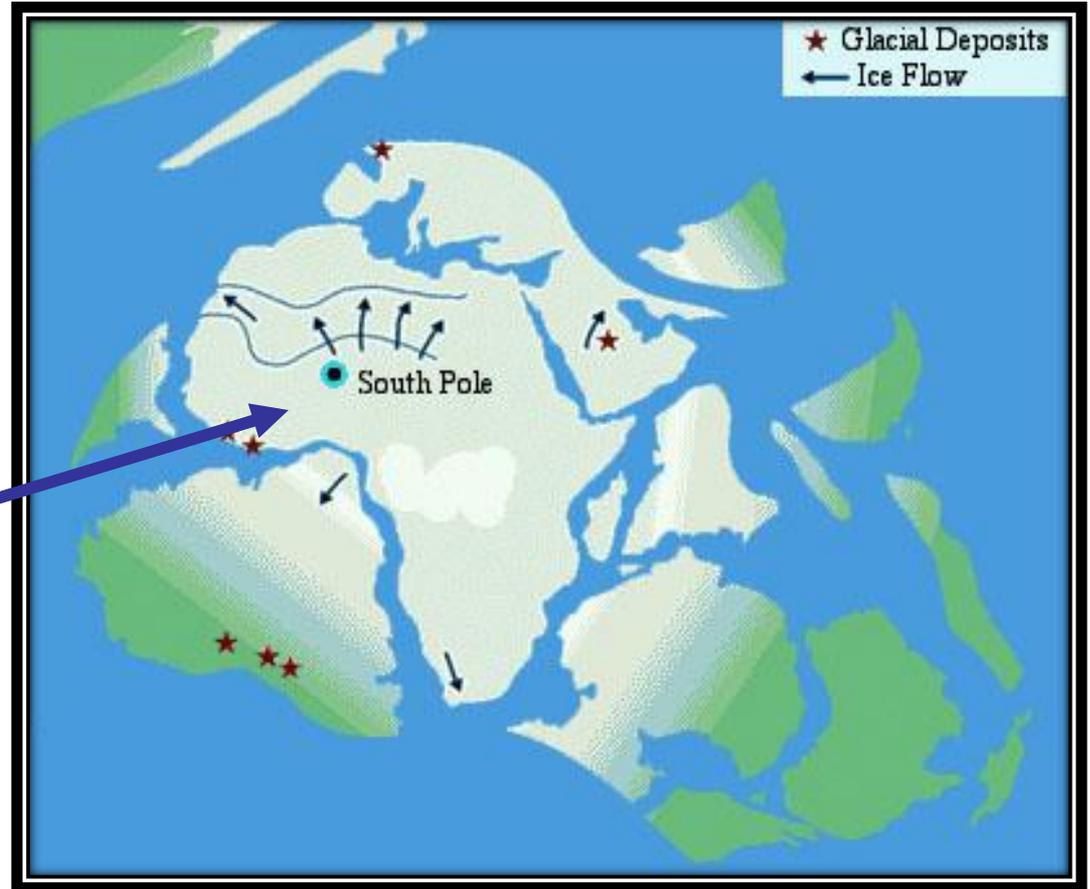
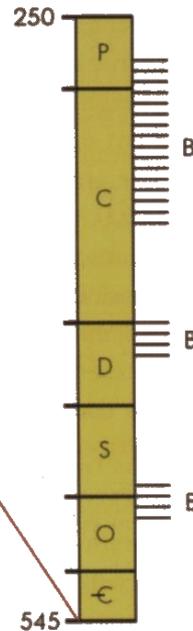
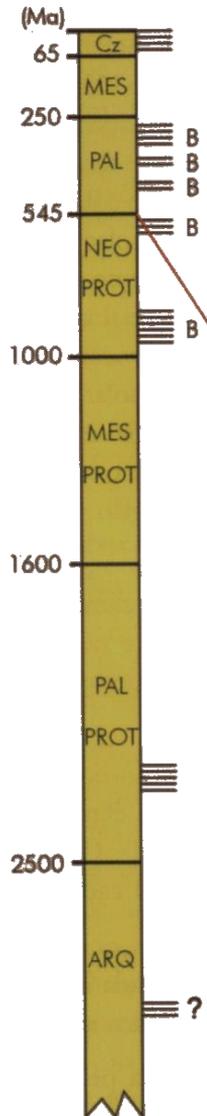
Dois momentos de extinção
Nenhum grande grupo totalmente extinto
Que se saiba!



Ambiente recifal

Extinção do Ordoviciano

A primeira grande extinção do Paleozóico

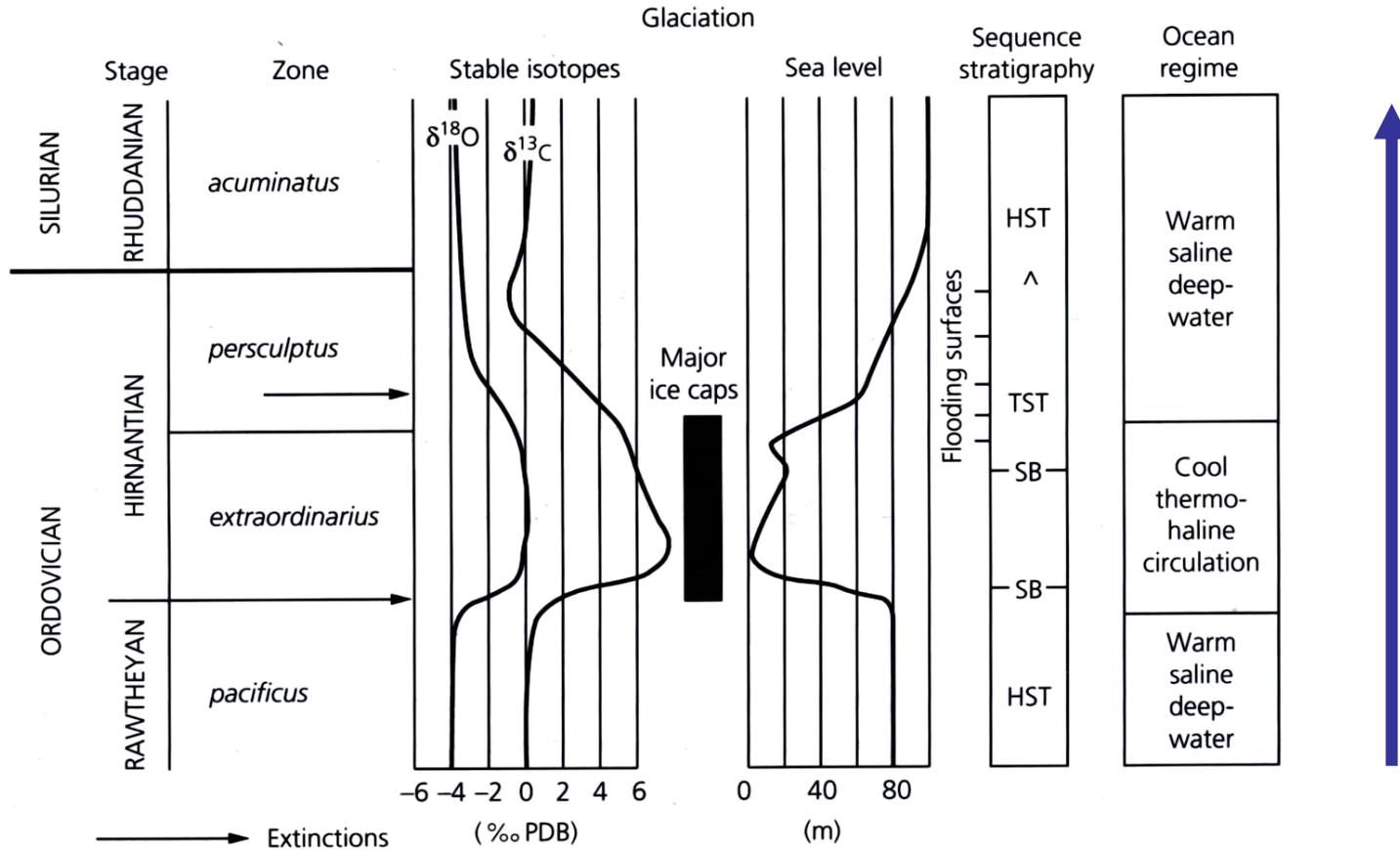


“Duas fases”
Início e fim da
glaciação

Extinção do Ordoviciano

A primeira grande extinção do Paleozóico

Aumento da temperatura e do nível do mar



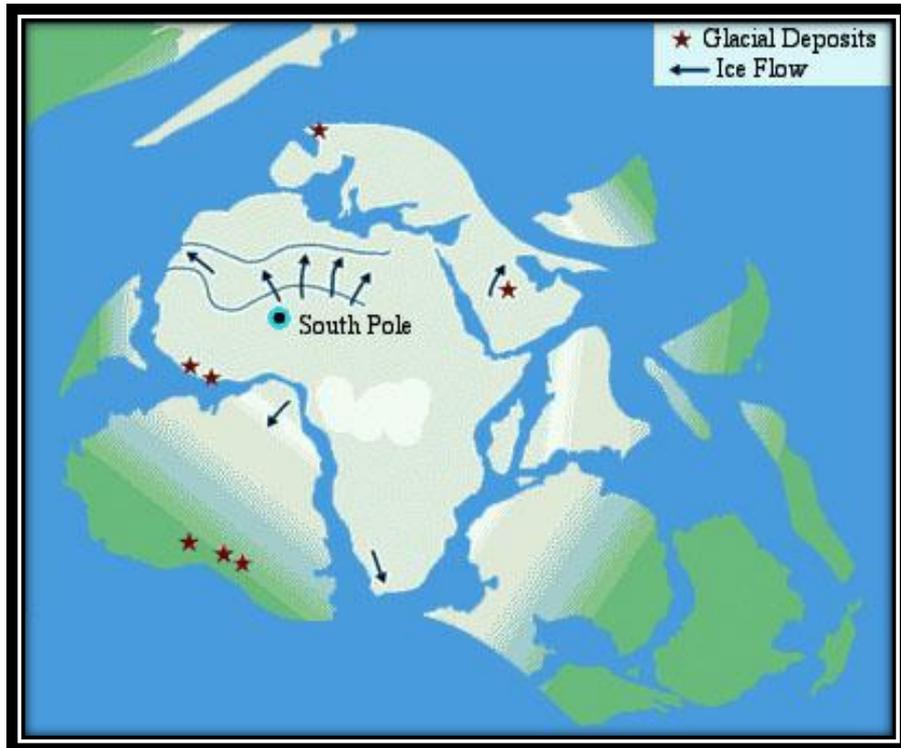
Queda da temperatura e do nível do mar

Extinção do Ordoviciano

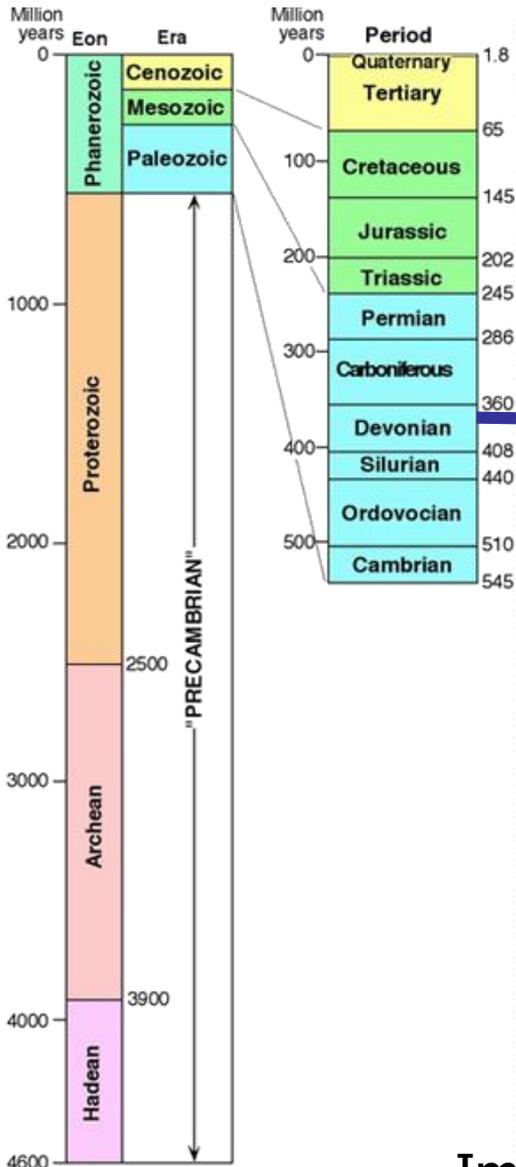
Dois pulsos de extinção

I – **Glaciação**: regressão marinha, aumento da circulação oceânica (corrente termo-hialina), aeração do fundo oceânico e material tóxico para a superfície

II – **Deglaciação**: transgressão marinha, diminuição de circulação oceânica, inundação de áreas costeiras e anoxia

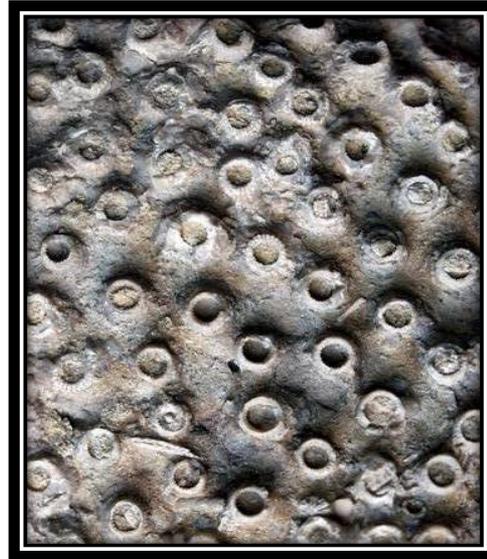


Extinção do Devoniano



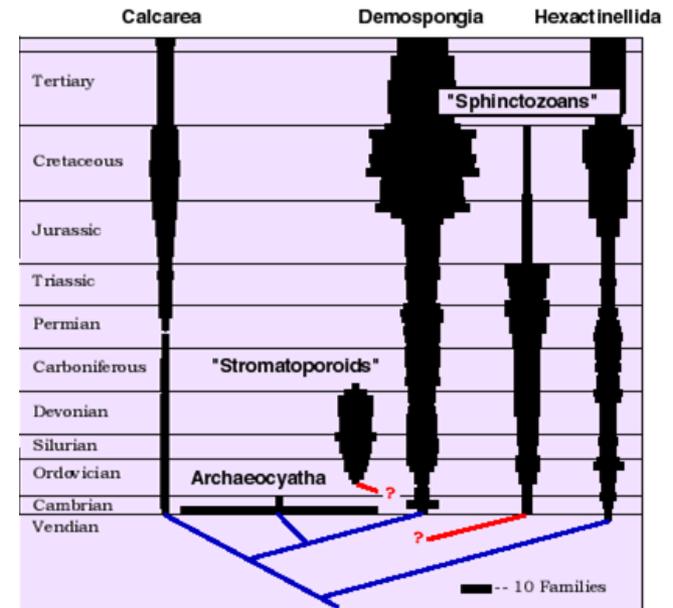
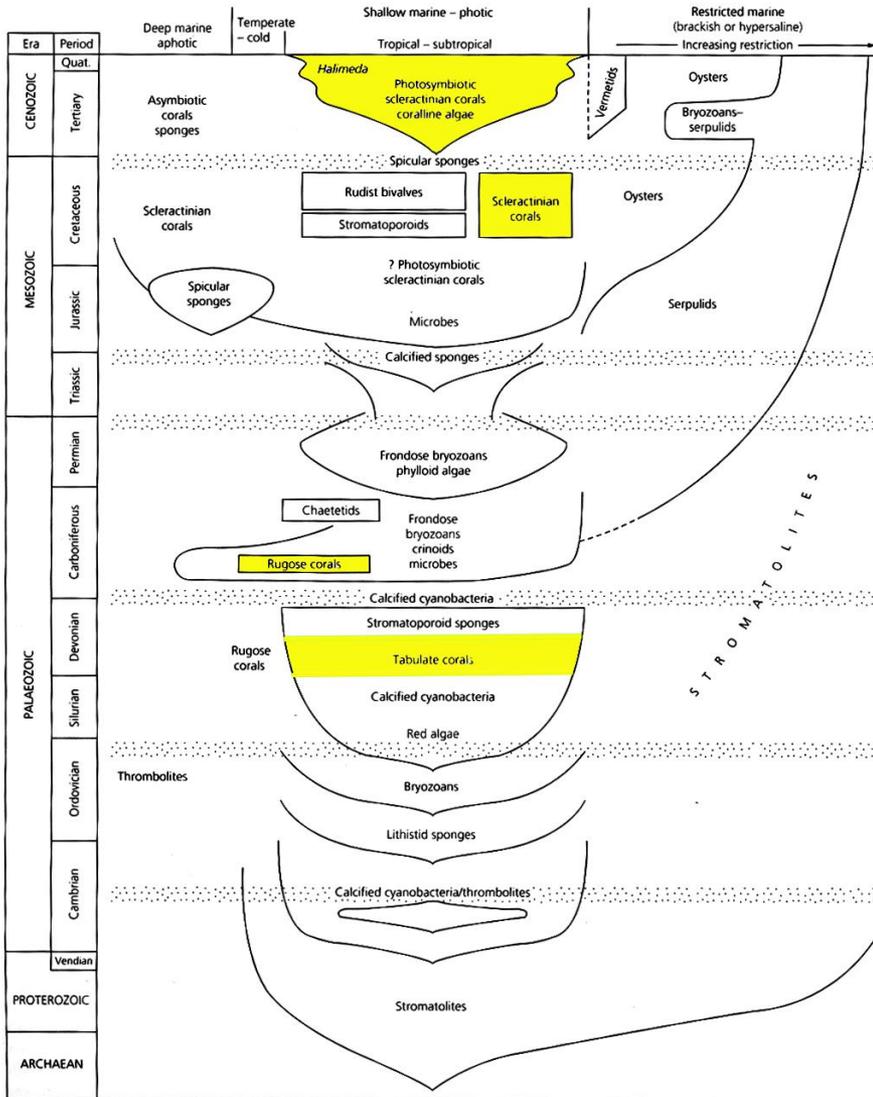
Impressão artística do Devoniano (*Cladoselepe* em recife)

Extinção do Devoniano

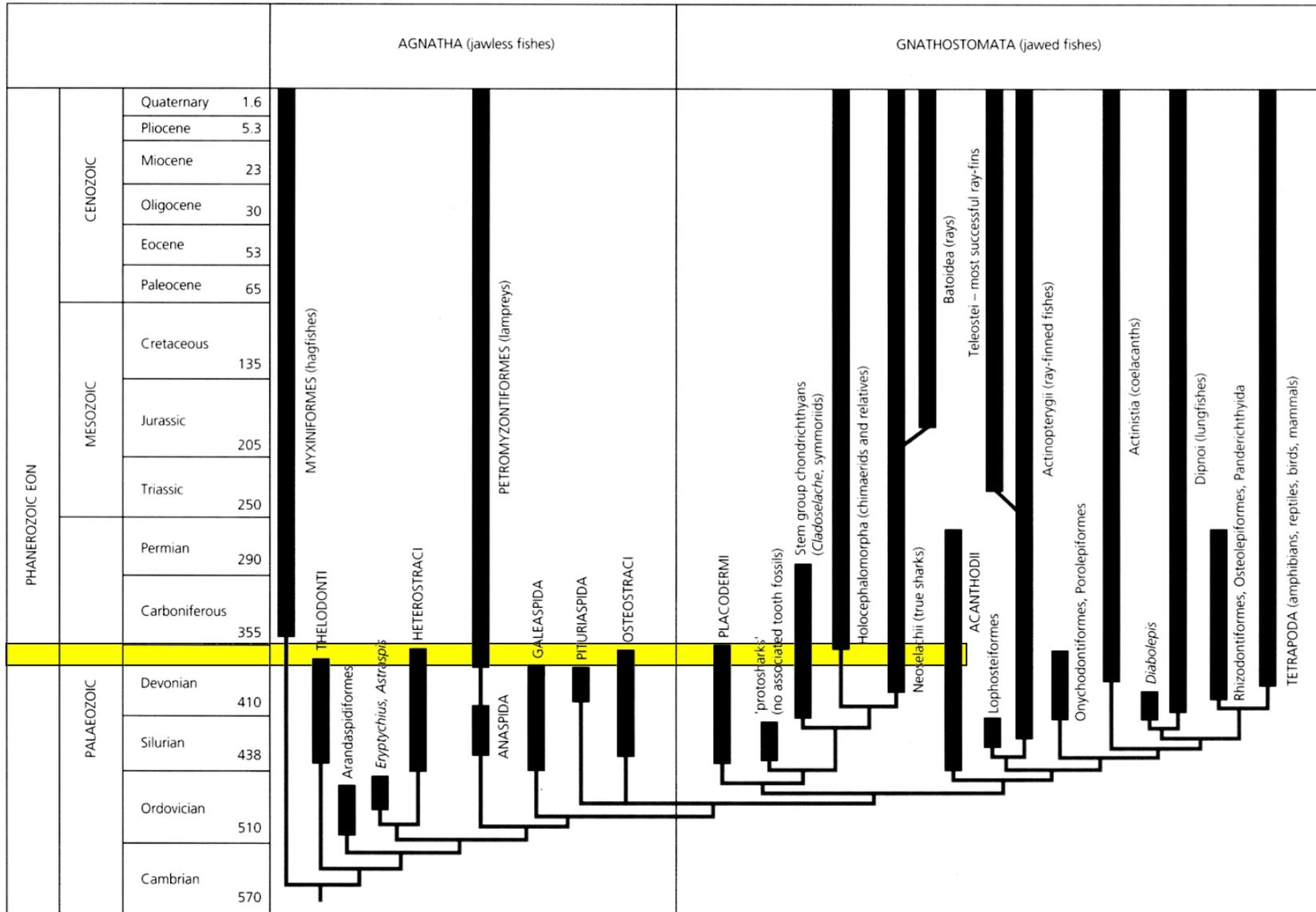


Extinção do Devoniano

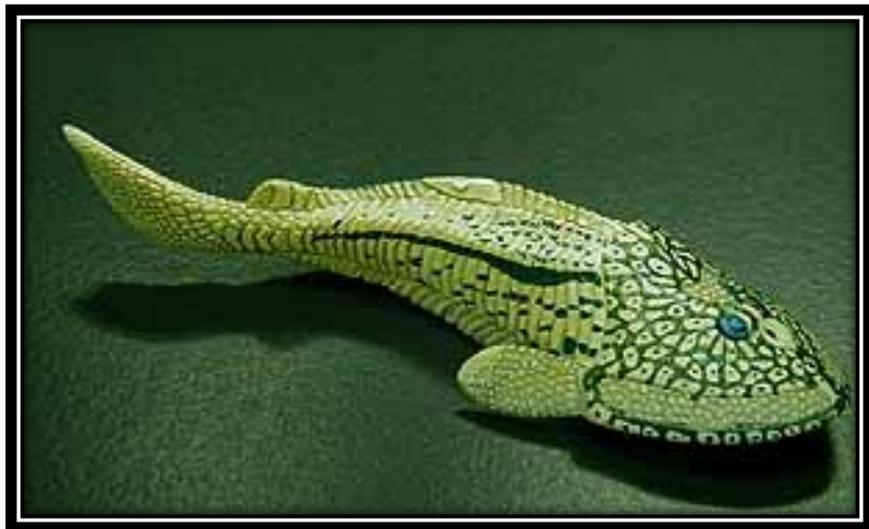
Mudança no padrão de bioconstrutores de recifes



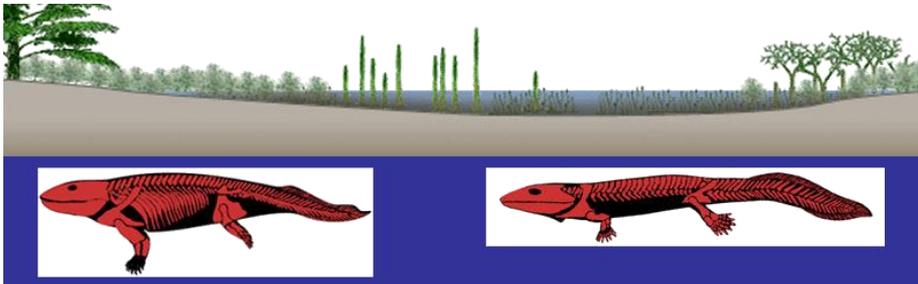
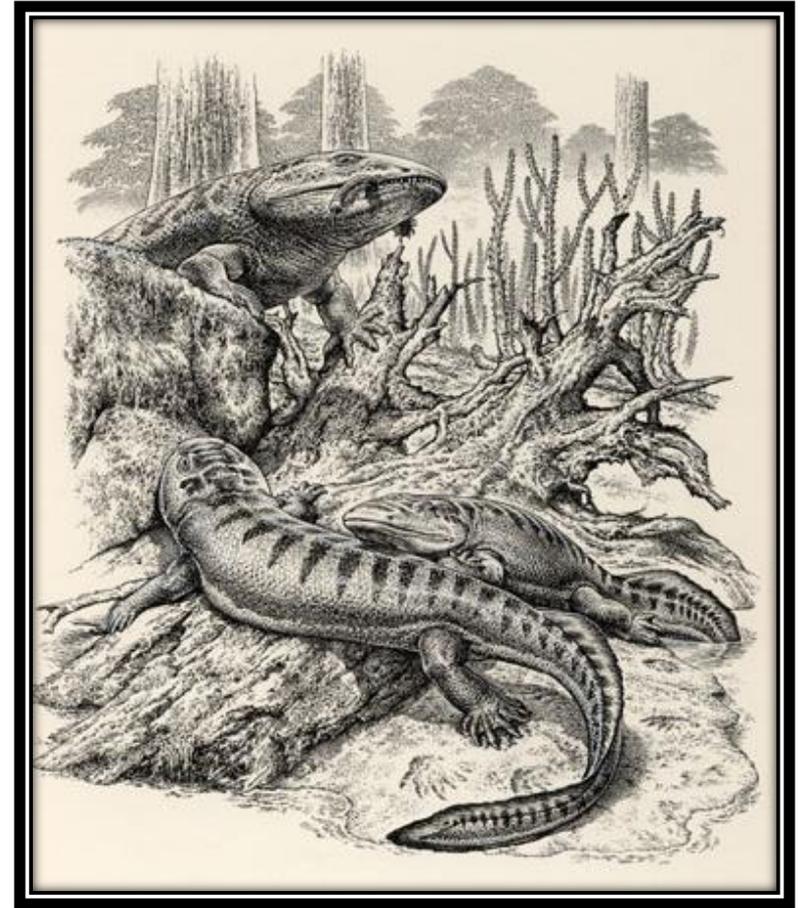
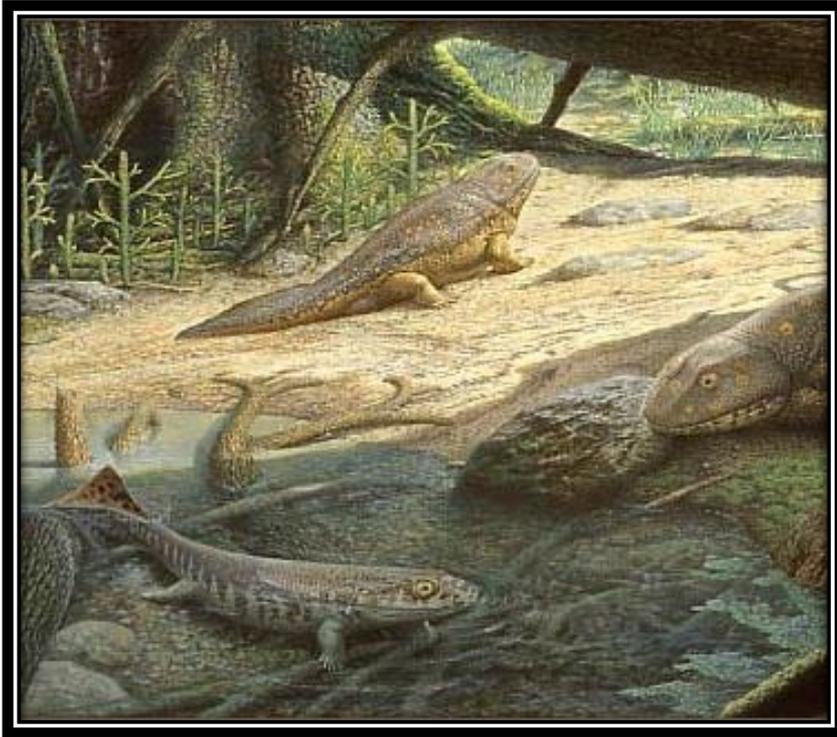
Extinção do Devoniano



Extinção do Devoniano



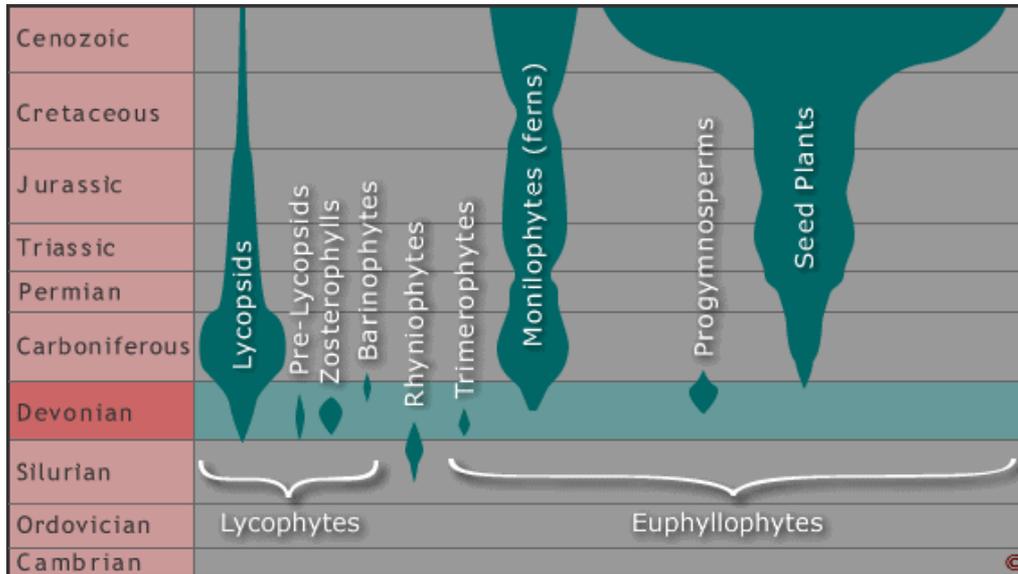
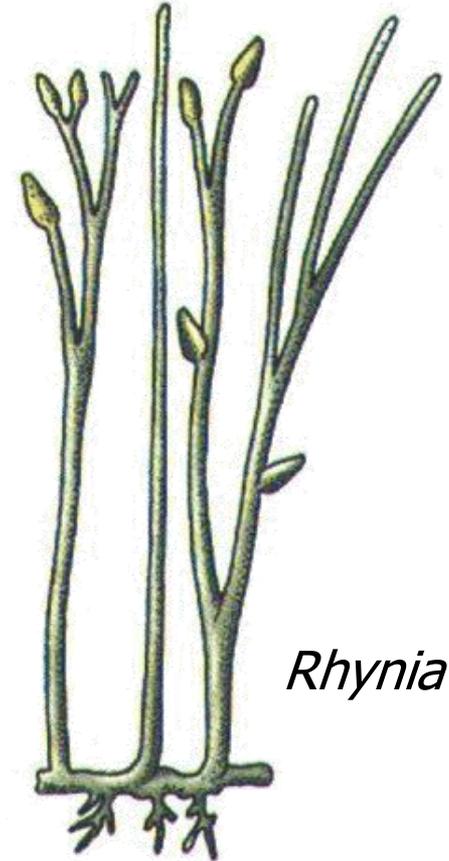
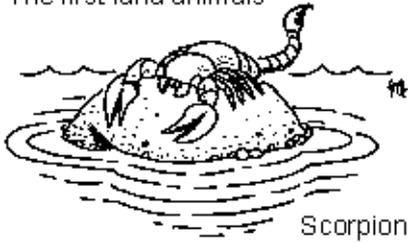
Extinção do Devoniano



Acanthostega e Ichthyostega

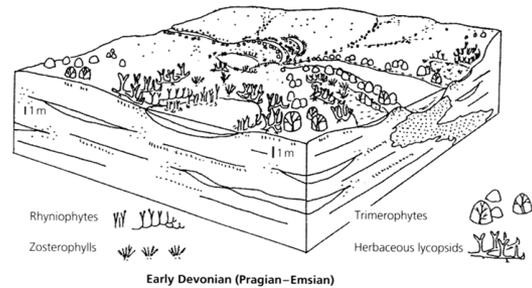
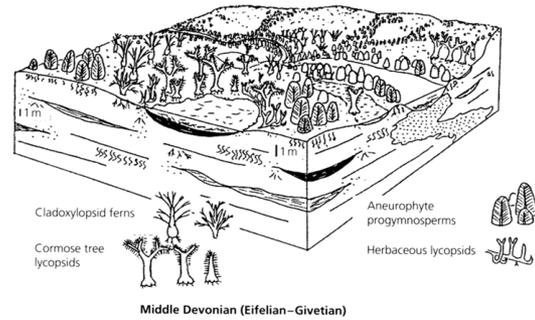
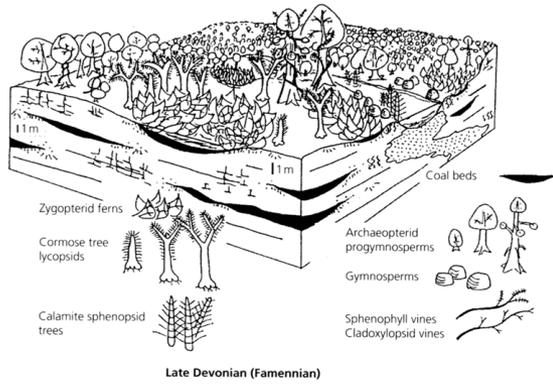
Extinção do Devoniano

The first land animals



Conquista do ambiente terrestre pelas plantas e animais

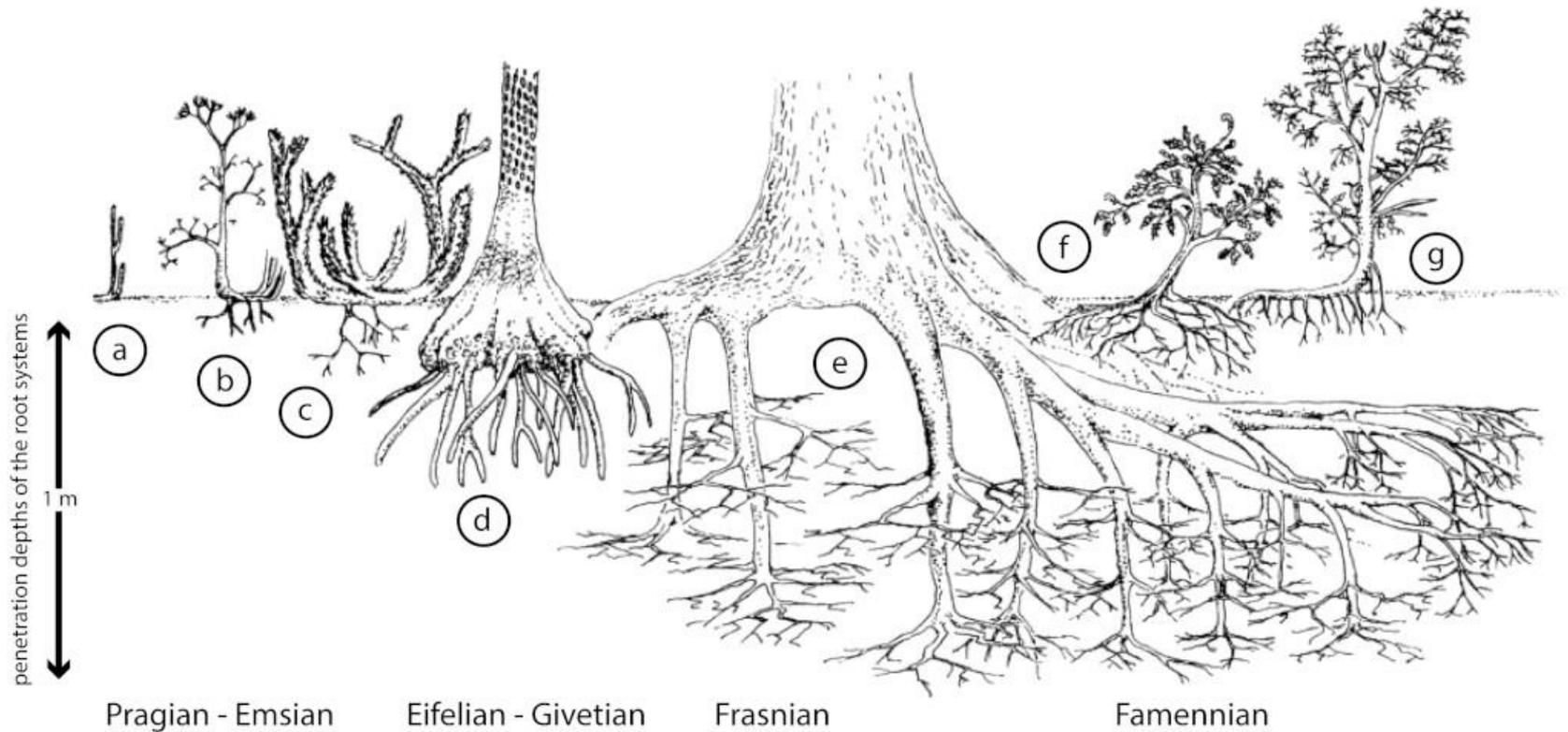
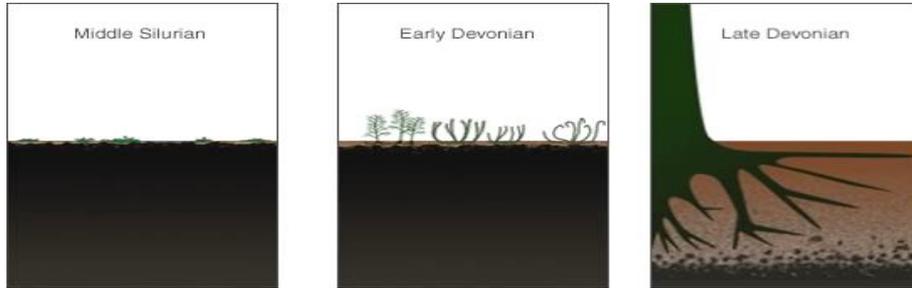
Extinção do Devoniano



Surgem as primeiras florestas

Extinção do Devoniano

Grandes eventos Bióticos – formação dos solos

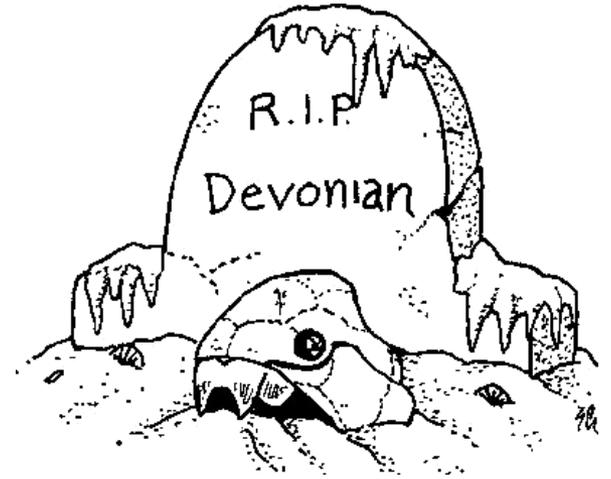


Extinção do Devoniano

Primeiras florestas



Sequestro de carbono
=
Resfriamento
"Efeito Ice-House"

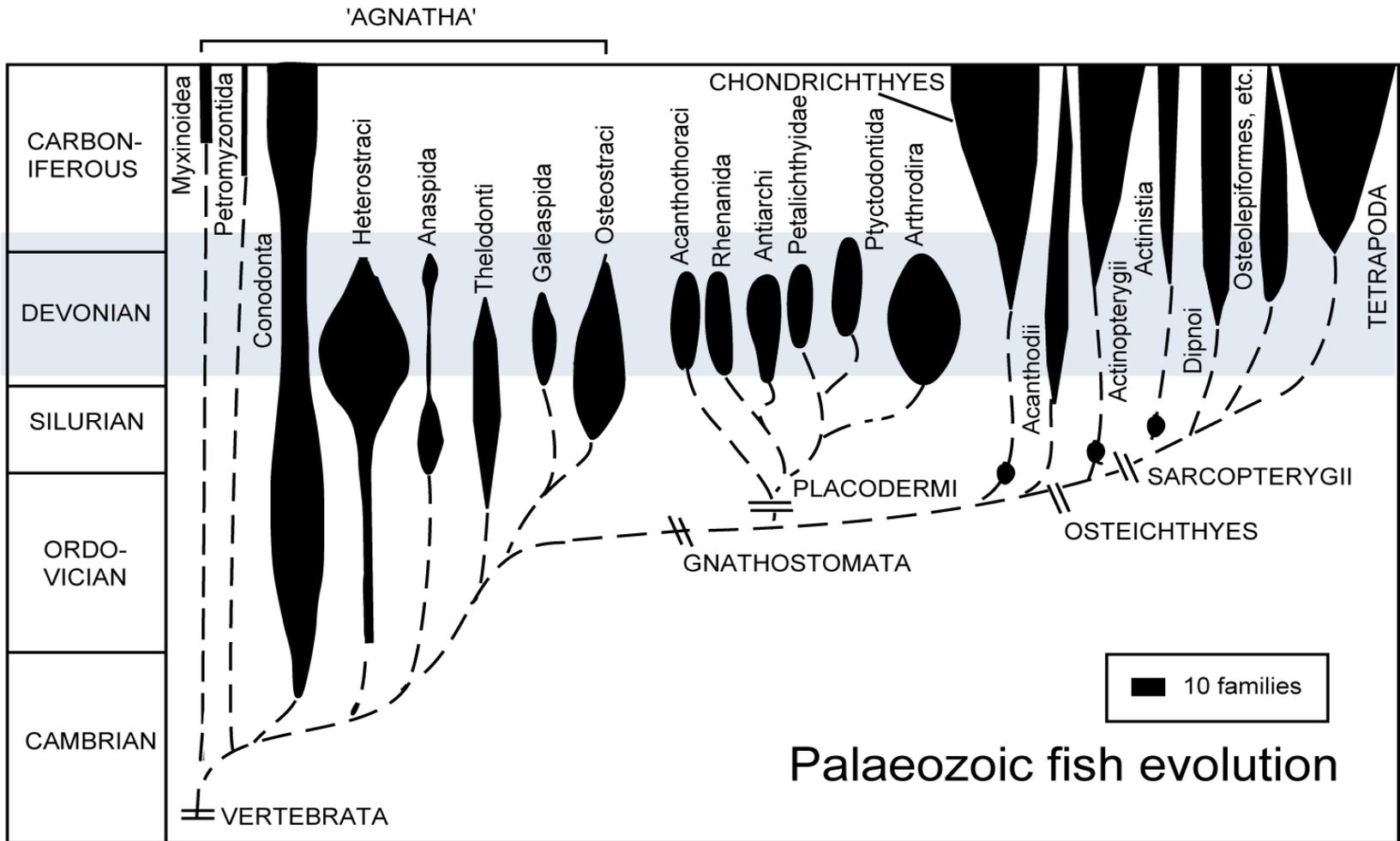


Input de matéria orgânica
no oceano = eutroficação e anoxia



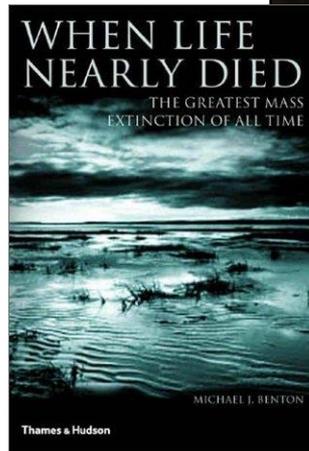
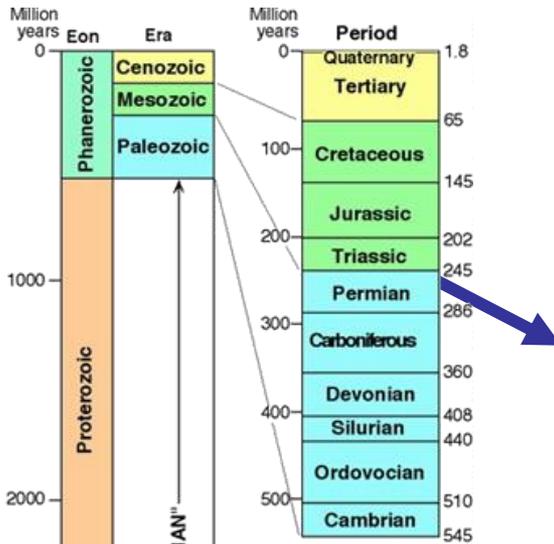
Conseqüências da extinção do Devoniano

Irradiação dos condrictes, peixes ósseos, peixes pulmonados e tetrápodes;



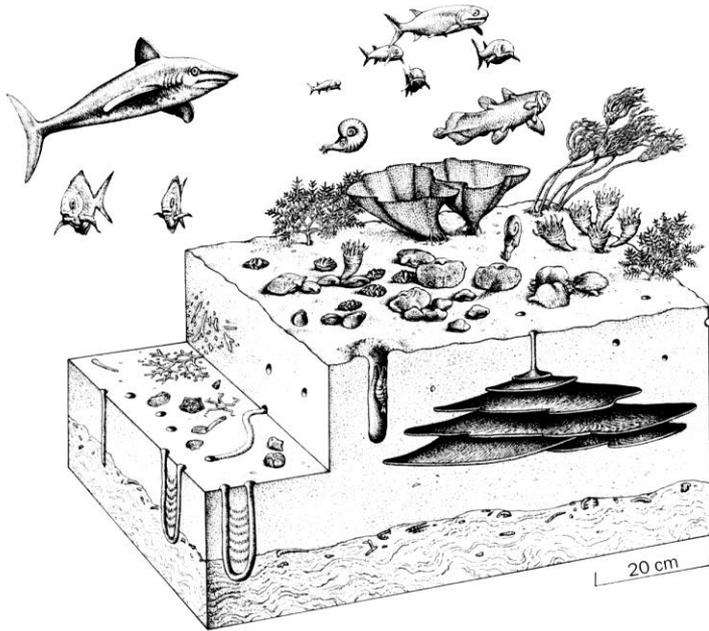
Extinção Permo-Triássico

A “mãe” das extinções em massa

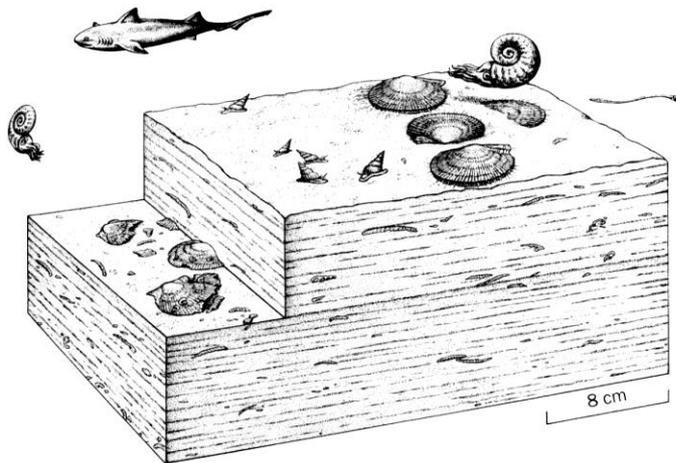
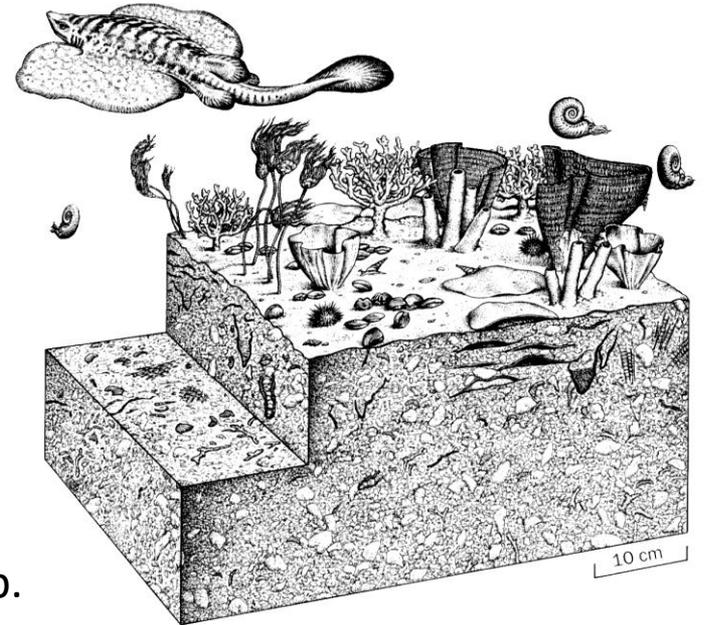


Crânio de gorgonópsio (Karoo, África do Sul)

Extinção Permo-Triássica - Perda de 85% da vida marinha

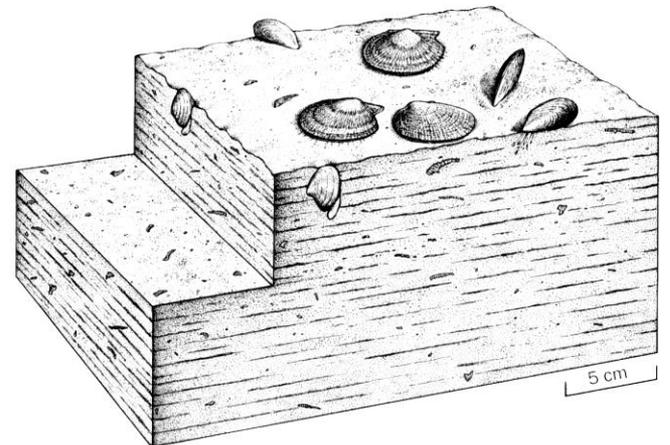


Permiano sup.



Groenlândia

Triássico inf.

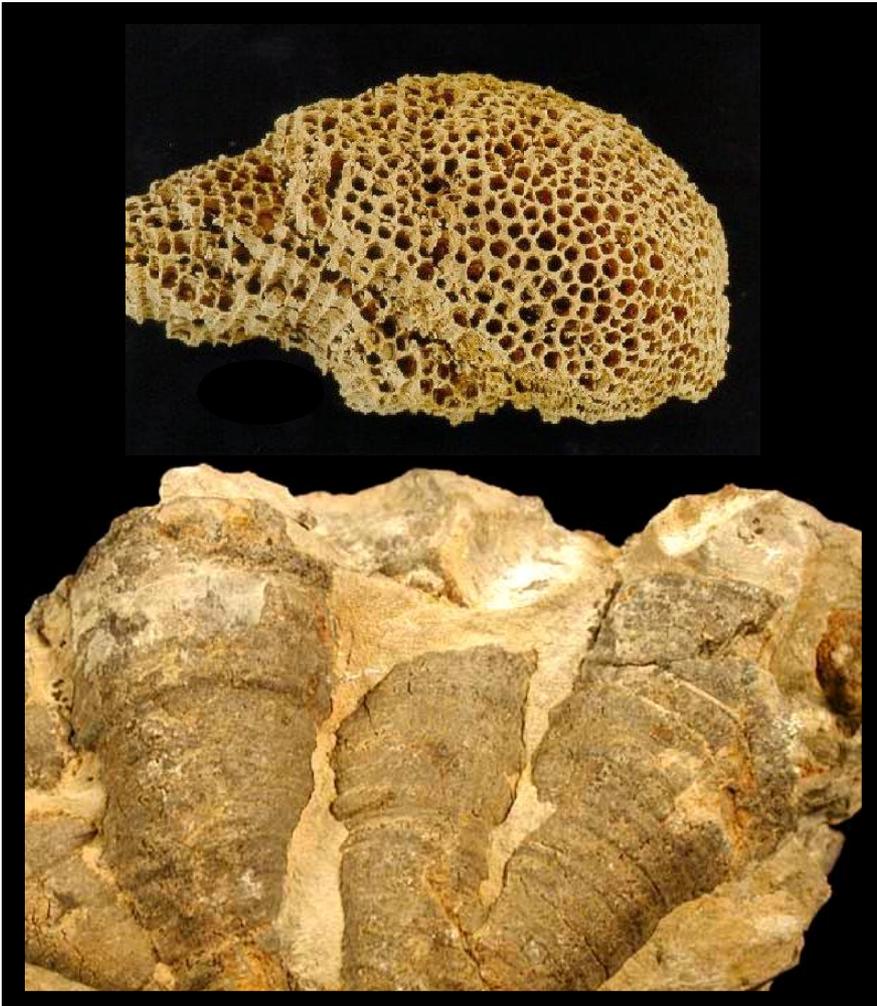


China

Extinção Permo-Triássica

Extinção de trilobitas, rugosos e tabulados

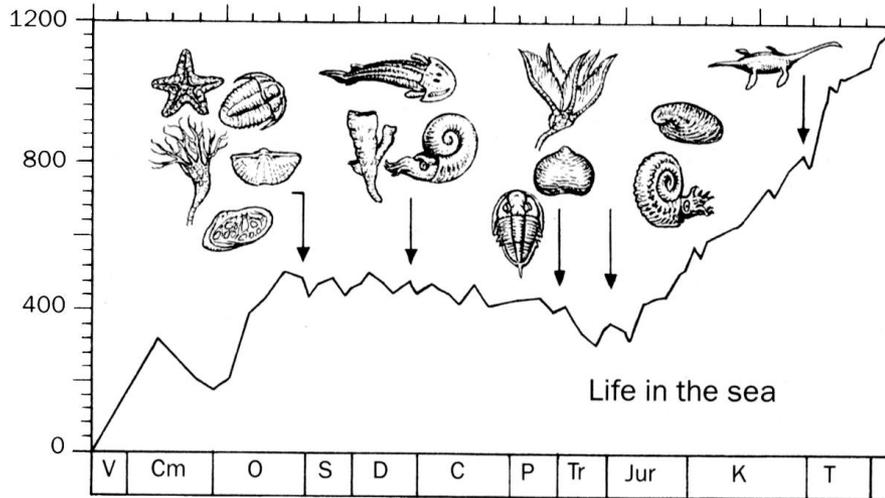
Redução na diversidade de braquiópodos, crinóides e cefalópodos



Extinção Permo-Triássica

Extinção de trilobitas, rugosos e tabulados

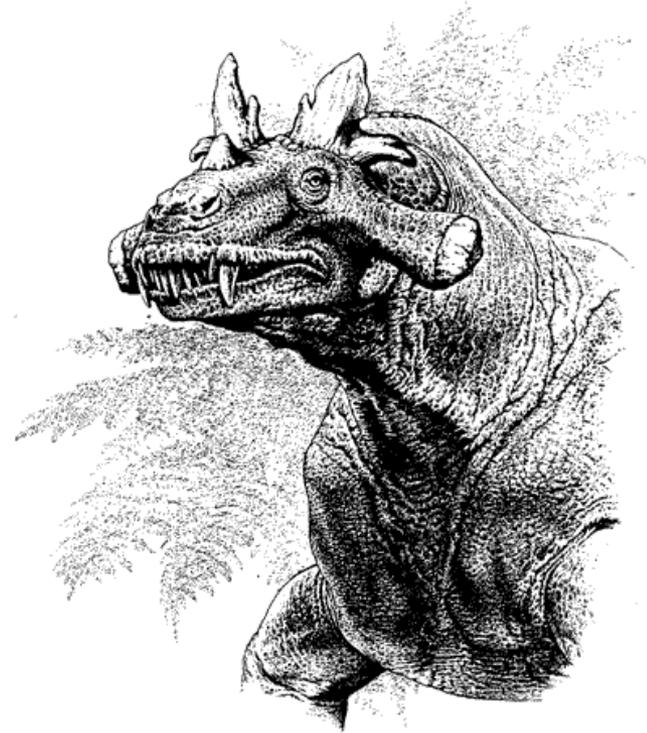
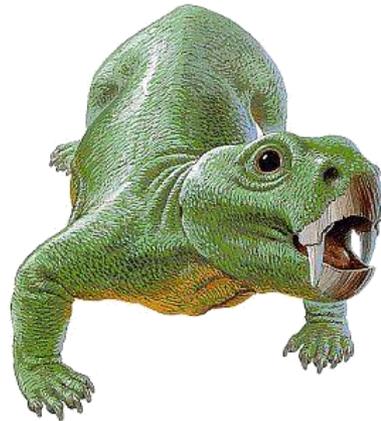
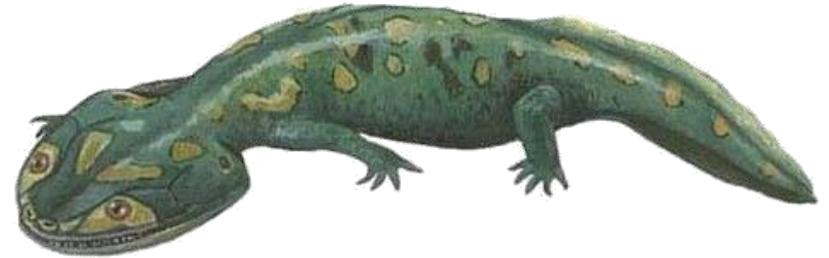
Redução na diversidade de braquiópodos, crinóides e cefalópodos



Extinção Permo-Triássica

Grupos extintos: pareiazauros, dinocefálios e gorgonópsios

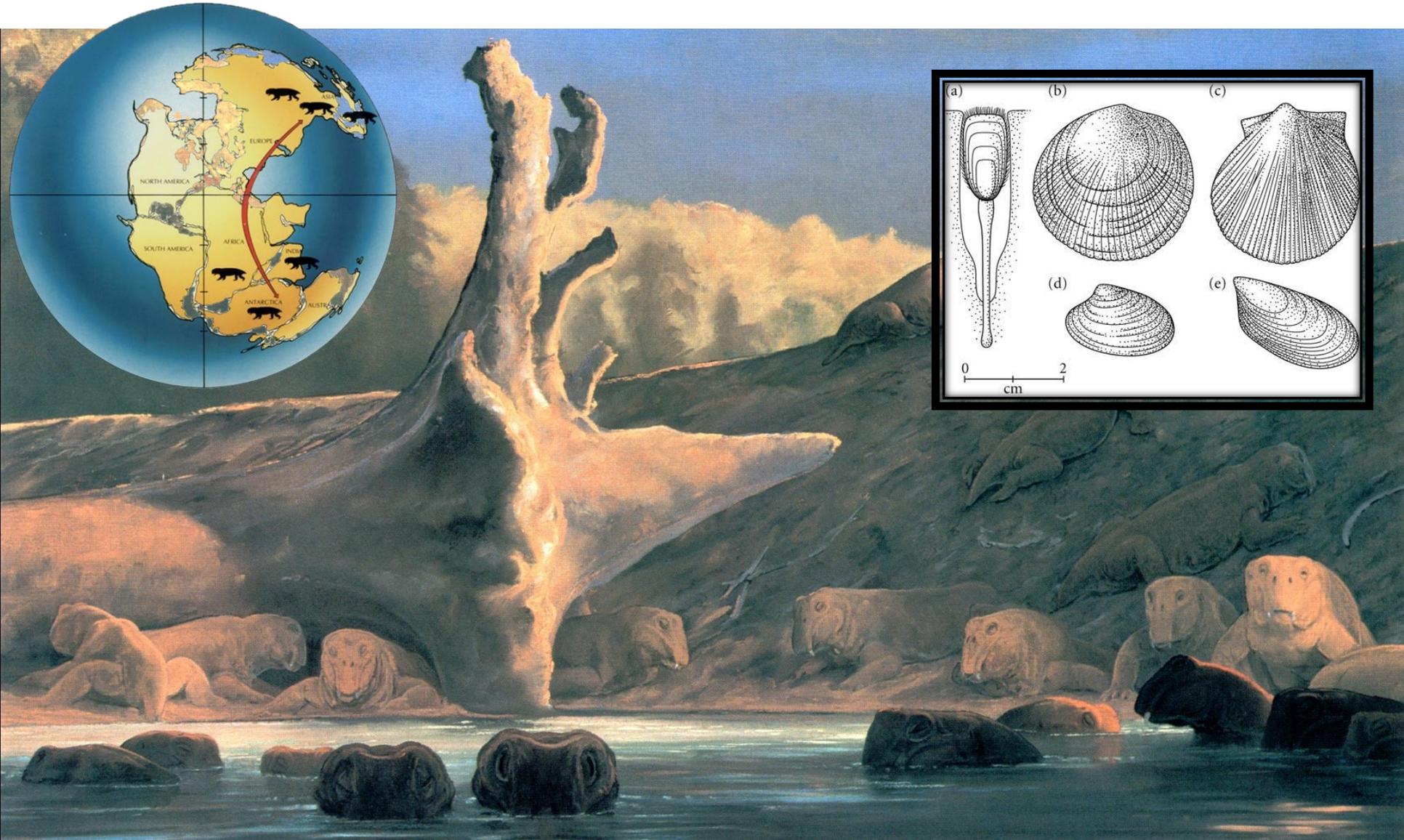
Diversidade muito reduzida: dicinodontes e temnospôndilos



Extinção Permo-Triássica

Grupos extintos: pareiazauros, dinocefálios e gorgonópsios

Diversidade muito reduzida: dicinodontes e temnospôndilos



Extinção Permo-Triássica

Formação do Pangea, regressão, e redução das áreas plataformais
Extinção da fauna marinha

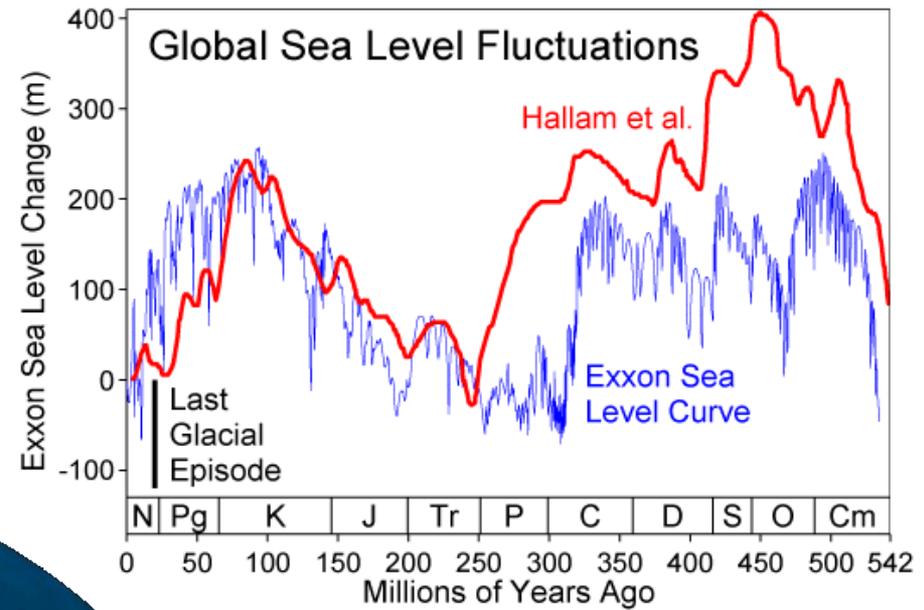
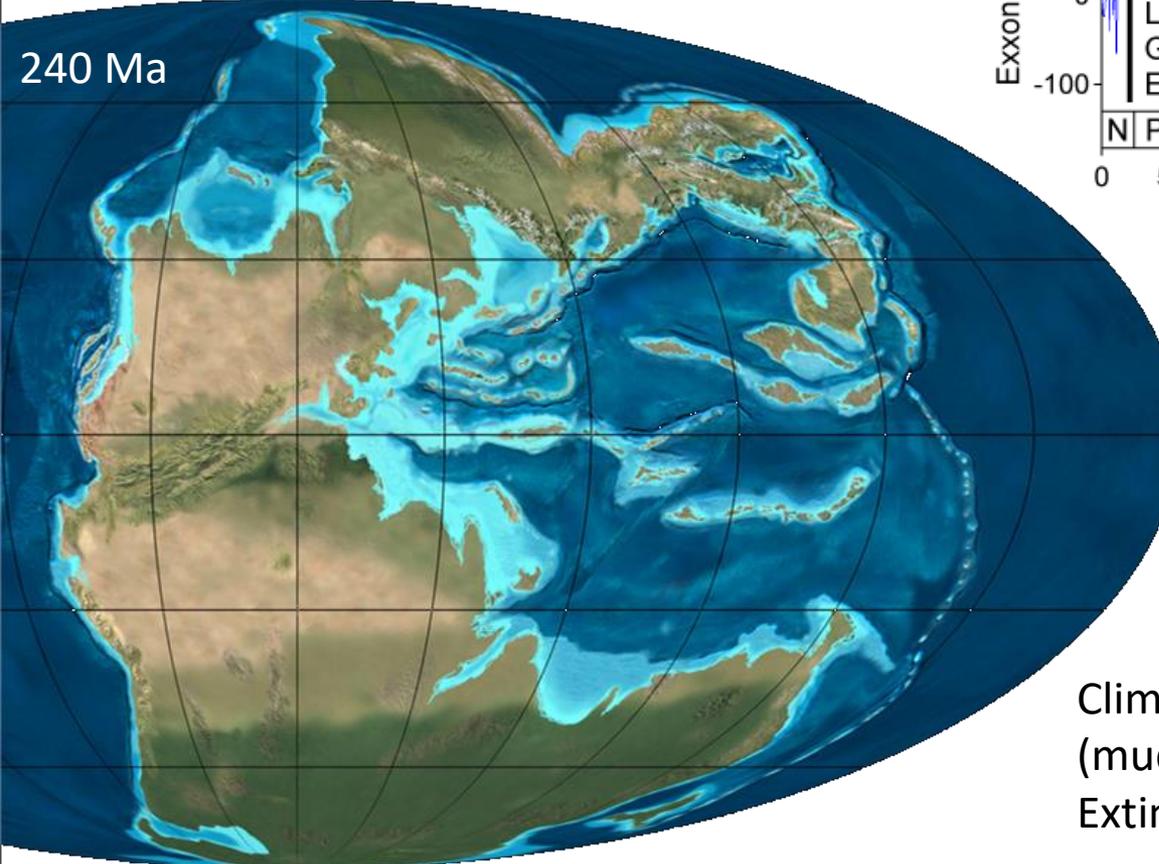
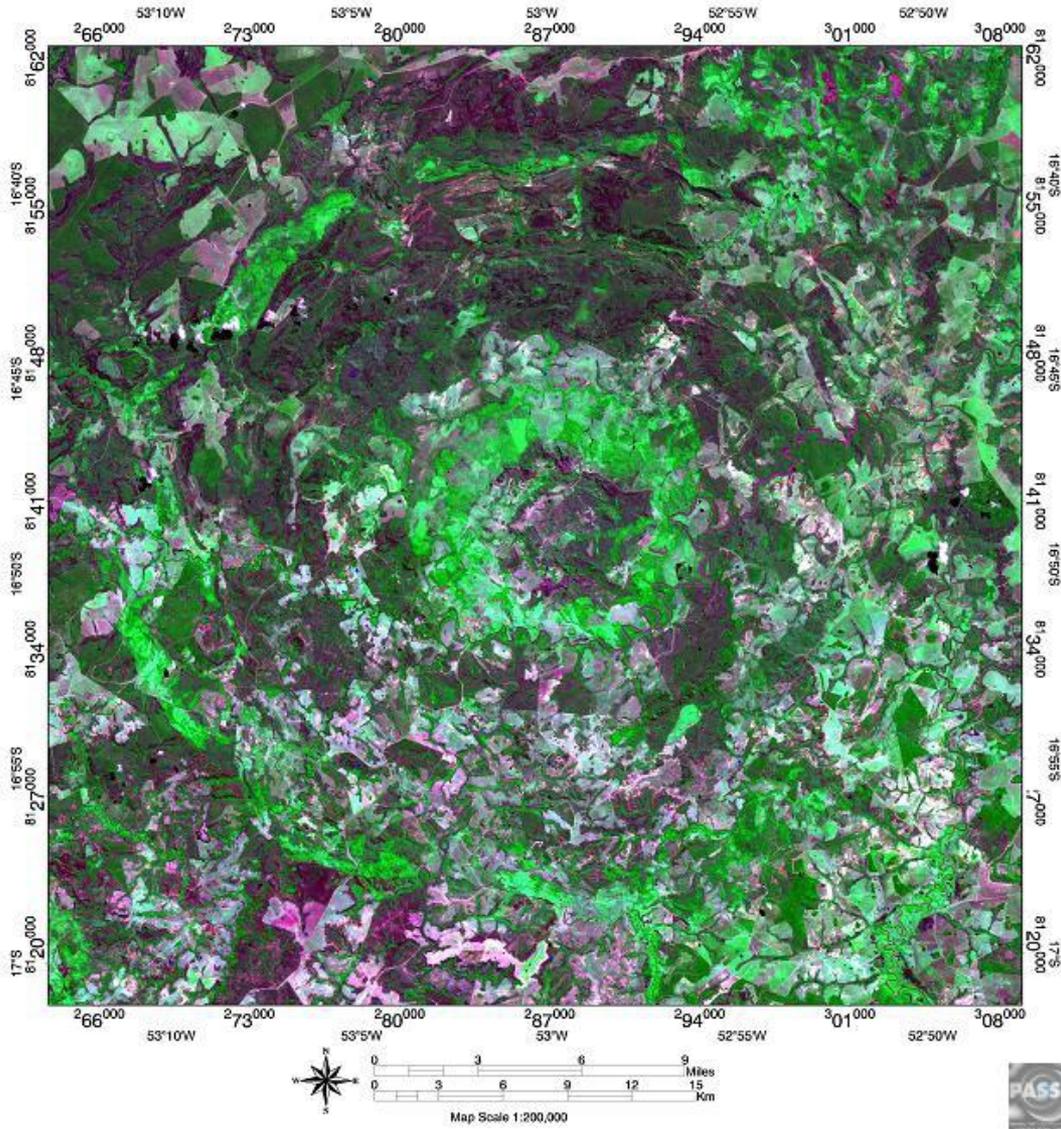


Tabela clássica de
variação do nível do mar

Clima mais árido nos continentes
(mudança registrada no Karoo)
Extinção da fauna terrestre

Extinção Permo-Triássica

Domo de Araguinha: maior cratera sul-americana



Extinção Permo-Triássica

Domo de Araguainha: maior cratera sul-americana

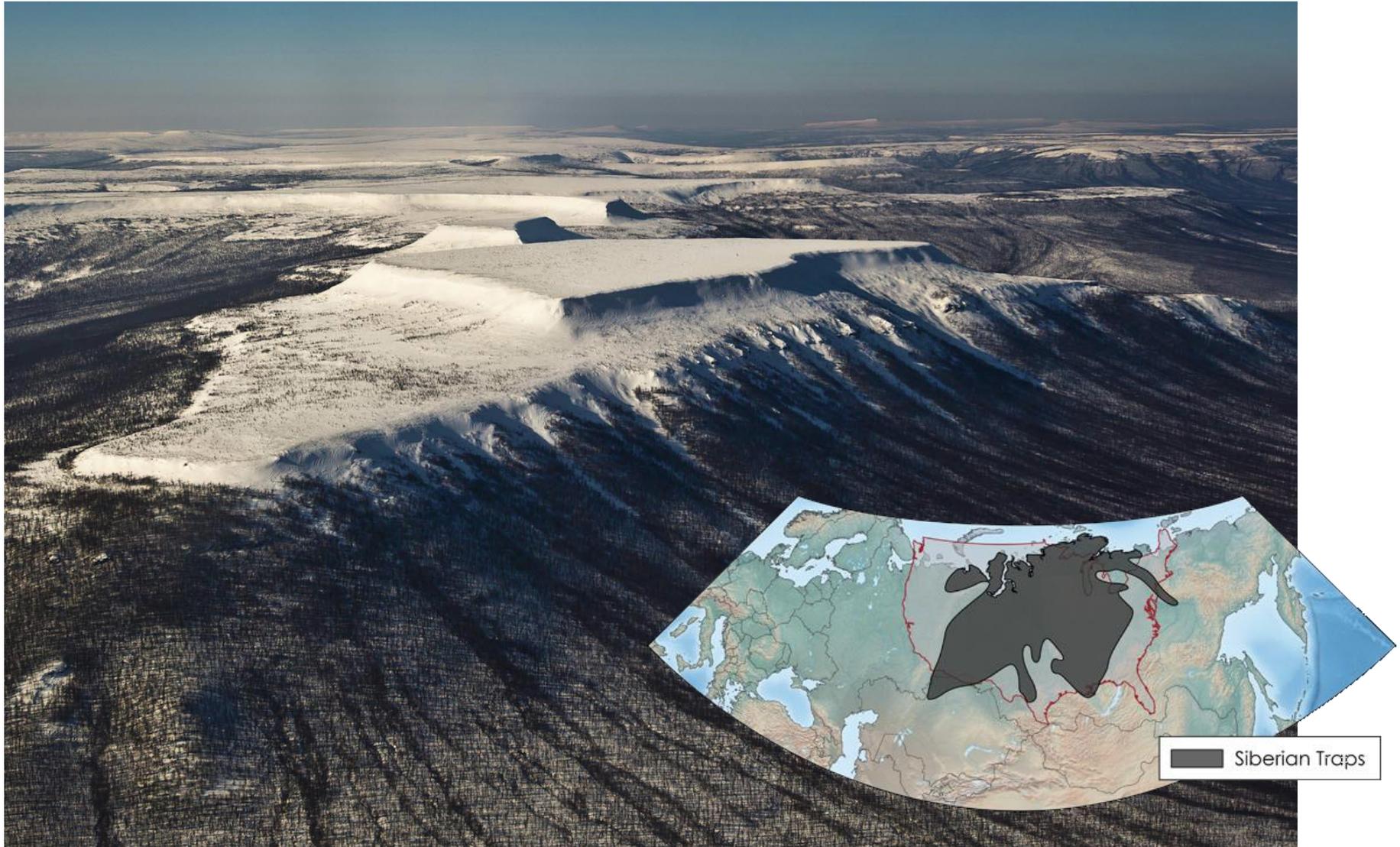
Danos de um grande impacto

Queda de corpo celeste teria gerado perturbações em vasta área do supercontinente Pangeia



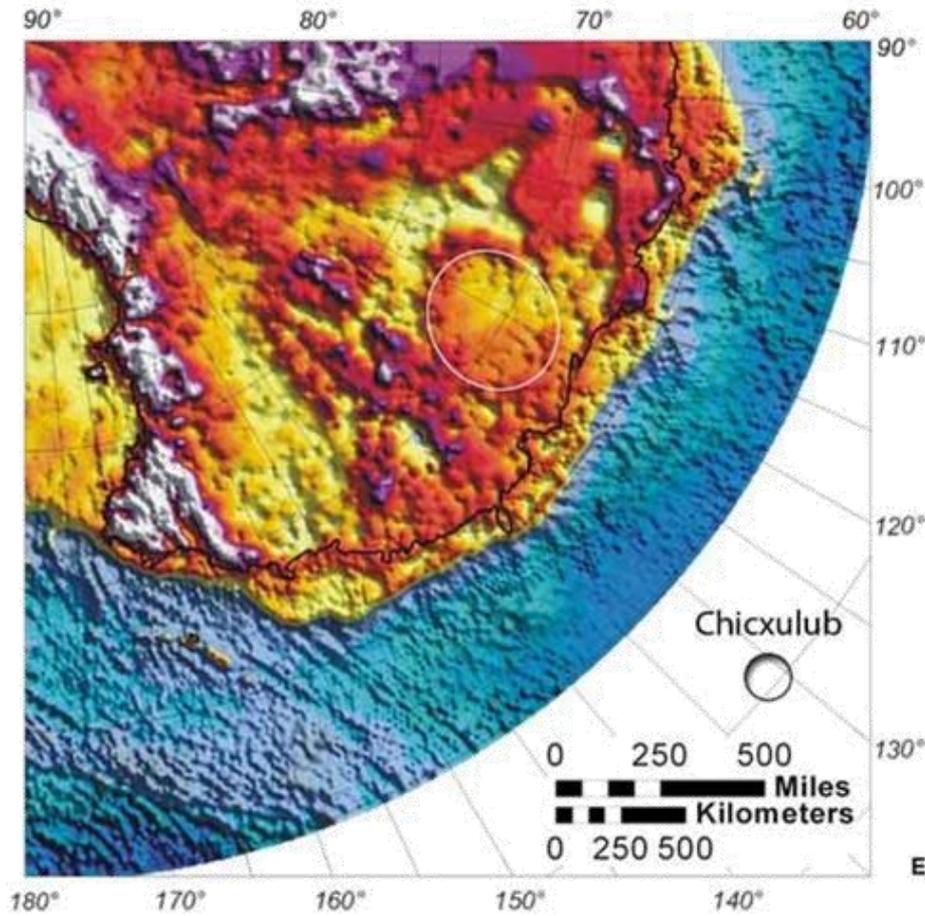
Extinção Permo-Triássica

Traps Siberianos: evidência e evento vulcânico de grande escala

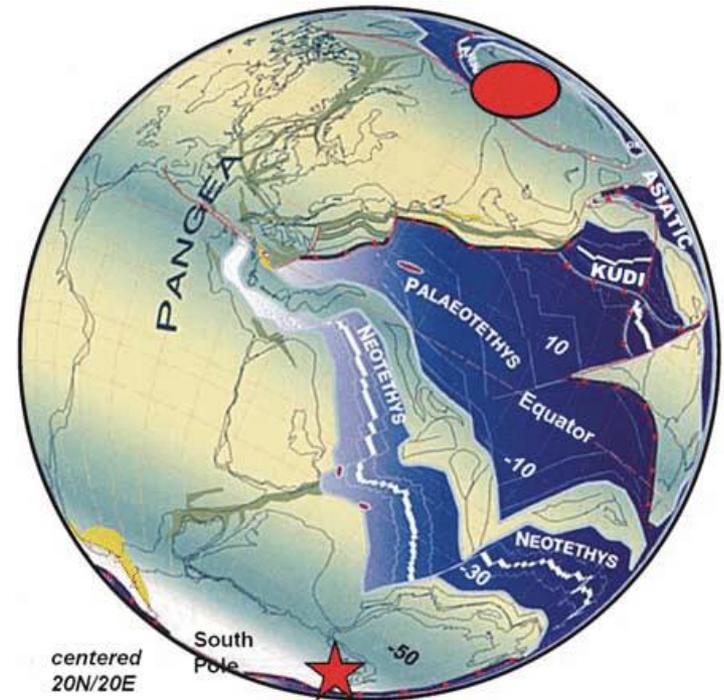


Extinção Permo-Triássica

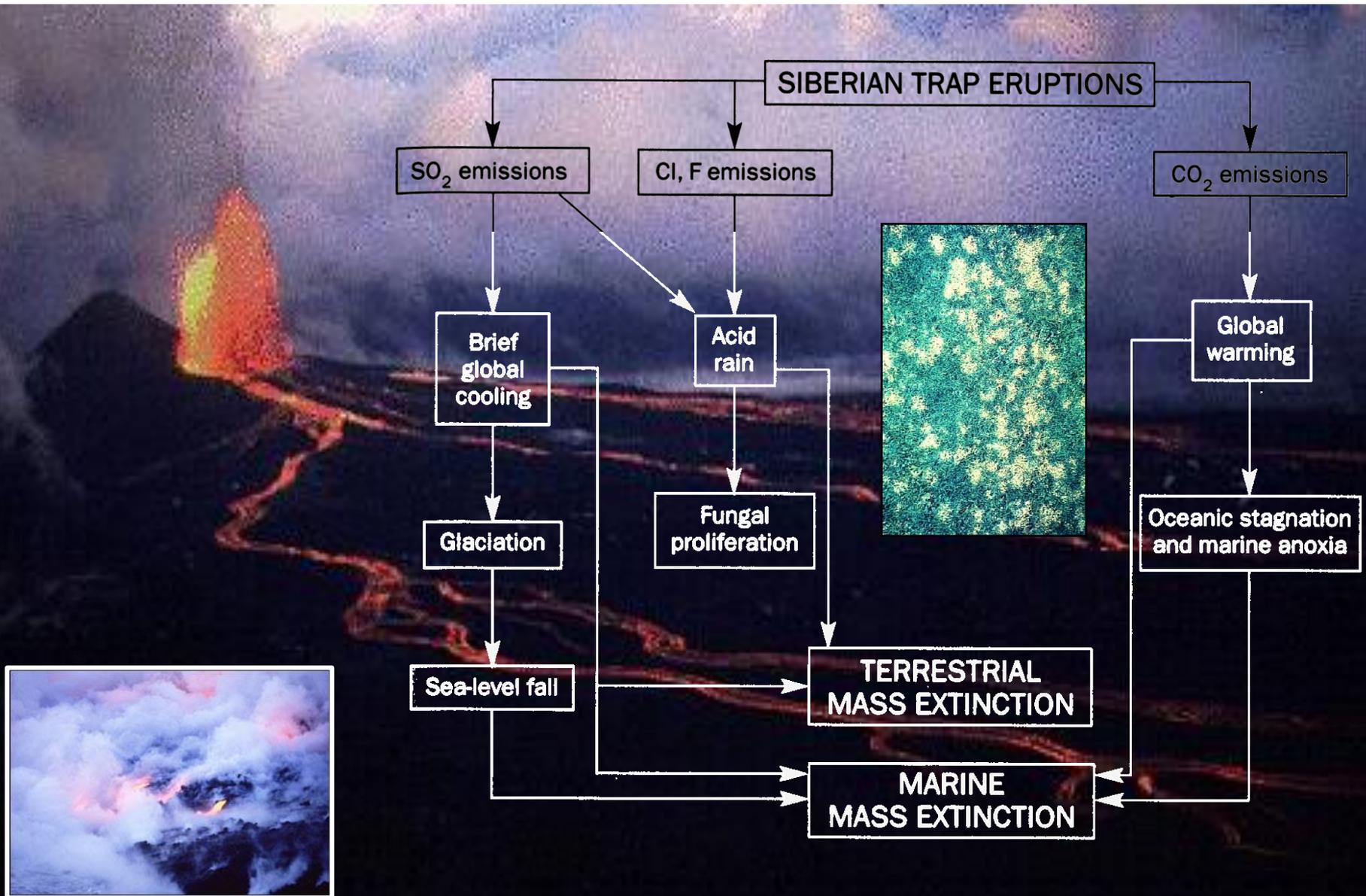
Traps Siberianos: evidência e evento vulcânico de grande escala



- ★ Wilkes Land Impact
- Siberian Traps

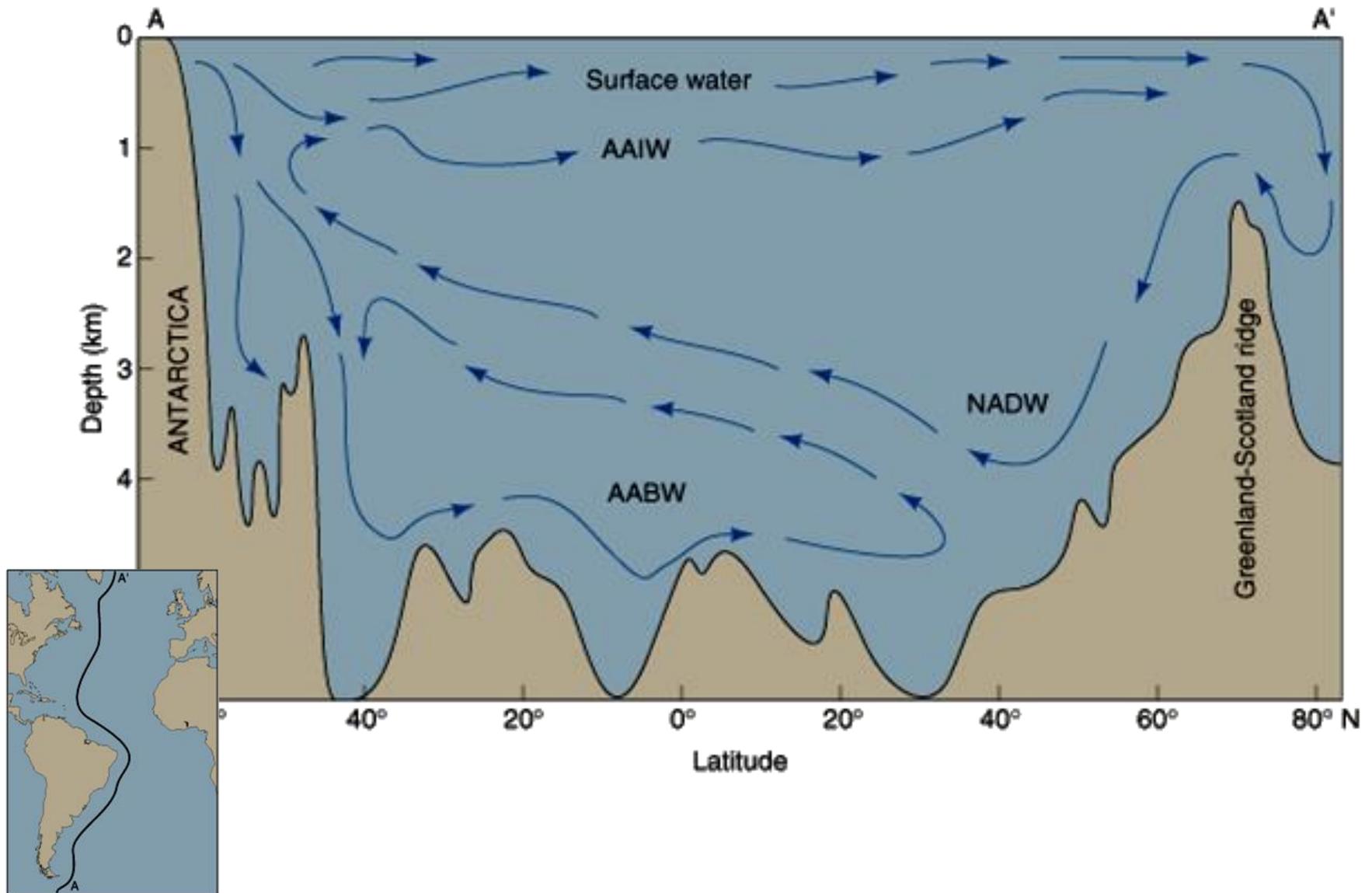


Extinção Permo-Triássica



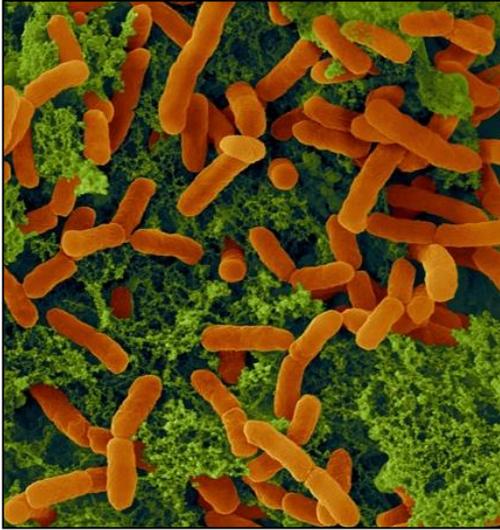
Extinção Permo-Triássica

Traps Siberianos: evidência e evento vulcânico de grande escala



Extinção Permo-Triássica

Traps Siberianos: evidência e evento vulcânico de grande escala

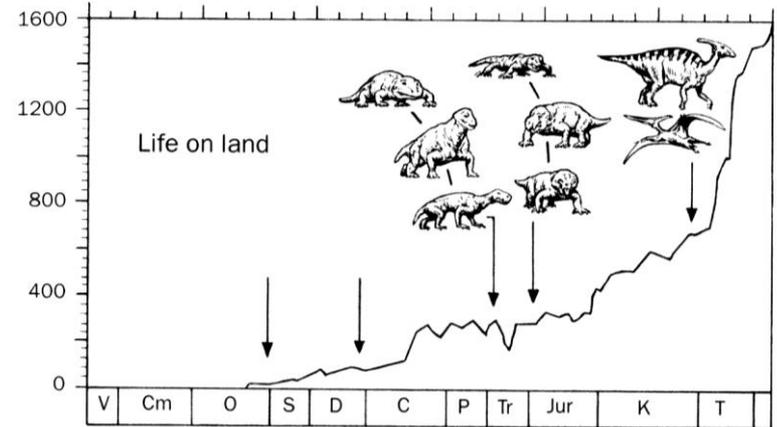
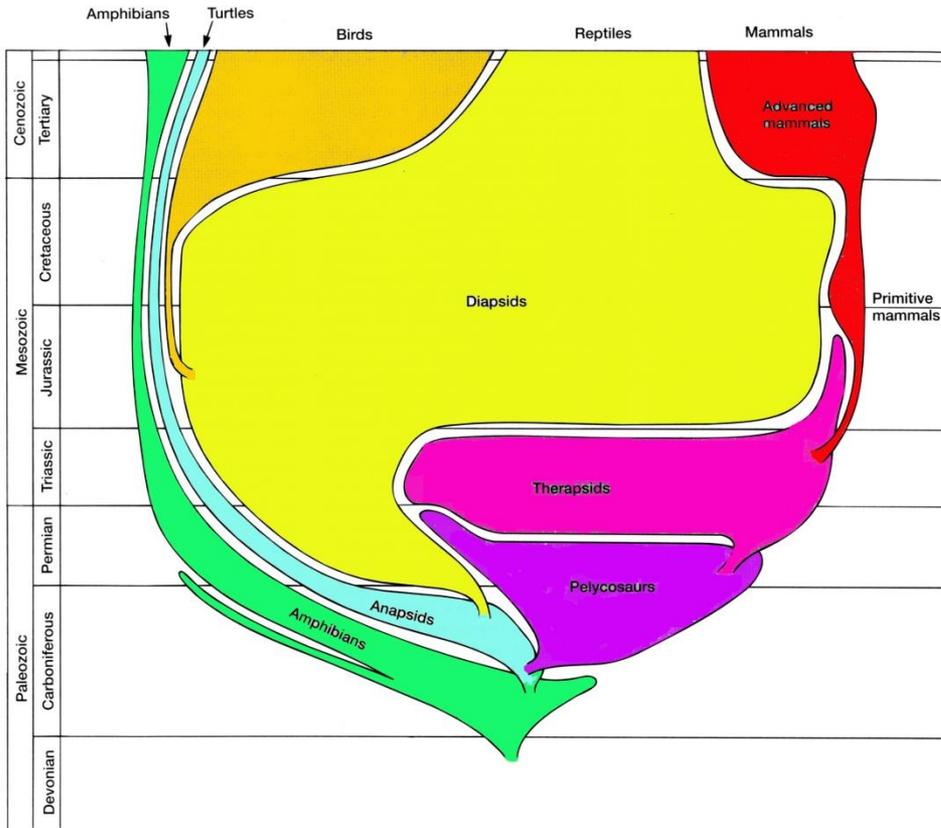


sulfureto de hidrogênio

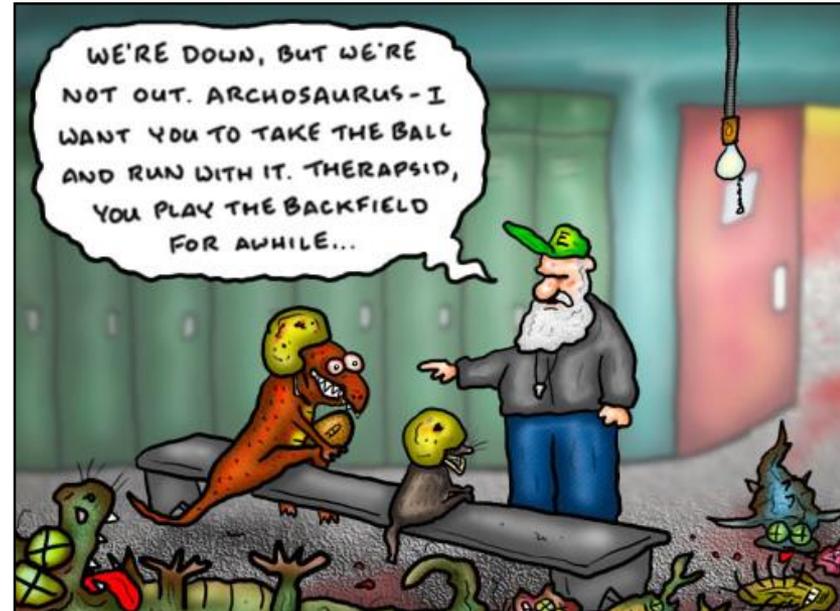


Extinção Permo-Triássica

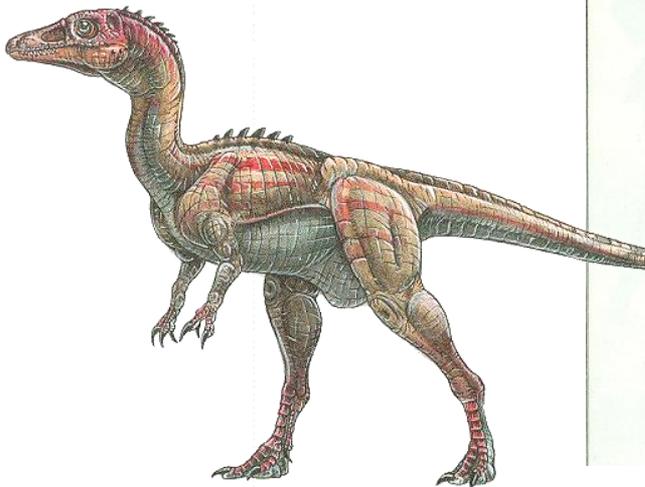
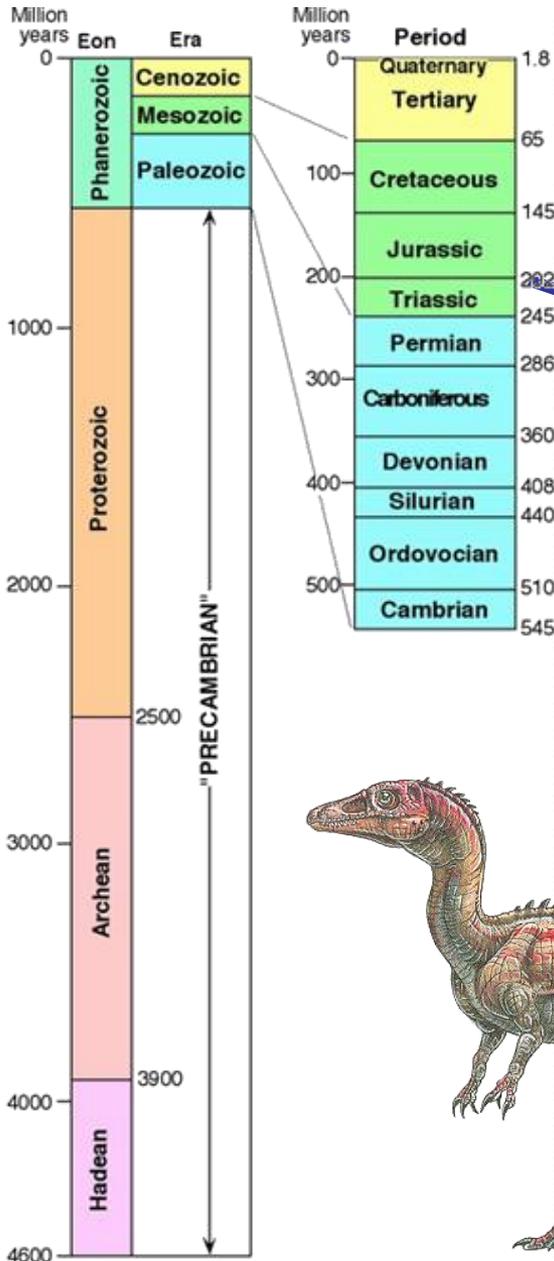
Inicia período mesozóico de domínio dos diápsidos



“Professor” Darwin no intervalo de jogo entre o Permiano e o Triássico



Extinção do Triássico



Dinosaurs' Lucky Break

Not necessarily superior competitors, dinosaurs may simply have benefited from the ill fortune of their reptilian predecessors

by Michael J. Benton

Throughout the history of life, there have been many major upheavals in which whole groups of animals were replaced by others. Perhaps the most famous was the replacement of the dinosaurs by the mammals 65 million years ago. Another major change occurred 150 million years earlier, when the dinosaurs took over the position of dominance that had been held for 80 million years by mammallike reptiles.

What triggered these great upheavals? Scientific thinking about the various factors that might have been responsible for such replacements has undergone some significant changes of its own. At times, for example, scientists have suggested that the mammals caused the extinction of the dinosaurs by eating their eggs or by competing for the same food resources. Now, however, most people are convinced that the mammals played only a minor role, if any (largely because both groups had lived side by side for millions of years), and that, instead, environmental change was primarily responsible. The mammals apparently sat around for 150 million years in the Mesozoic undergrowth until, with the extinction of the dinosaurs, they had their opportunity to radiate into newly available niches.

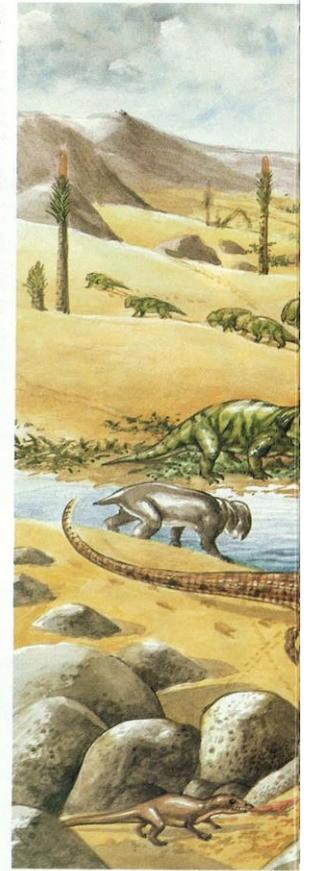
But what about the initial radiation of the dinosaurs? The transition from mammallike reptiles to dinosaurs has been described by many authors and is frequently quoted as an example of major competitive replacement among vertebrates. (The use of the word *competition* in this context is convenient but potentially misleading. Individuals can compete, and one could even consider two species as competing, but at higher taxonomic levels, any large-scale replacements would probably be the result of numerous such events combined, together with other factors, in an essentially random way. The net result could more accurately be described as differential survival of one taxon compared with another that occupied a similar range of niches. For the purposes of this article, however, I will stick with the more familiar term of competition.)

According to nearly all published accounts, the replacement of mammallike

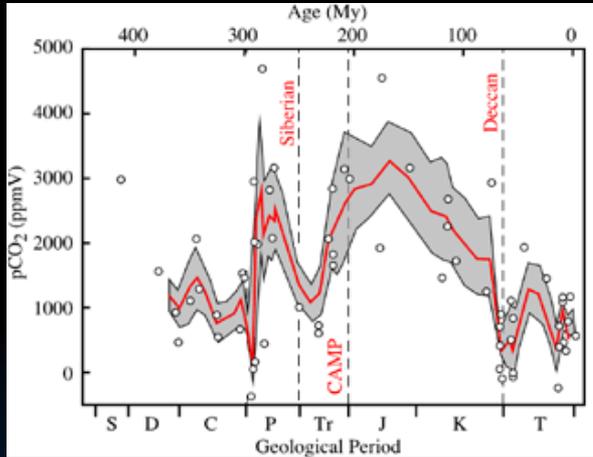
reptiles by the dinosaurs went as follows: During the Permian period and the early part of the Triassic (from 290 to 225 million years ago), the land was dominated by the mammallike reptiles, which ranged in size and shape from a rat, or smaller, to a hippopotamus. At the end of the Permian, major upheavals occurred and many lineages became extinct. In the early Triassic, faunas of herbivorous mammallike reptiles, almost certainly unbalanced by these events, were heavily dominated by these events, were heavily dominated by huge numbers of a single genus, *Lystrosaurus*. New faunal elements also appeared at this time: the thecodontians, which included the ancestors of the dinosaurs. The carnivore niches throughout most of the Triassic were shared by advanced mammallike reptiles, such as *Traversodon*, and thecodontians, some of which, such as *Rauisuchus*, became very large. The thecodontians are supposed to have gradually outcompeted the mammallike reptiles and taken over the carnivore niches. Toward the end of the Triassic, there were still some herbivorous mammallike reptiles, such as *Dinodontosaurus*, and some herbivorous thecodontians arose. Dinosaurs, according to most of these accounts, first appeared on the scene in the middle Triassic. Eventually, the mammallike reptiles and thecodontians waned and the dinosaurs increased in importance, supposedly as a result of competition. The replacement was complete after about 40 million years.

Dinosaur superiority in this alleged competition has been variously attributed to features of their posture and locomotion or to their thermoregulation. Mammallike reptiles and thecodontians are said to have had a sprawling or semierect posture, with their legs stuck out sideways and bent downward only at the knee and elbow. In dinosaurs, the legs were tucked right under the body, giving them an erect posture, as seen in most mammals. This enabled them to take longer strides and support greater weight.

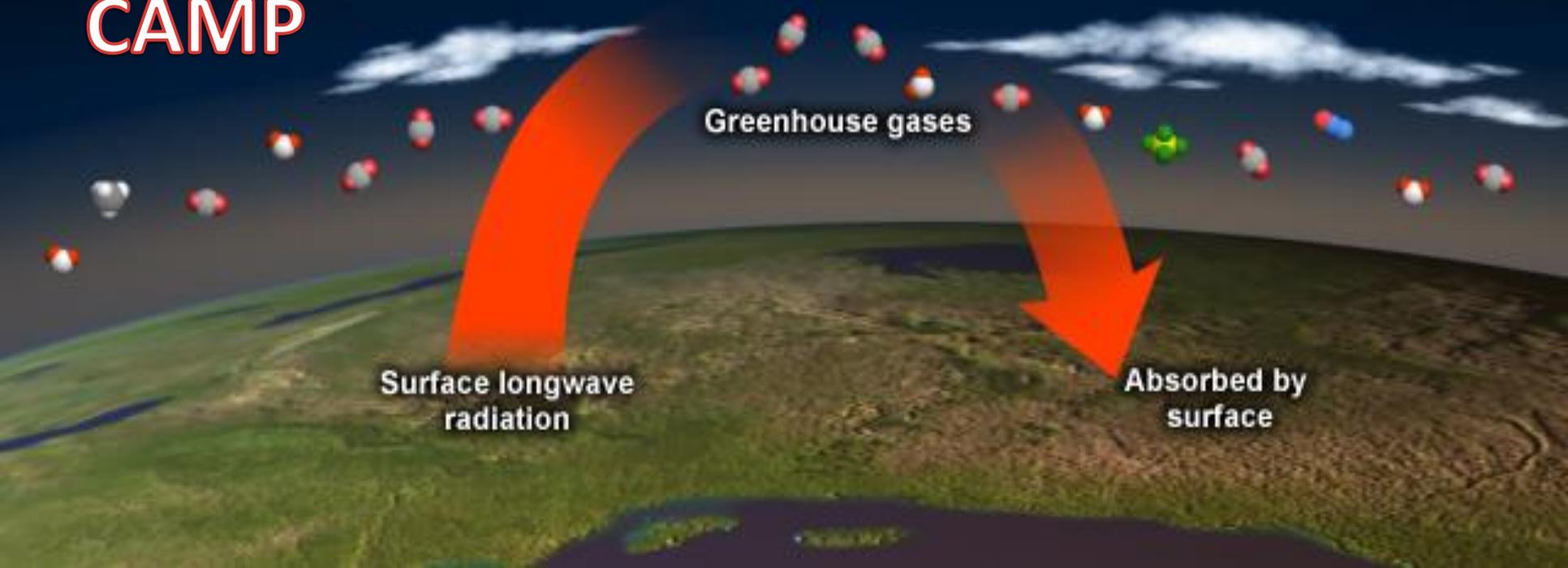
In the past decade, many authors, including myself, have devoted hundreds of pages to speculations about the thermal physiology of the dinosaurs and why it was better than that of mammallike reptiles.



Extinção do Triássico

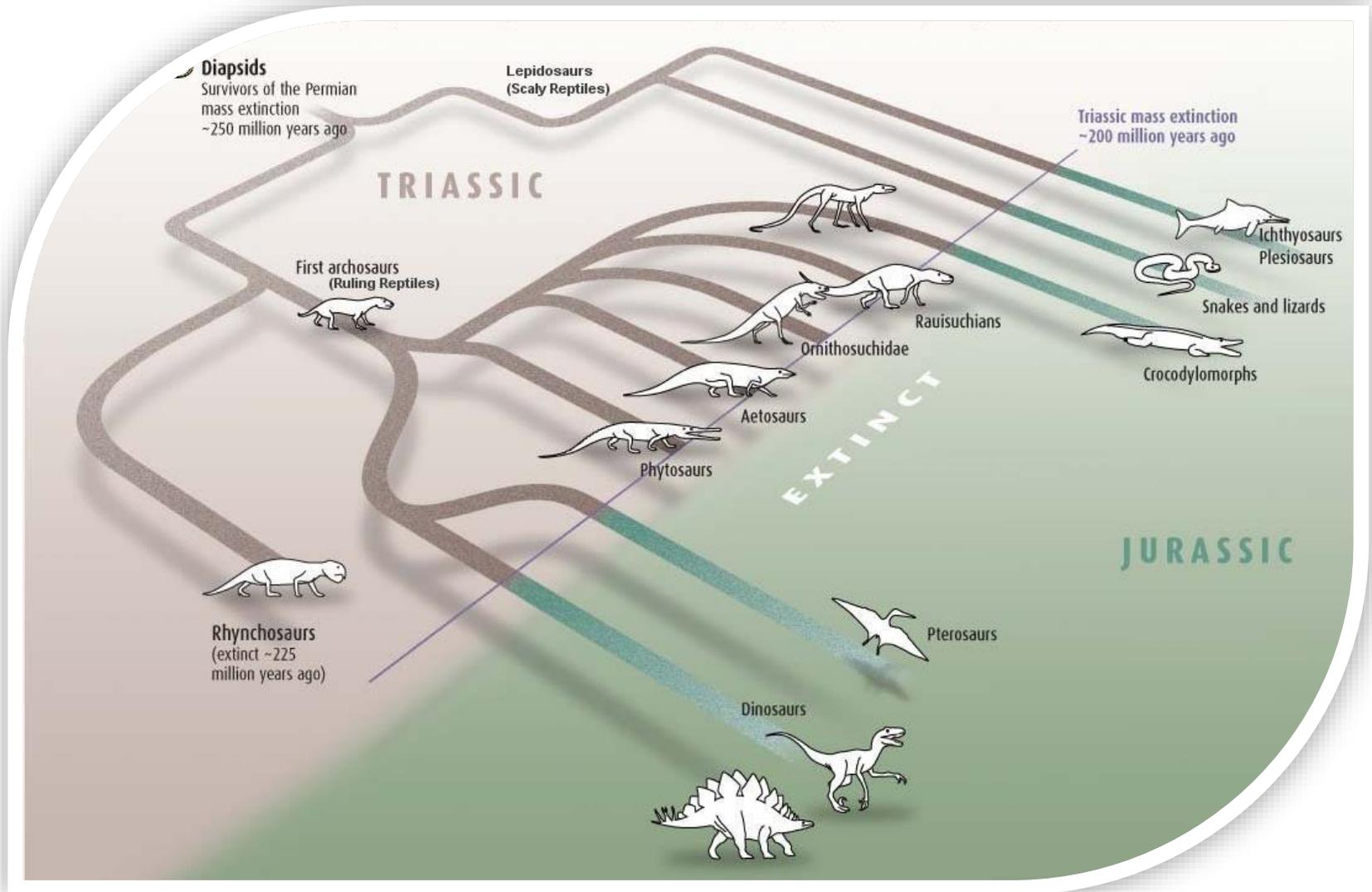


CAMP

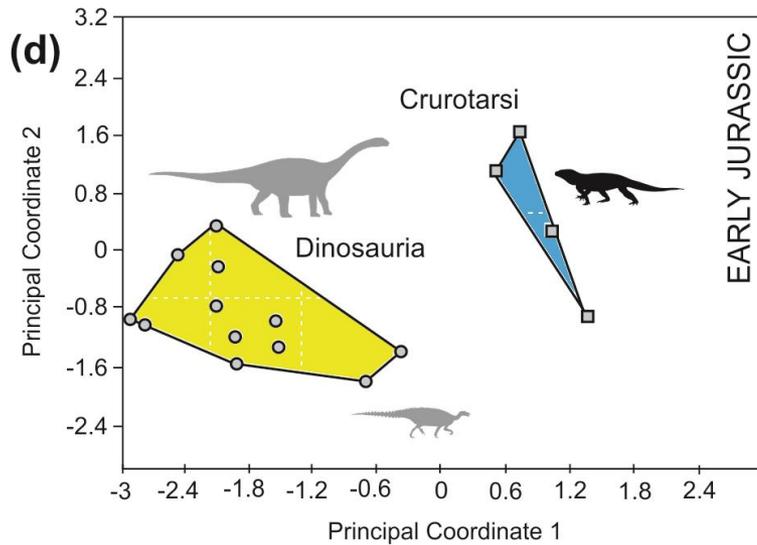
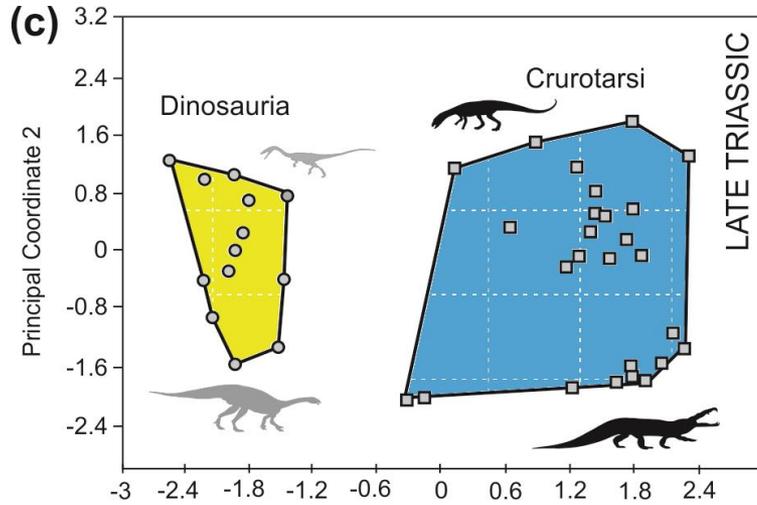


Extinção do Triássico

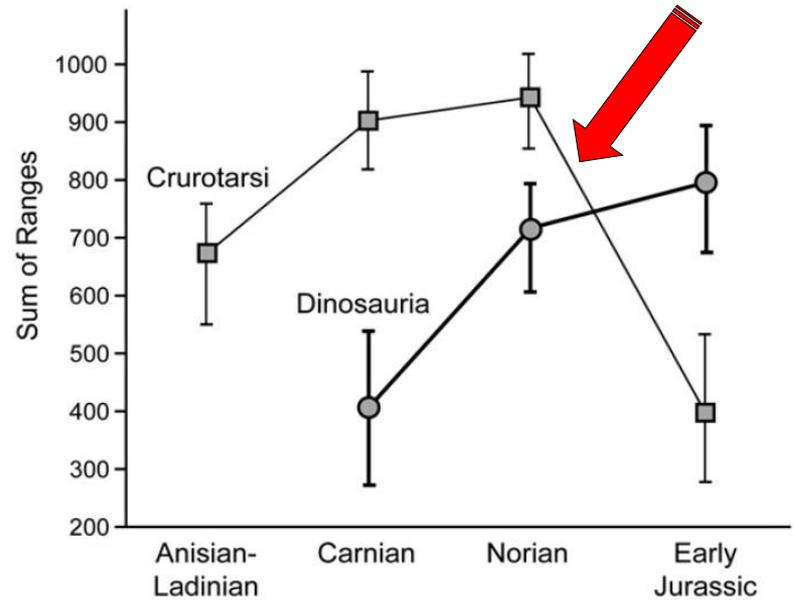
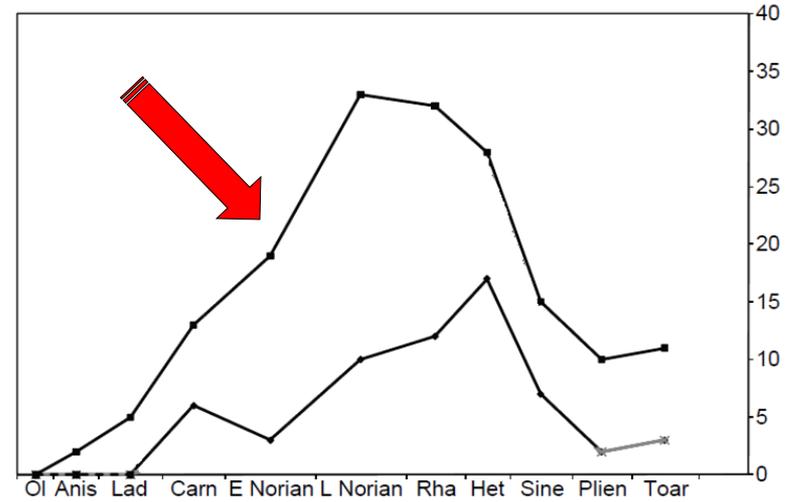
Grupos mais afetados – Vertebrados: dicinodontes, pseudosúquios.



Extinção do Triássico



All Dinosauria

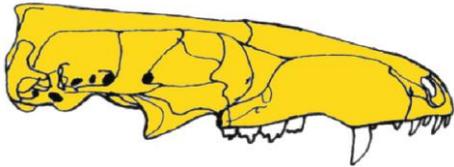


Extinção do Triássico

Origem dos grupos terrestres de vertebrados recentes
(mamíferos, tartarugas, arcossauros e lepidossauros)



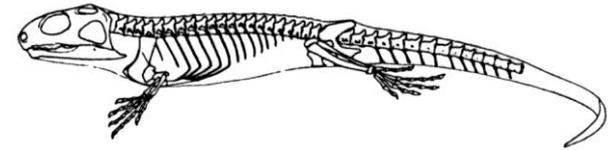
Adelobasileus
(EUA)



Sinoconodon
(China)



Odontochelys
(China)

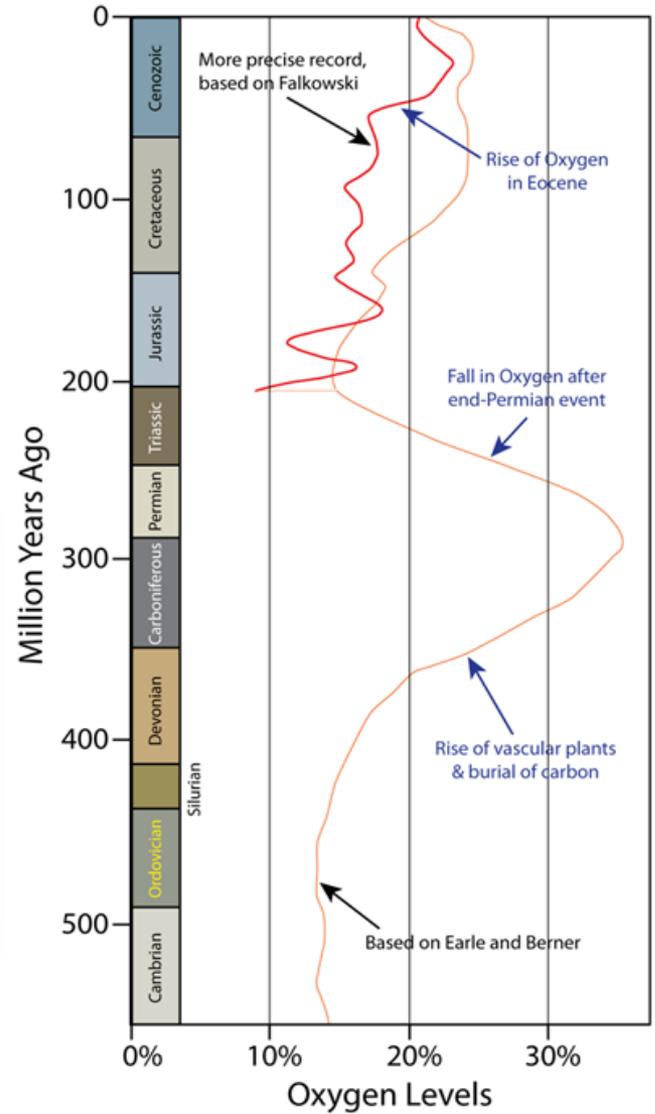
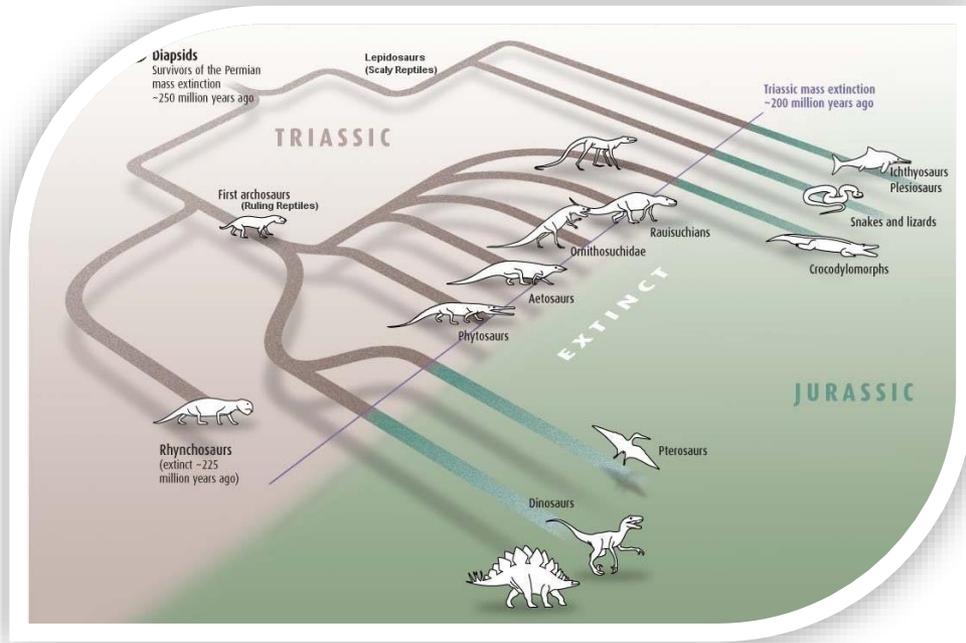
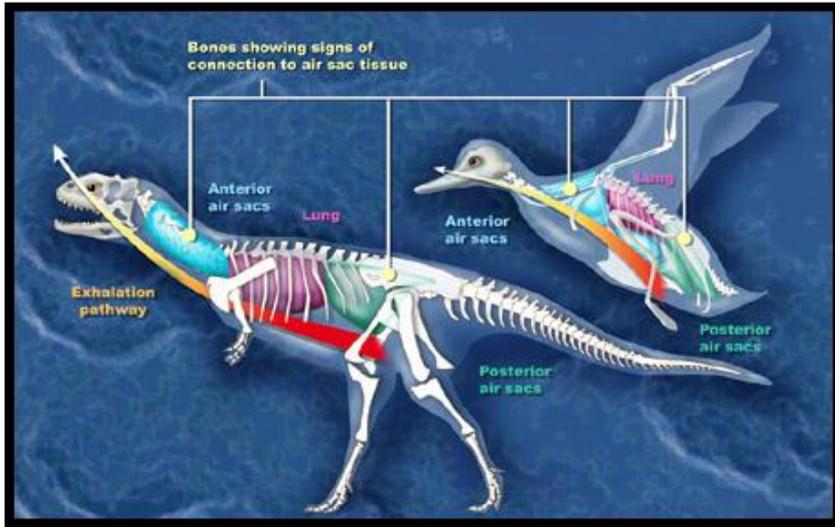


Brachyrhinodon (Escócia)



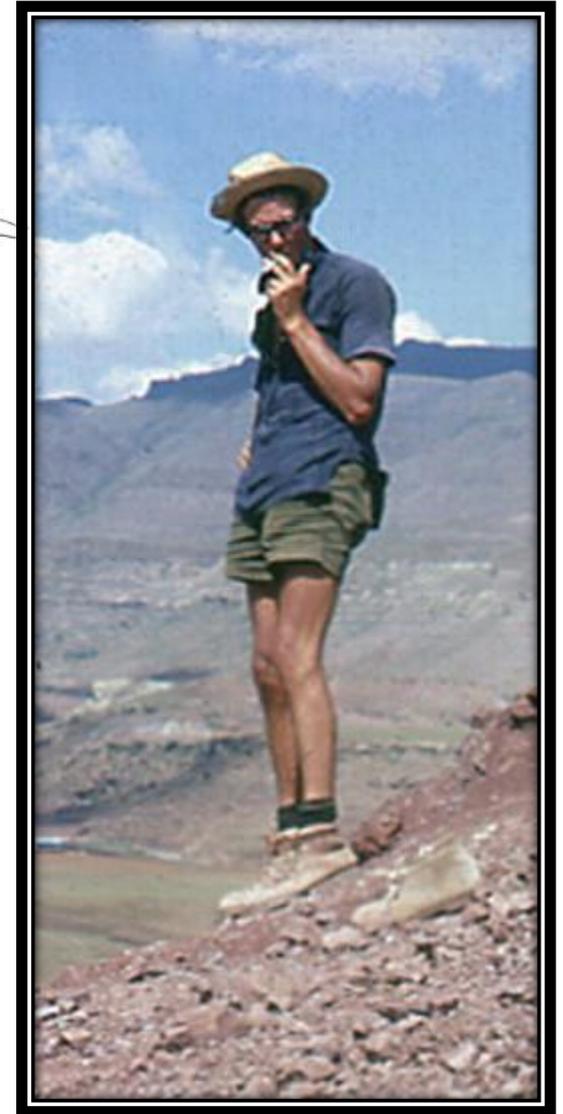
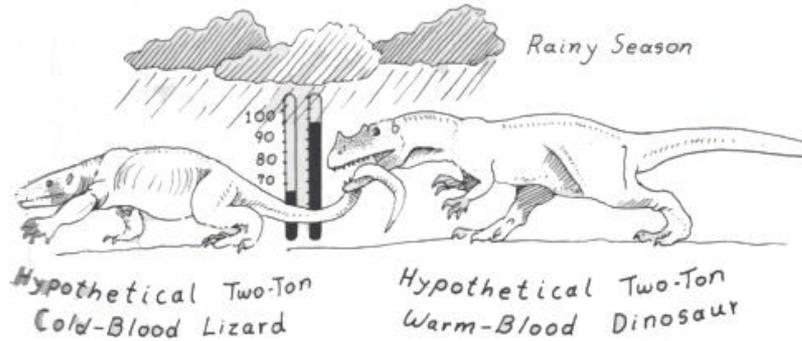
Postosuchus (EUA)

Extinção do Triássico



Extinção do Triássico

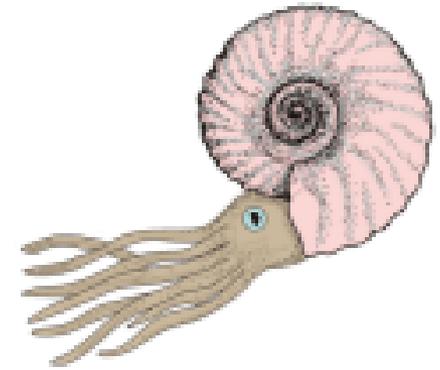
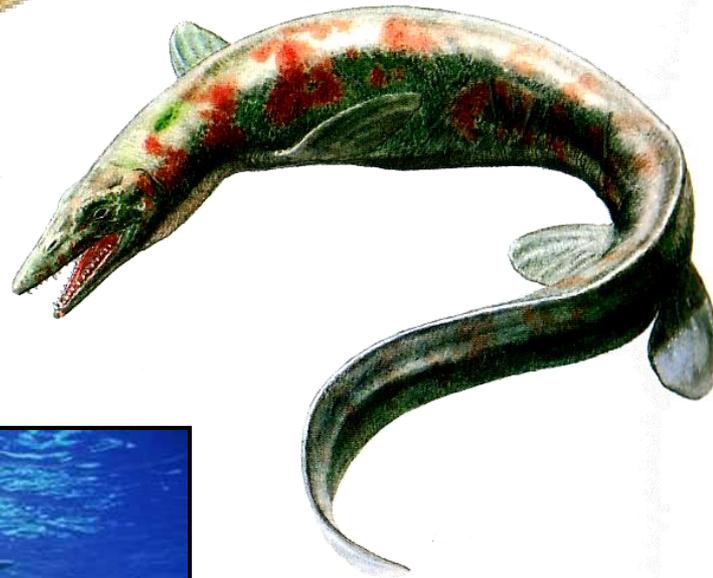
Seventies



Extinção em massa K-T (Cretáceo-Terciário)

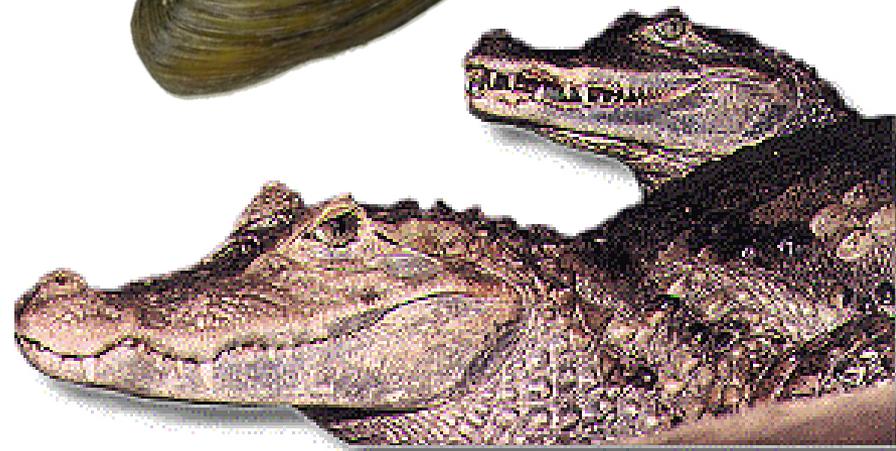
Desaparecimento de 50% dos gêneros e 20% das famílias

Além da maioria dos dinossauros, se extinguiram pterossauros, plesiossauros, mosasauros, amonitas, belemnitas e rudistas



Extinção em massa K-T (Cretáceo-Terciário)

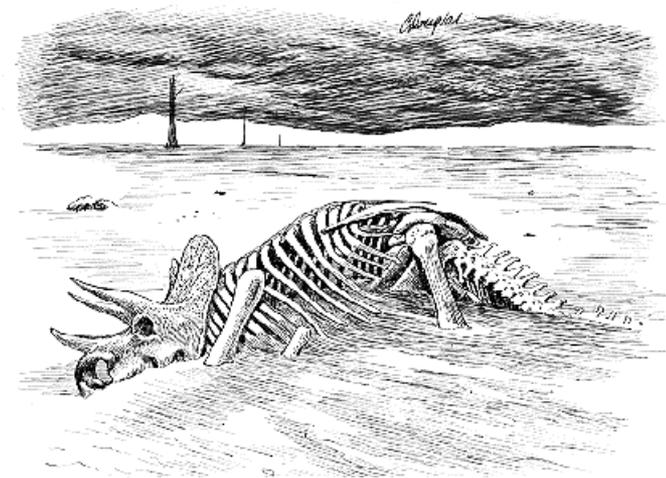
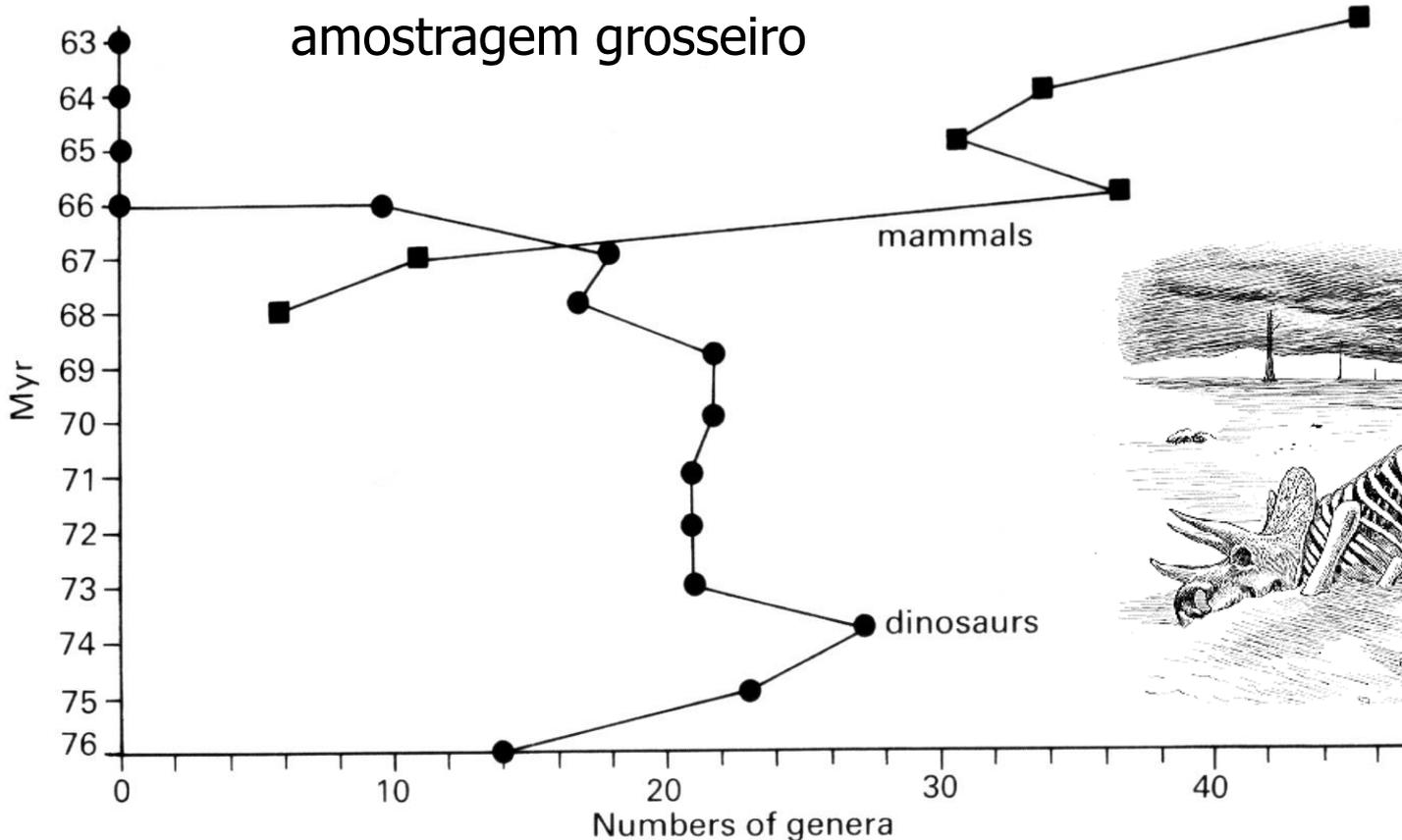
Pouca (ou nenhuma) perda de diversidade: crocodilos, mamíferos, tartarugas, lagartos, bivalves e gastrópodos



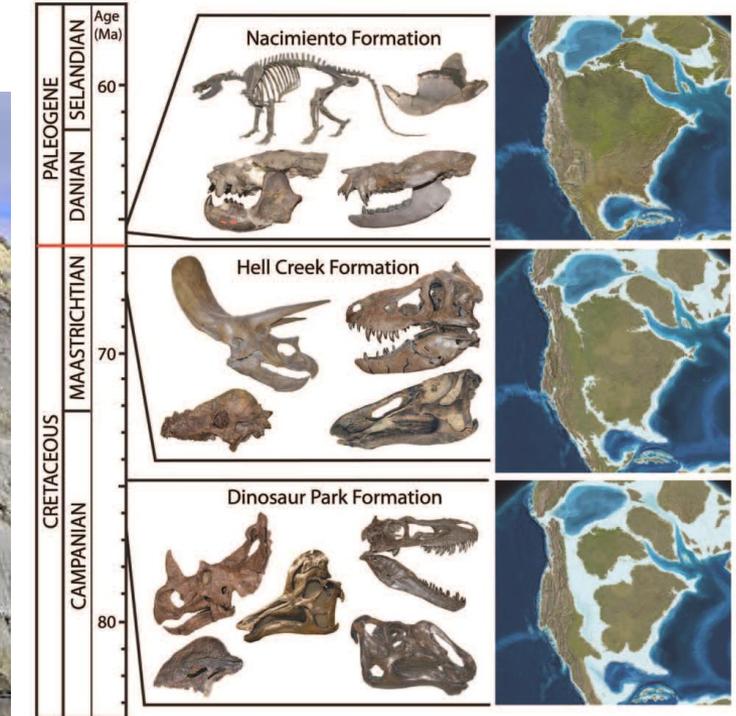
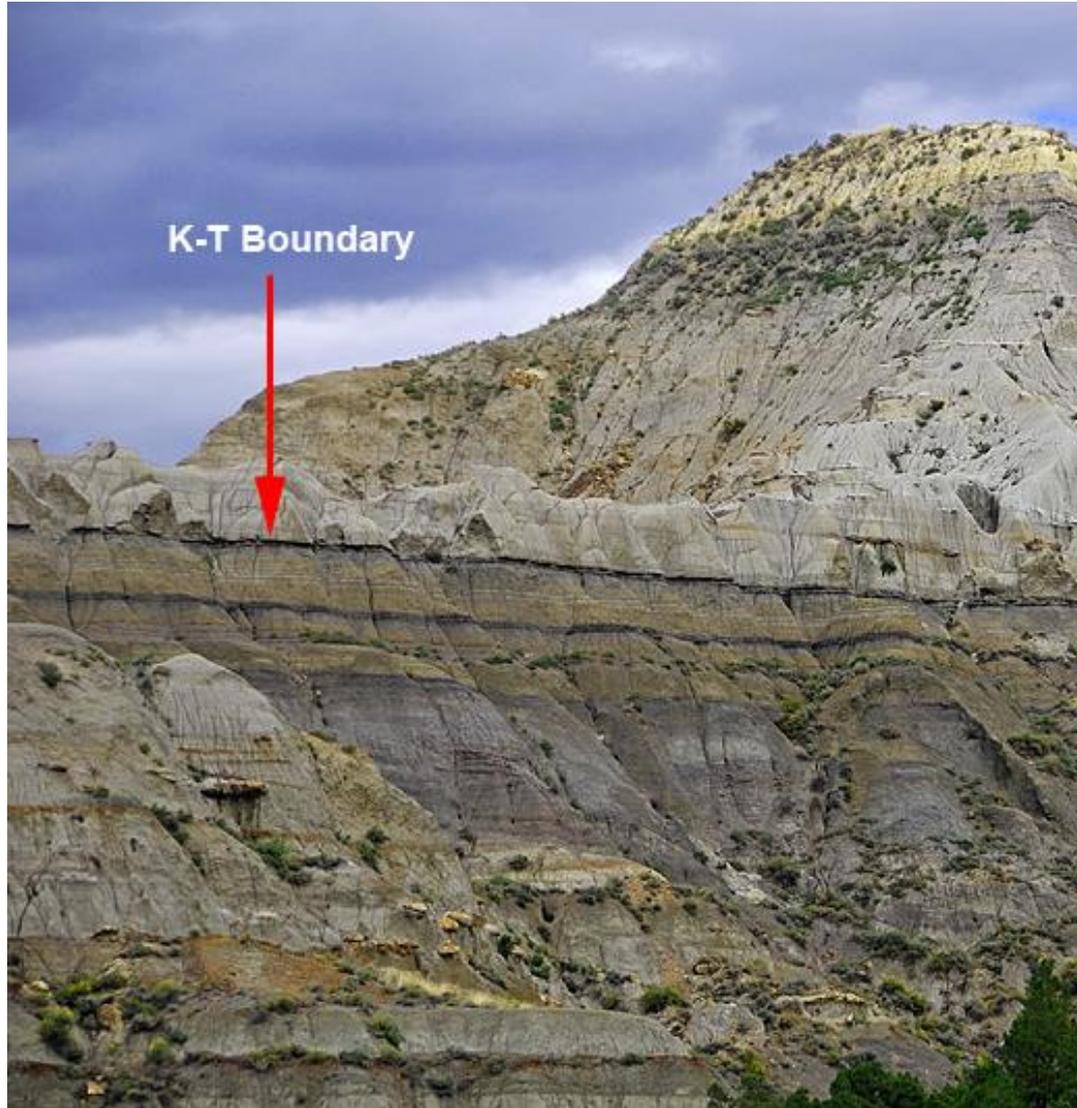
Extinção em massa K-T (Cretáceo-Terciário)

Evento catastrófico ou gradativo? Belemnitas, amonitas, plesiossauros, pterossauros, já estavam em declínio
Bem como alguns dinossauros?! (controverso)

Problema: intervalo de amostragem grosseiro



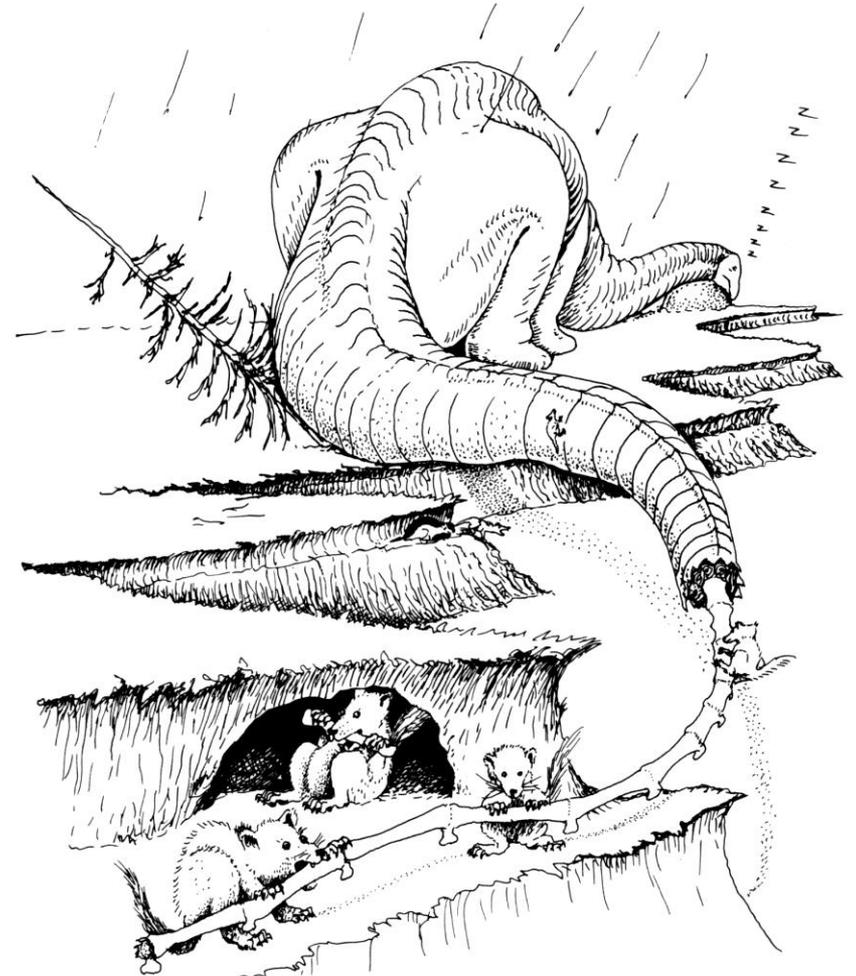
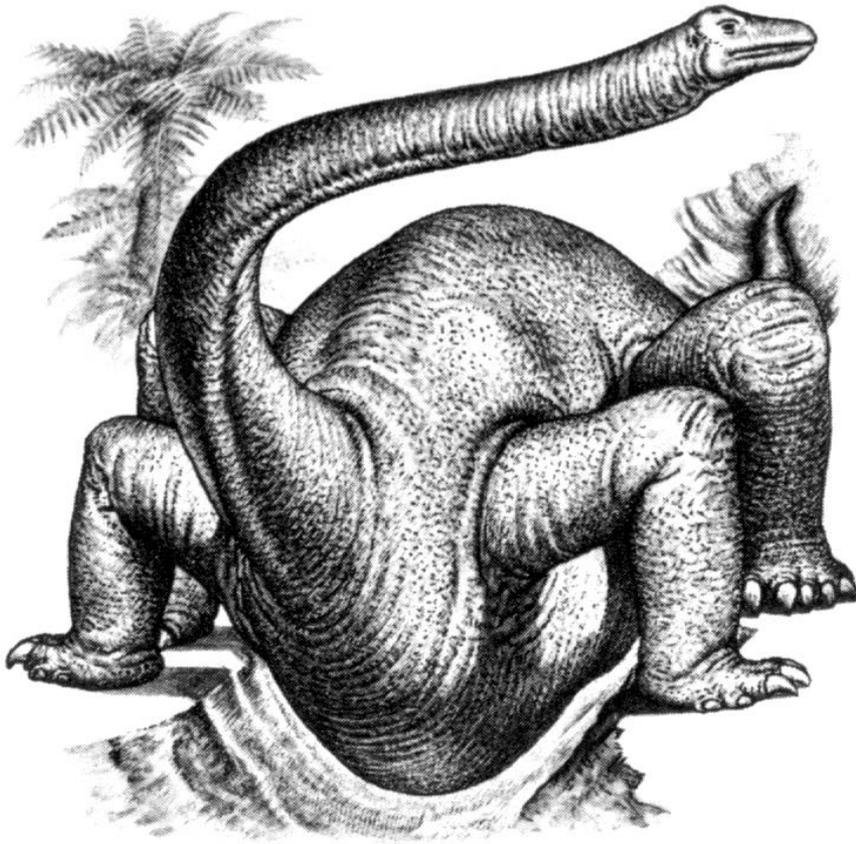
Extinção em massa K-T (Cretáceo-Terciário)



Extinção em massa K-T (Cretáceo-Terciário)

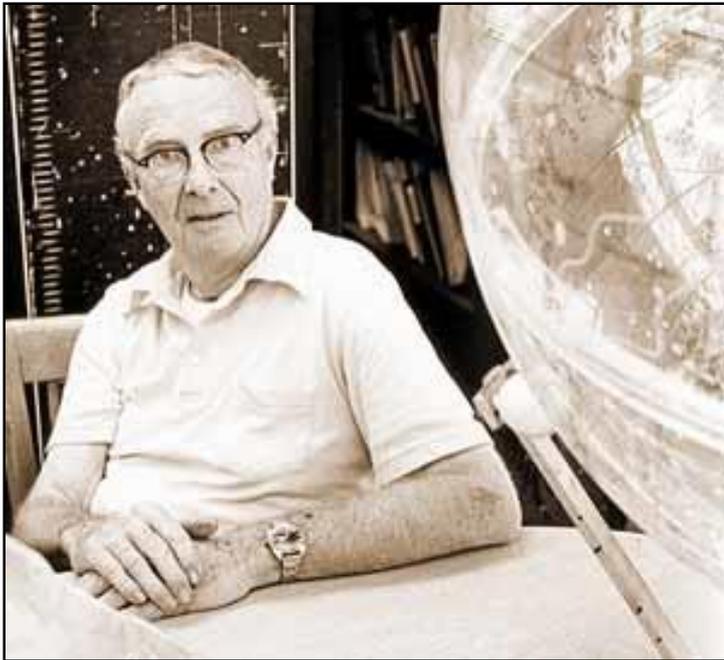
Causas: explicações arcaicas (pouca adaptabilidade)

Genética exaurida: gigantismo, excesso de espinhos!



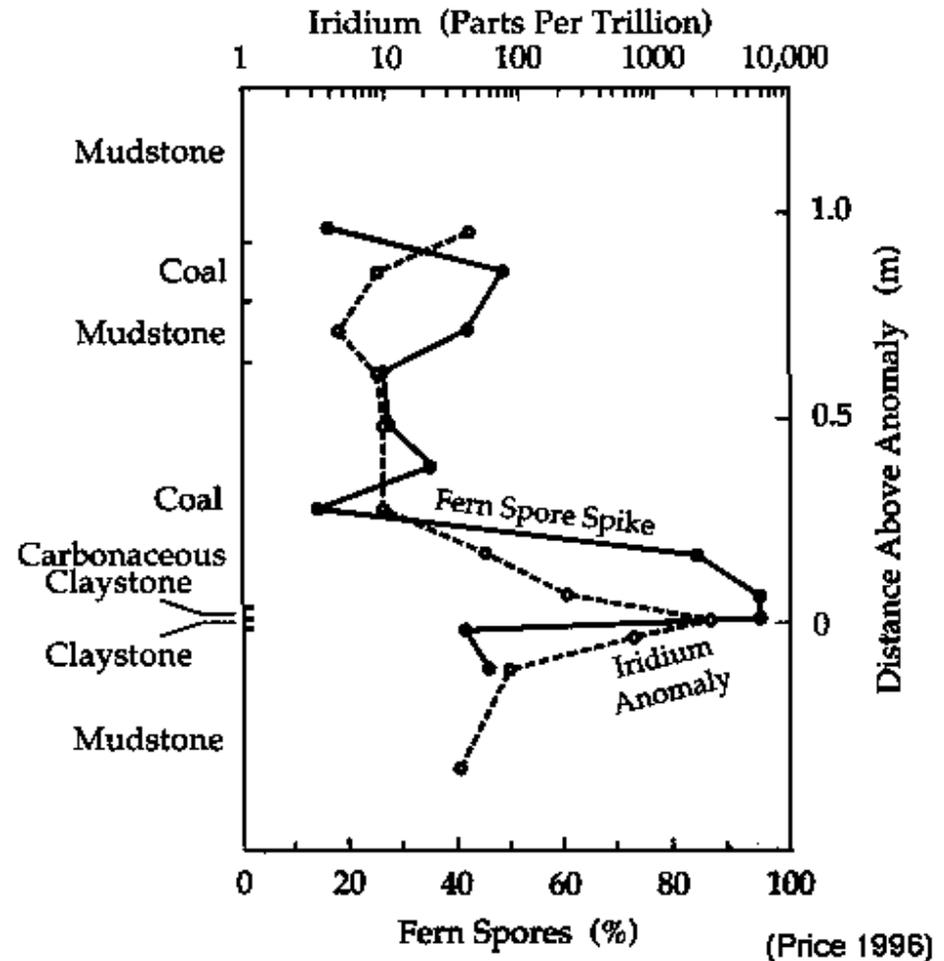
Extinção em massa K-T (Cretáceo-Terciário)

Causas: hipótese atuais - Impacto de Asteróide



Luis Alvarez (1980)

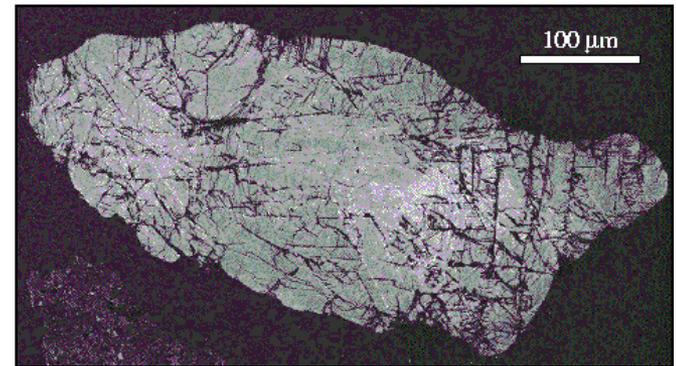
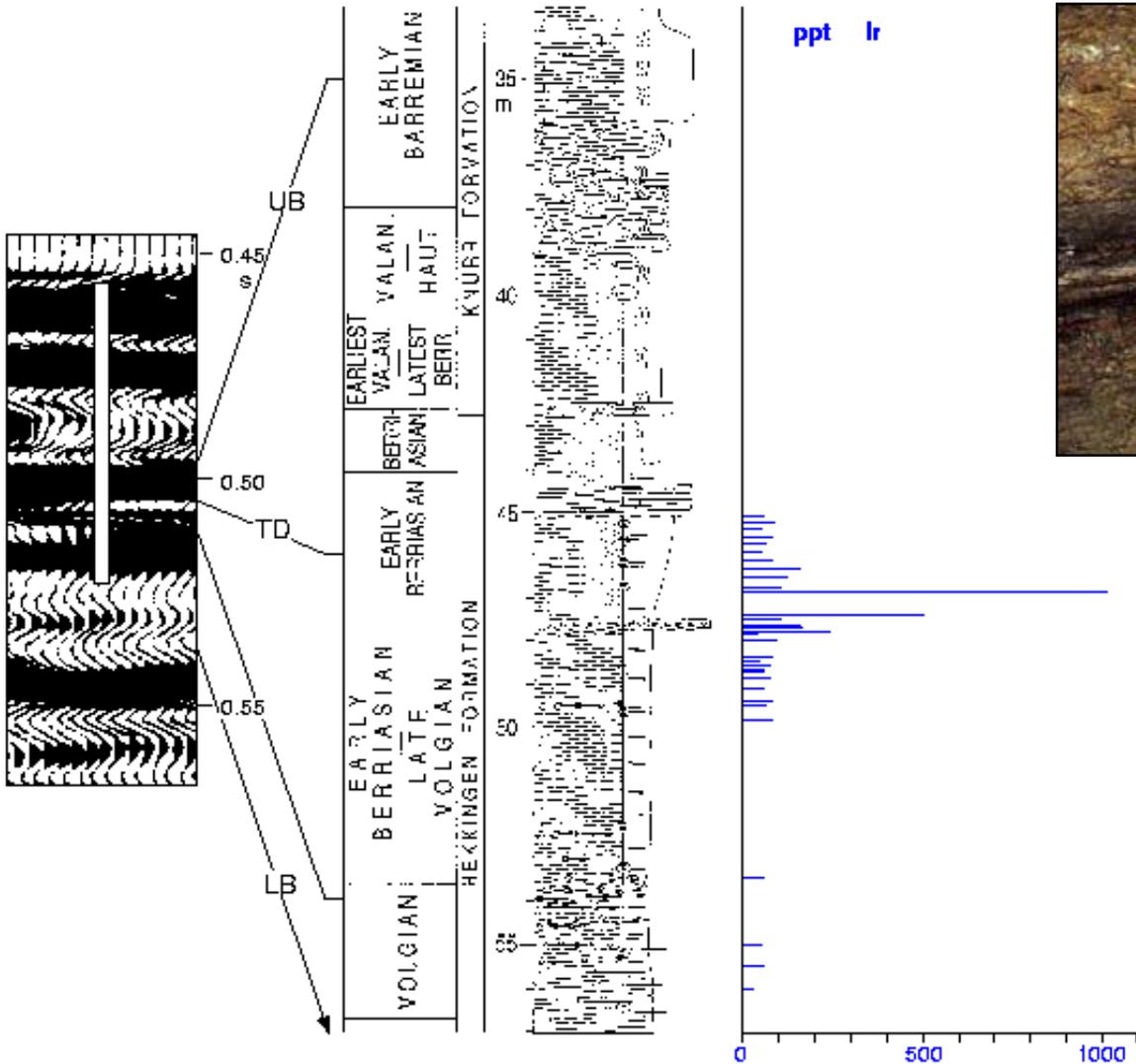
Anomalia de irídio: associada a quartzo impactado e extinção de pólen e plâncton



Pico de pteridófitas (oportunistas)

Extinção em massa K-T (Cretáceo-Terciário)

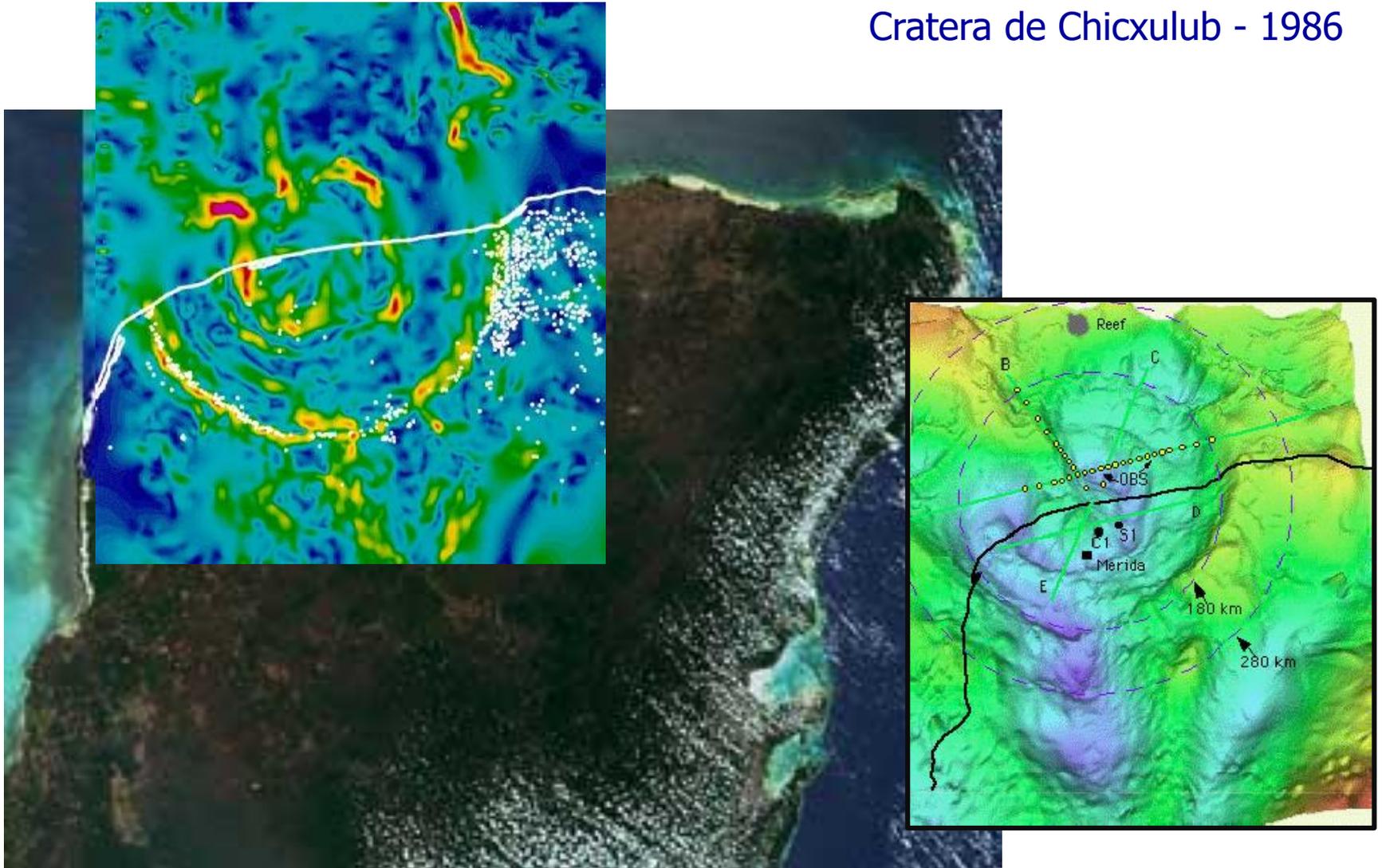
Anomalia de irídio e quartzo impactado



Extinção em massa K-T (Cretáceo-Terciário)

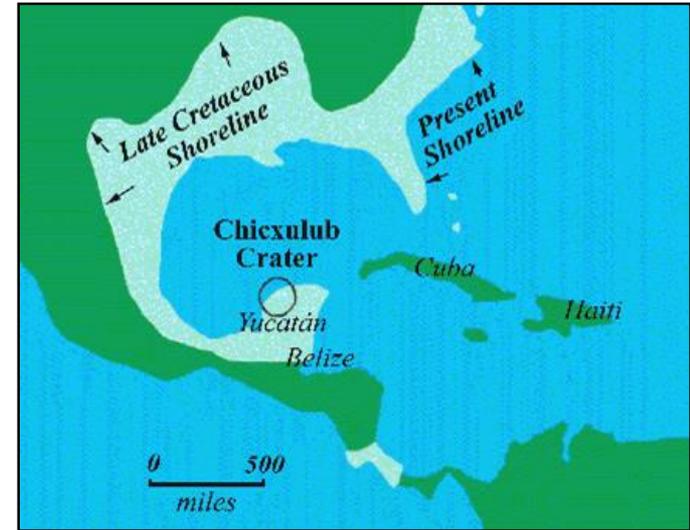
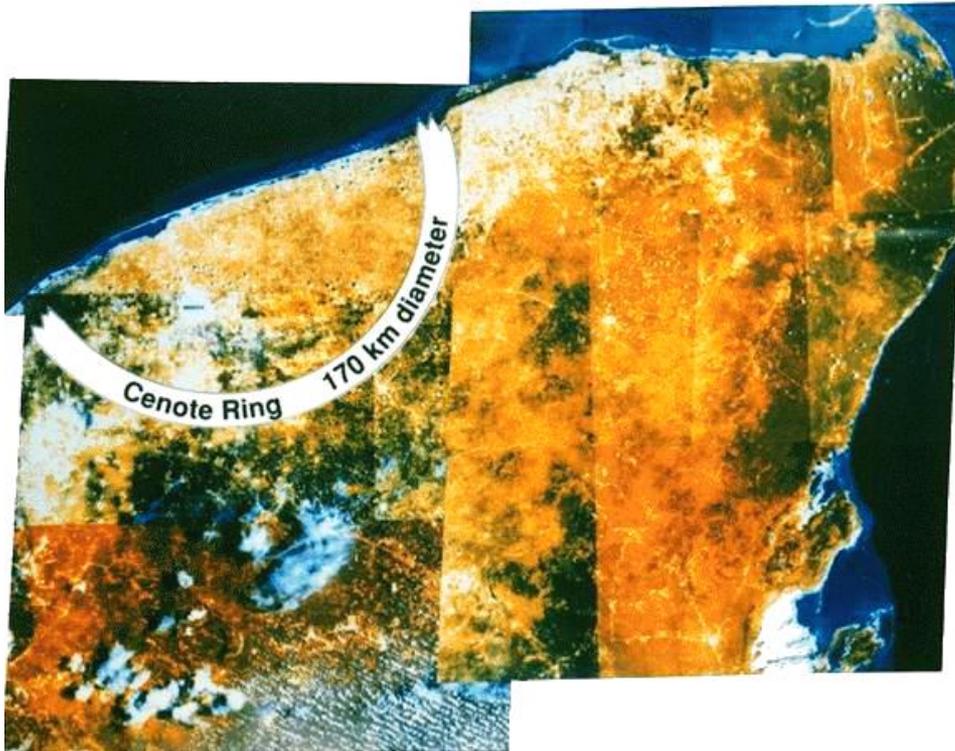
Causas: hipótese atuais - Impacto de Asteróide

Cratera de Chicxulub - 1986



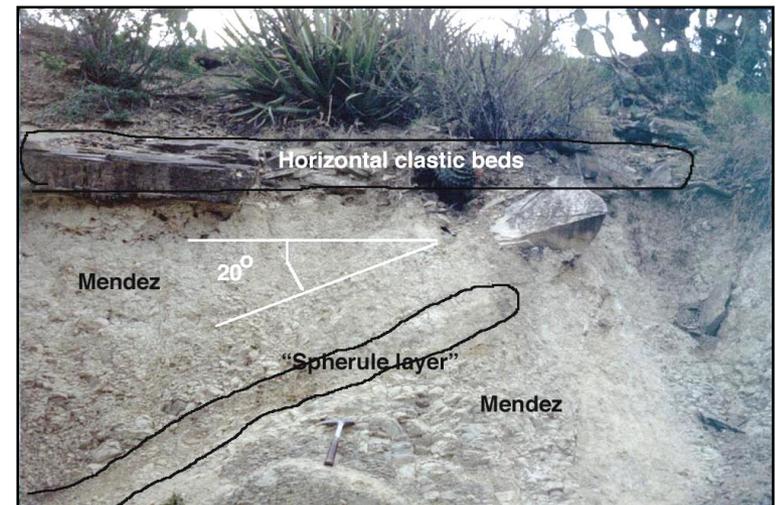
Extinção em massa K-T (Cretáceo-Terciário)

Causas: hipótese atuais - Impacto de Asteróide



Cratera de Chicxulub, K-T de Yucatán

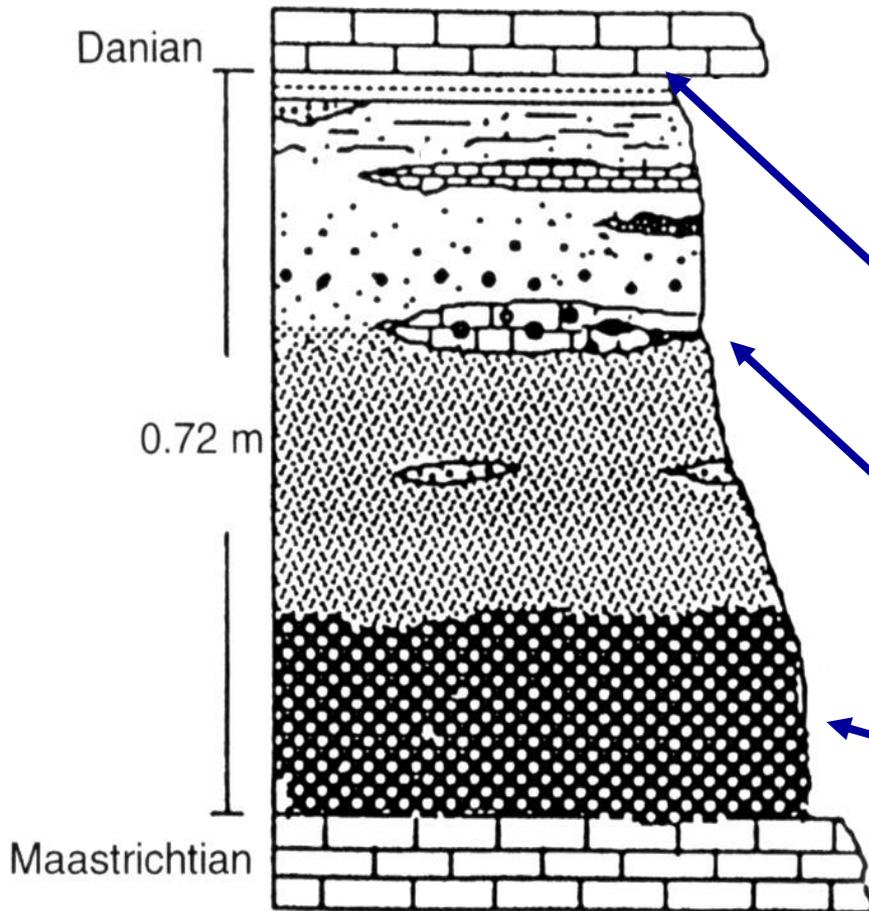
Afloramentos em El Penon



Extinção em massa K-T (Cretáceo-Terciário)

Causas: hipótese atuais - Impacto de Asteróide

Sessão de Beloc, Haiti



Anomalia de irídio

Evidências de tsunamis

Esférulas víteas

Impacto de Asteróide



Extinção em massa K-T (Cretáceo-Terciário)

Consequências: chuva ácida



* Ácido Nítrico: energia liberada pela impacto teria possibilitado a reação entre O_2 e N_2

* Ácido Sulfúrico: produzido a partir de SO_3 e SO_4 vaporizado das rochas próximas ao impacto



Extinção em massa K-T (Cretáceo-Terciário)

Consequências: nuvem de poeira

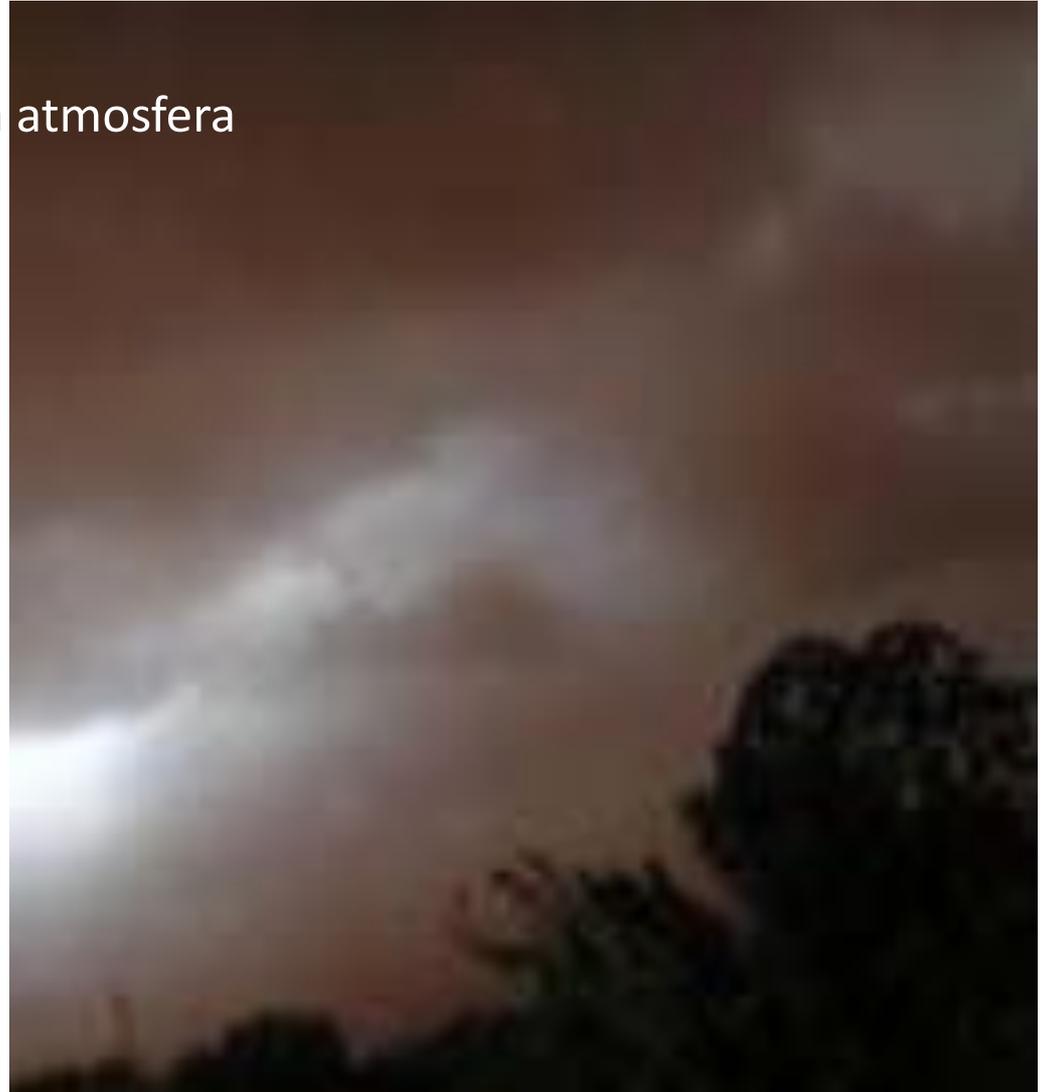
*Suspensão de partículas sólidas na atmosfera

*Longos períodos de escuridão

*Diminuição da temperatura

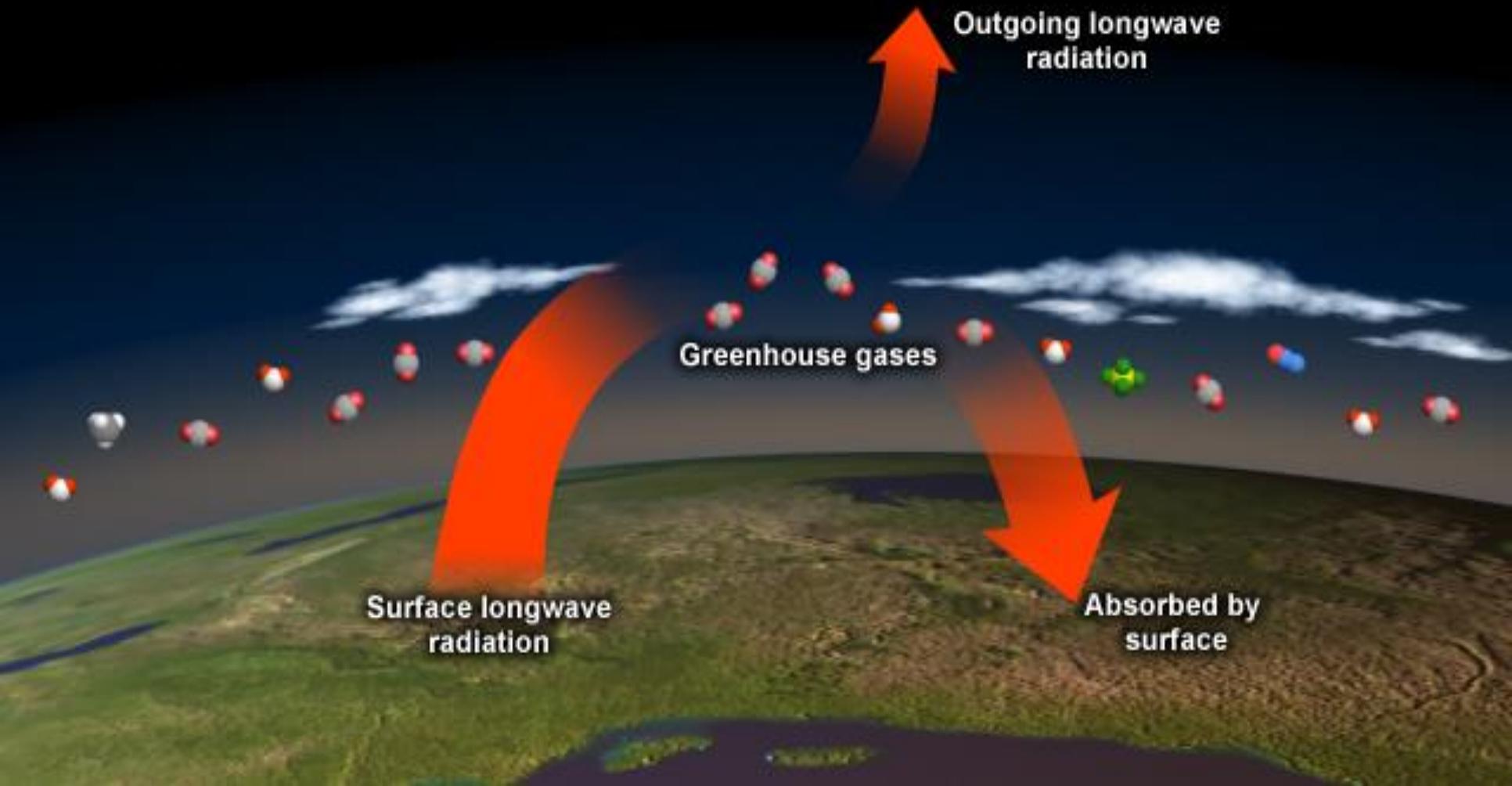
*Diminuição da fotossíntese

*Queda da produtividade primária



Extinção em massa K-T (Cretáceo-Terciário)

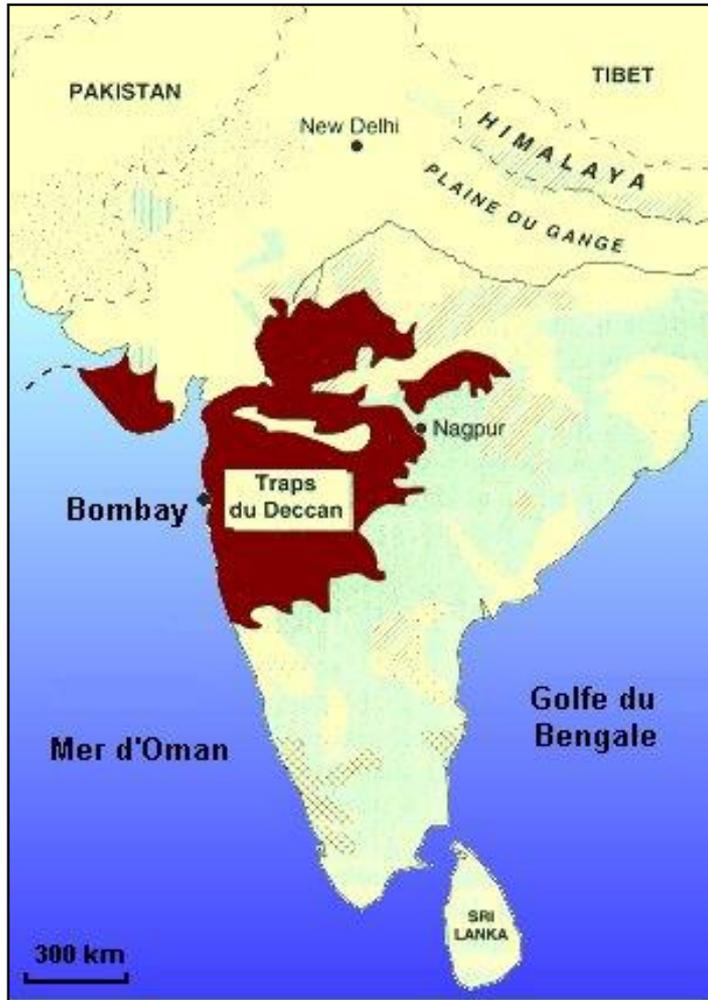
Consequências: efeito estufa



Extinção em massa K-T (Cretáceo-Terciário)

Causas: hipótese atuais – Vulcanismo

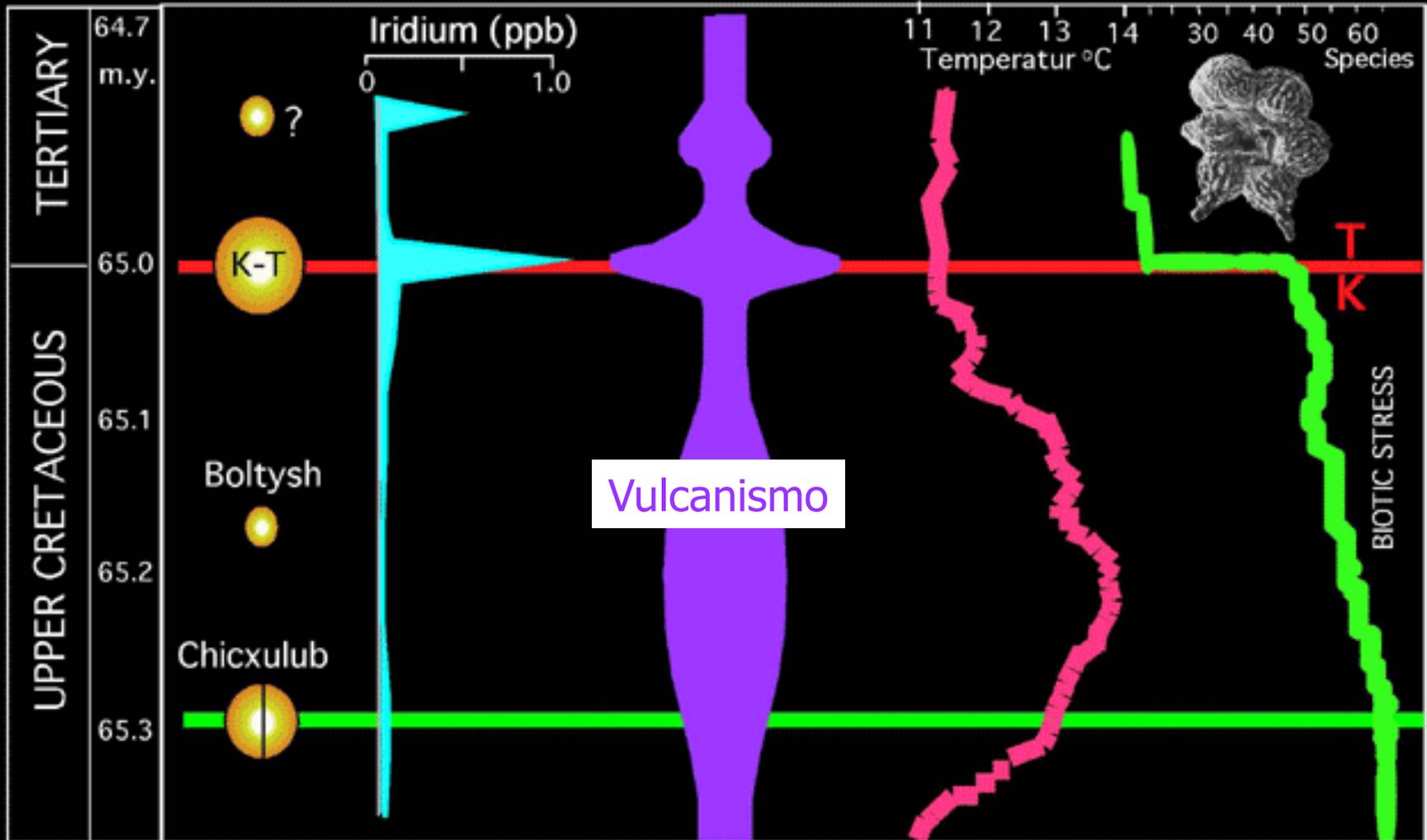
Poderia explicar anomalia de irídio e “pico de samambaias”



Deccan Traps, Índia
erupções em massa no K-T

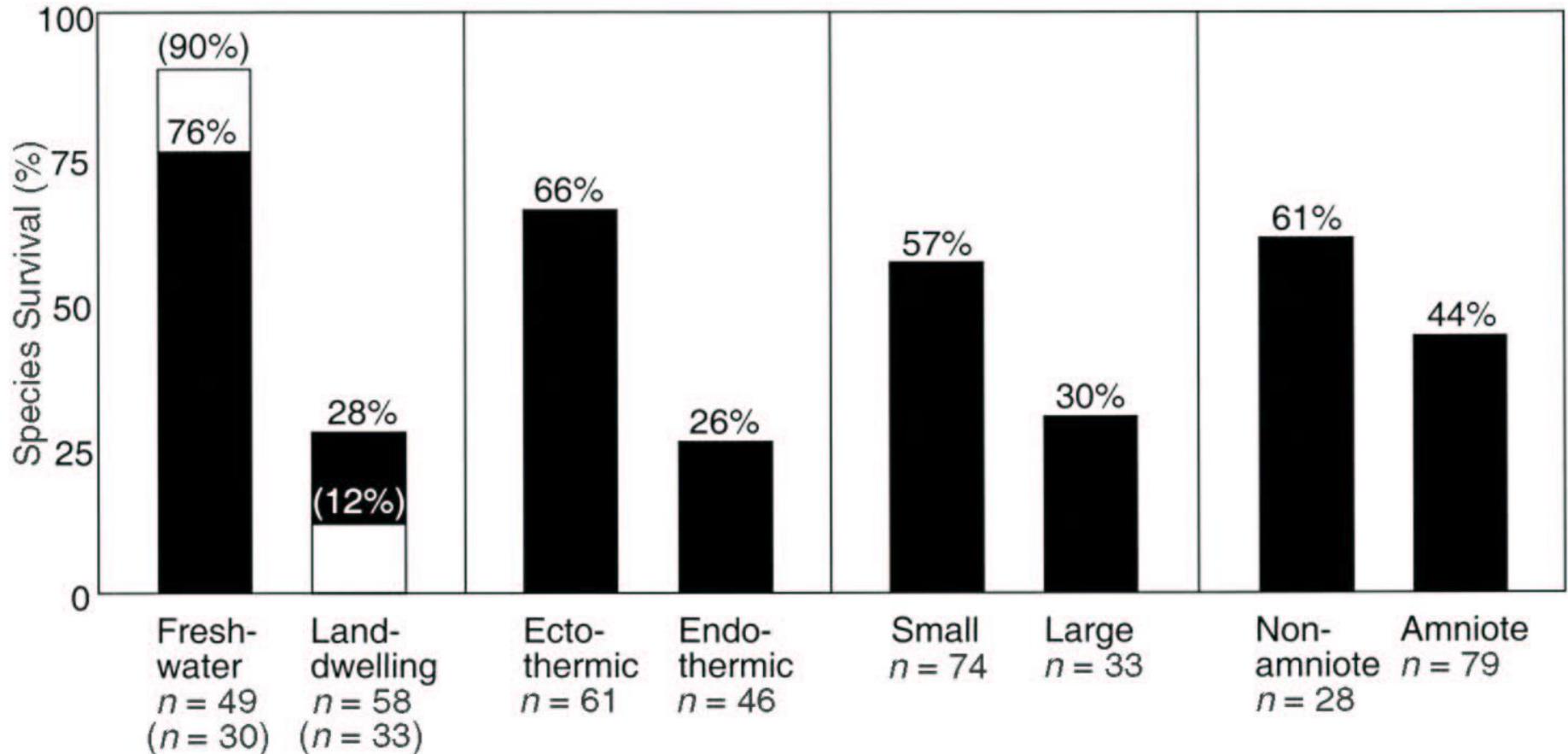
Extinção em massa K-T (Cretáceo-Terciário)

Chicxulub: 300 mil anos mais antigo



Extinção em massa K-T (Cretáceo-Terciário)

Consequências (em cenários de impacto ou vulcanismo):
inverno nuclear (redução da produtividade primária) e efeito estufa



Formas dependentes de ciclo detritívoro foram menos afetadas

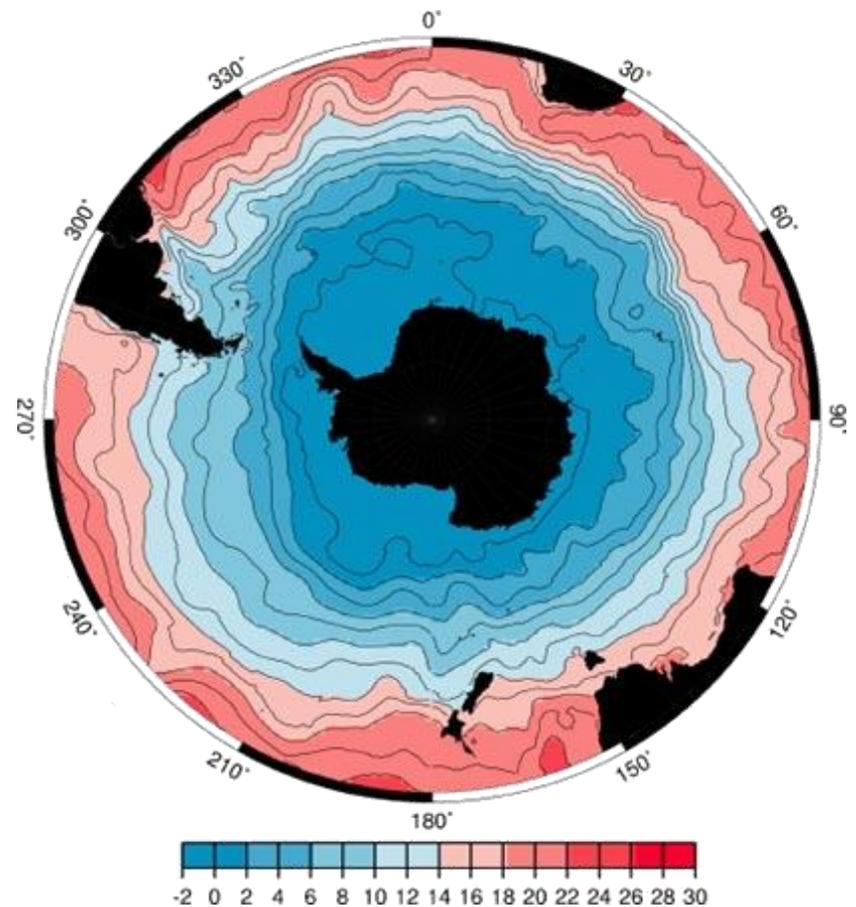
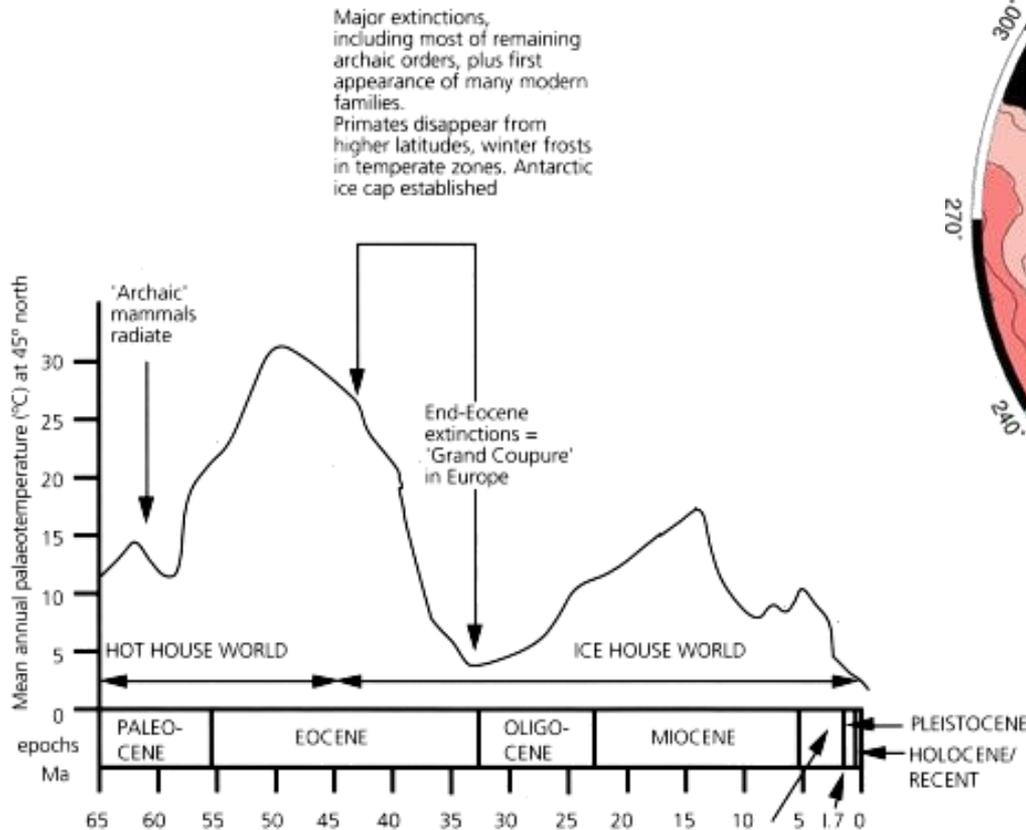
Extinção em massa K-T (Cretáceo-Terciário)



Depois da "big-five"

Antártica, "grand-coupure" e gramíneas

Formação da corrente circumpolar antártica e das calotas polares



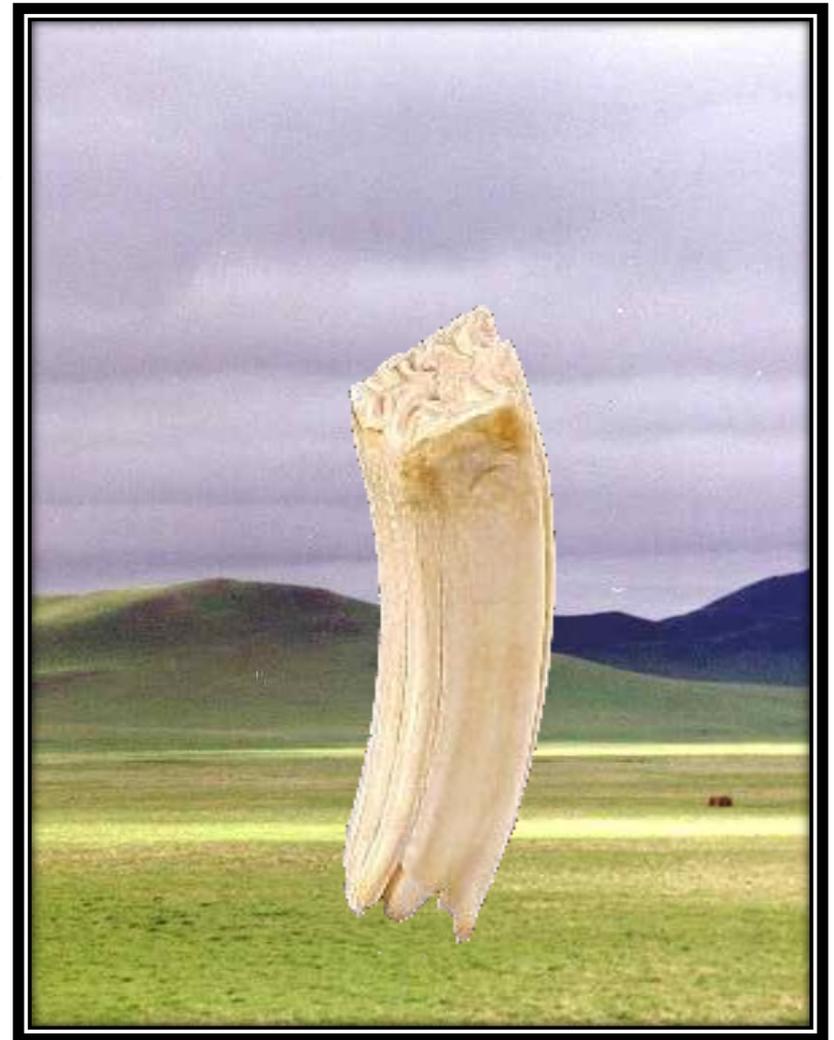
Depois da "big-five"

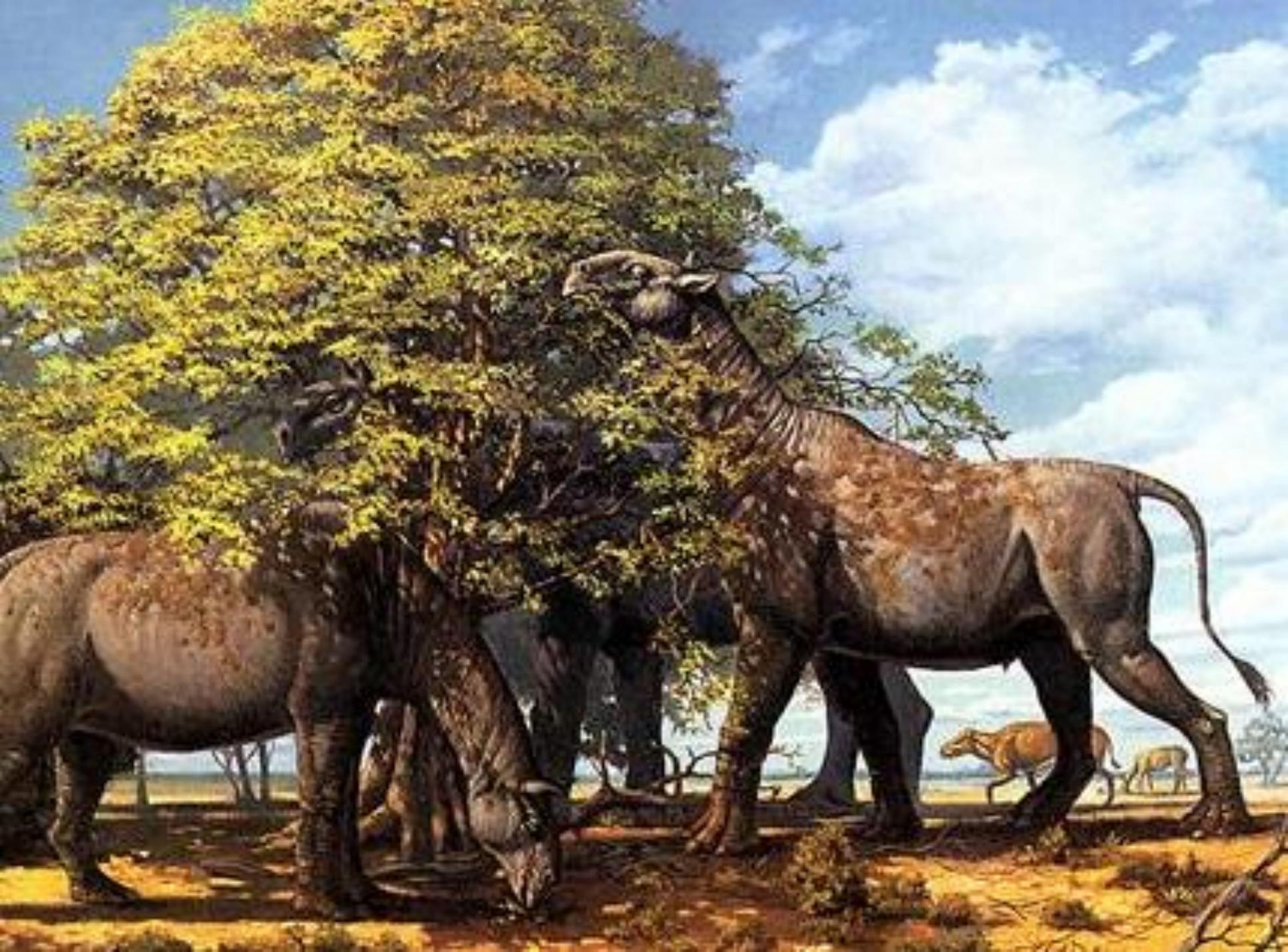
Antártica, "grand-coupure" e gramíneas



mamíferos do
Paleo-Eoceno

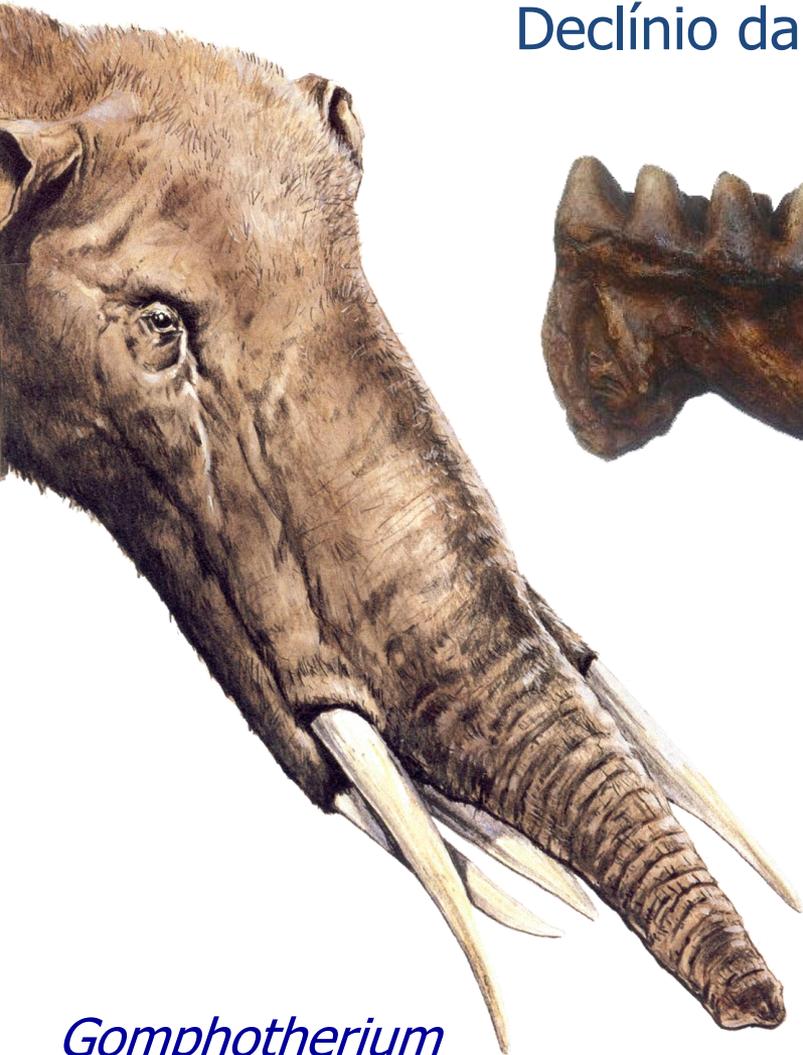
Molar
hipsodonte



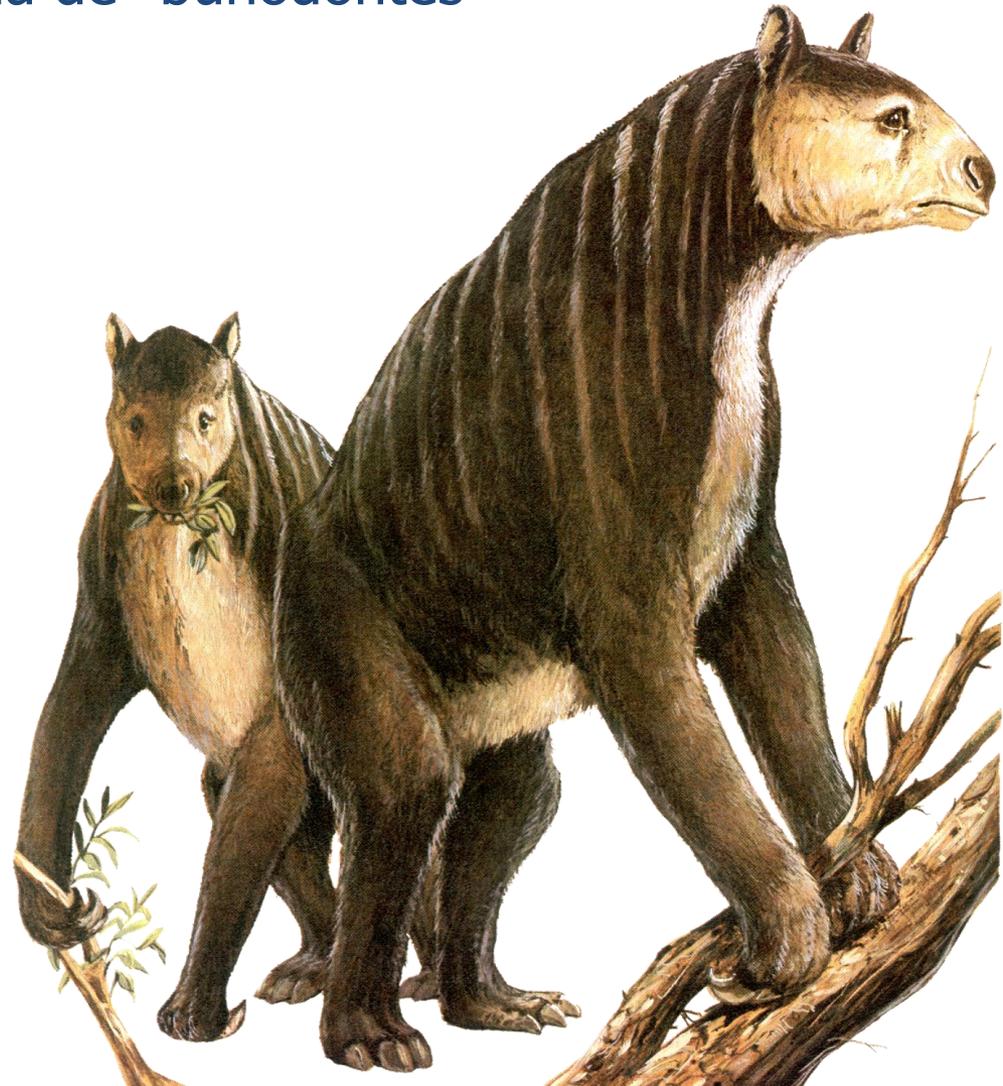


Depois da "big-five"
Antártica, "grand-coupure" e gramíneas

Declínio da fauna de "bunodontes"



Gomphotherium

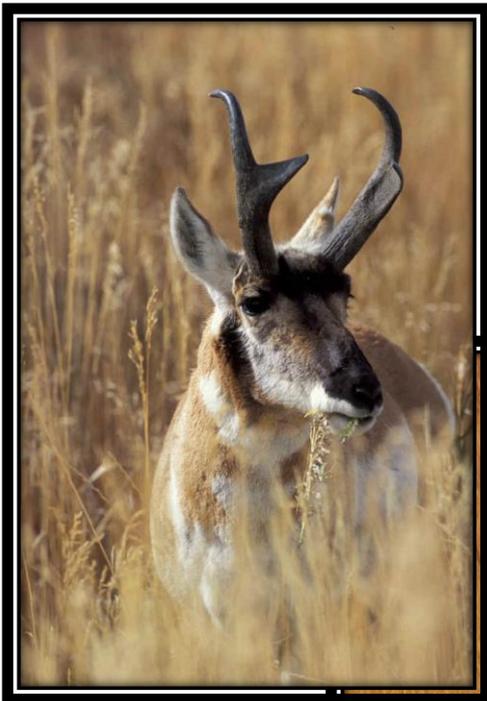


Depois da "big-five"

Antártica, "grand-coupure" e gramíneas

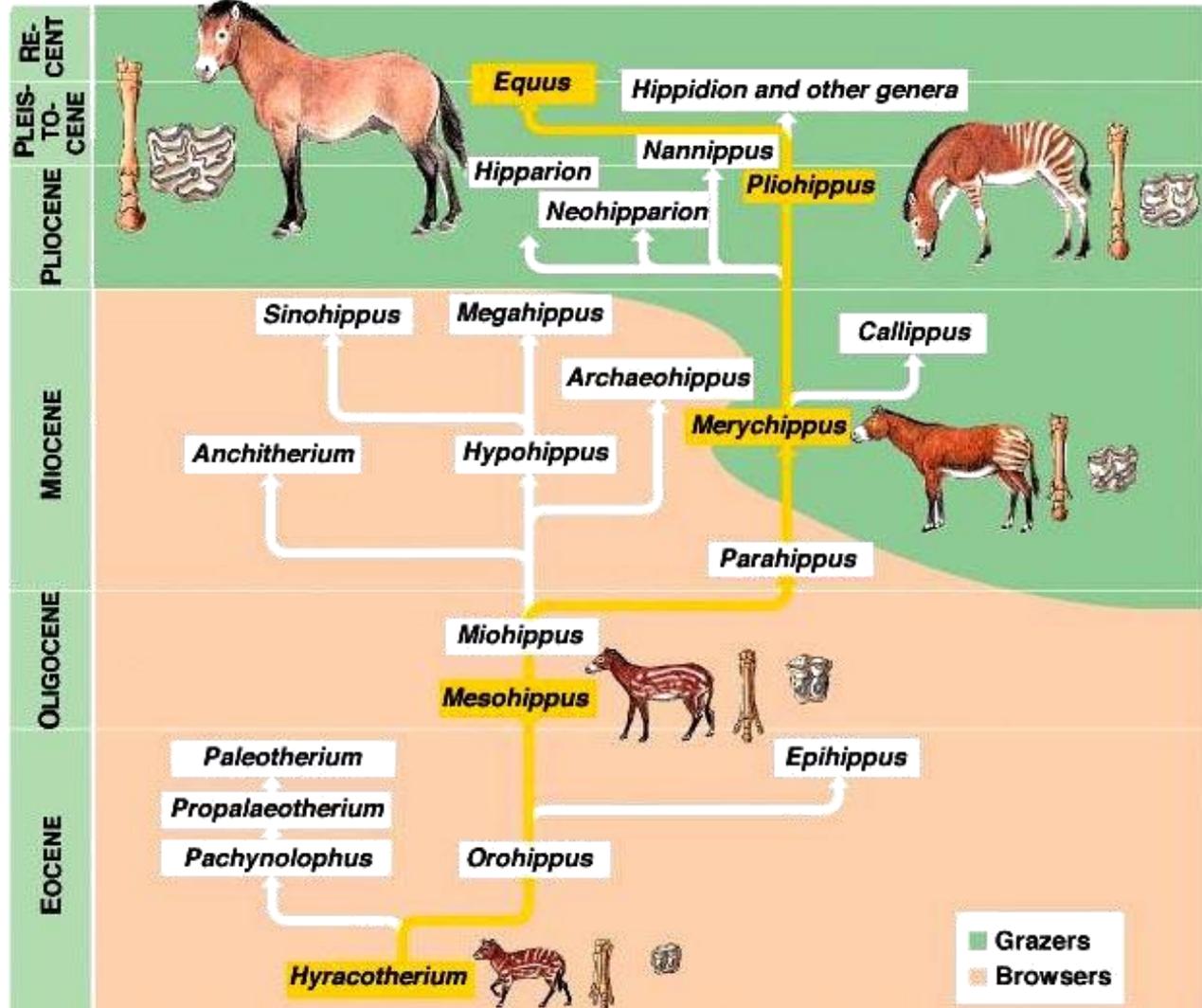
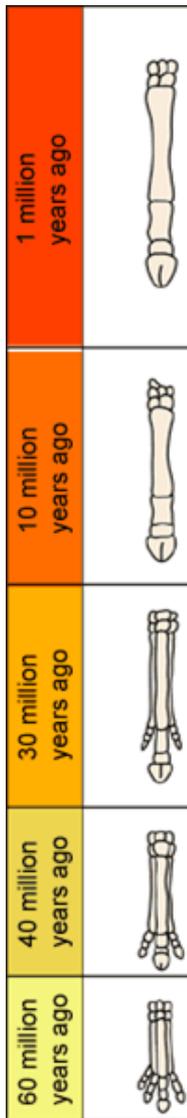
Domínio de Selenodontes na Eurásia, África e América do Norte

Cavalos na Eurásia e América do Norte



Depois da "big-five"

Antártica, "grand-coupure" e gramíneas

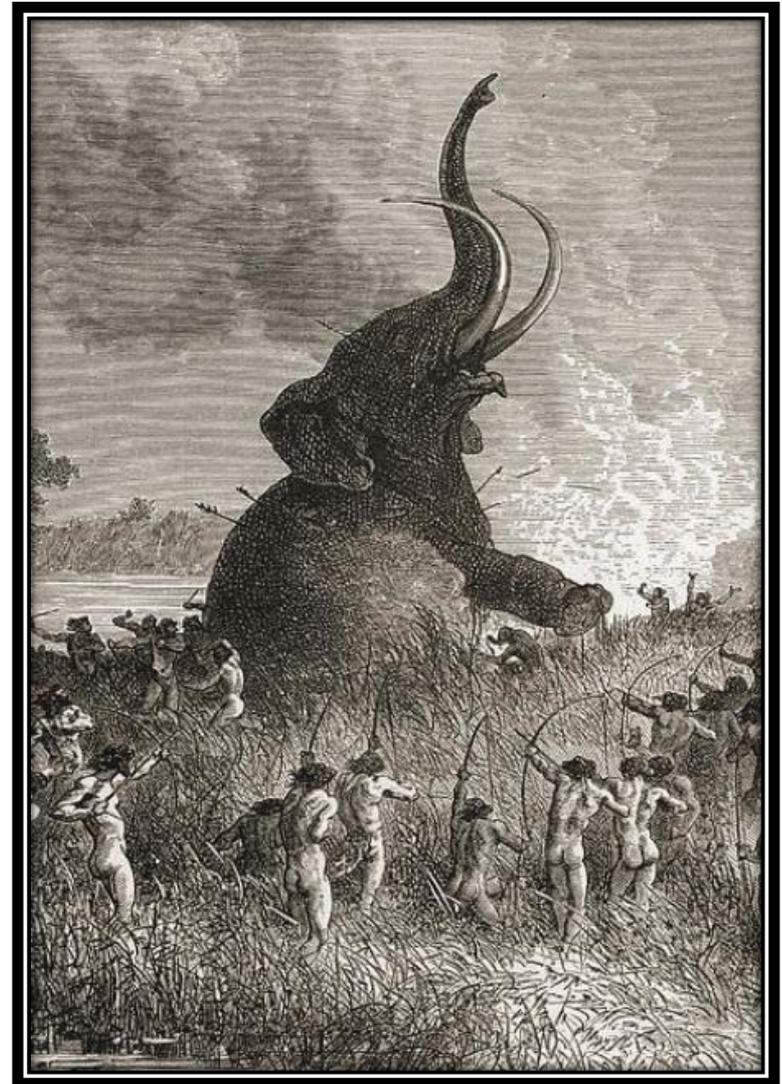
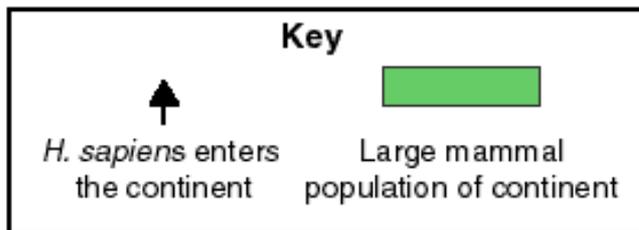
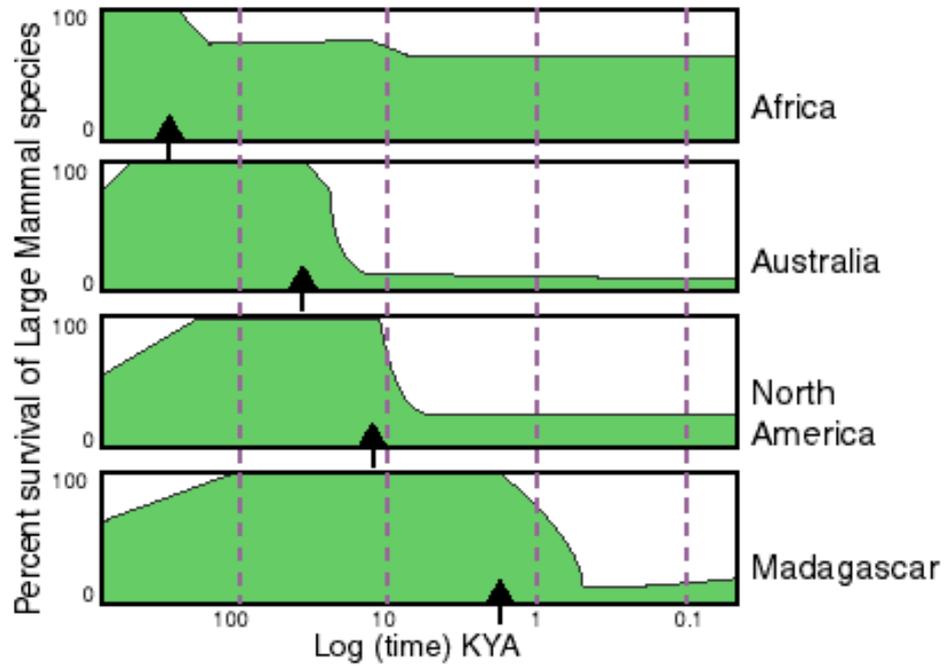


Depois da "big-five"
Irradiação do *Homo sapiens*



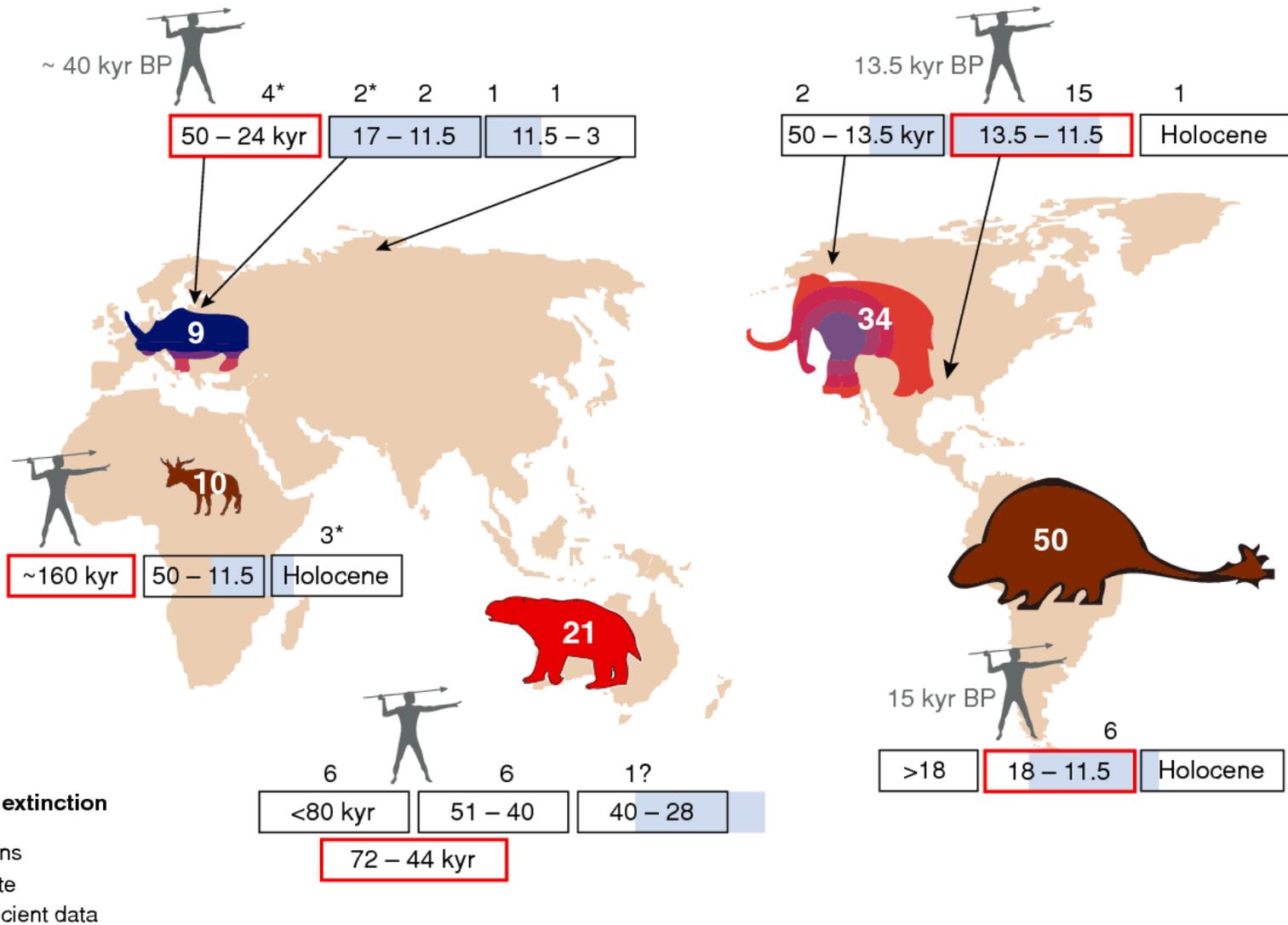
Depois da "big-five"

Irradiação do *Homo sapiens*



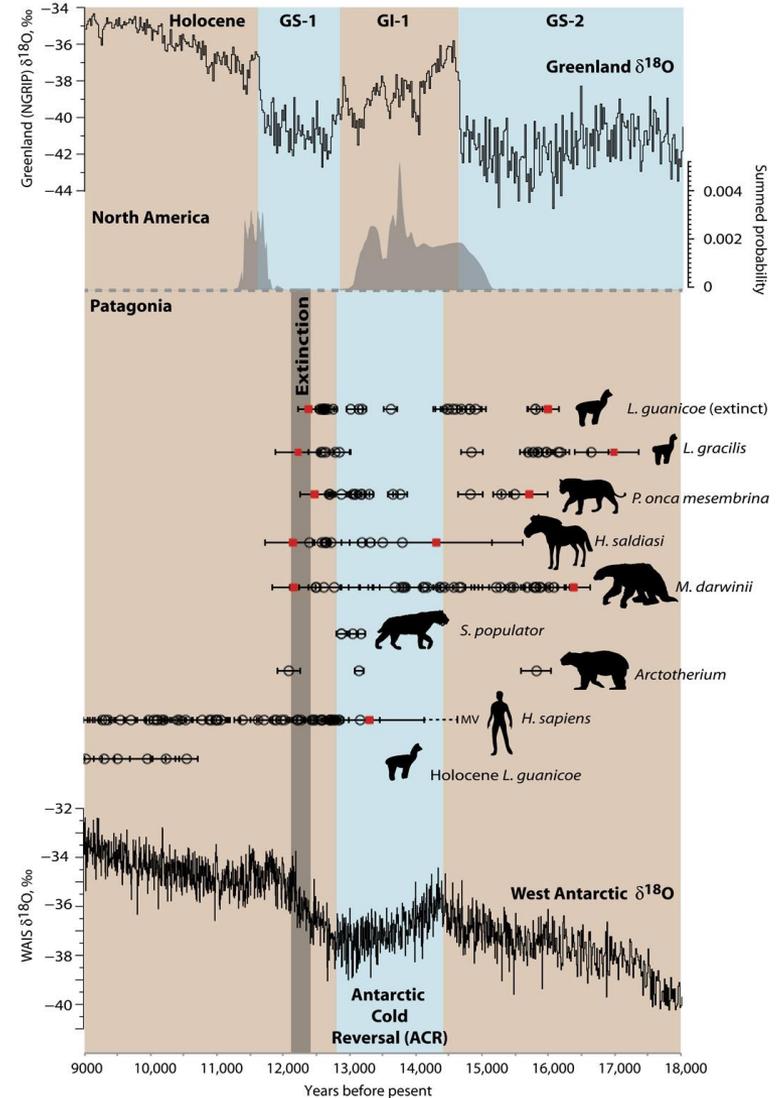
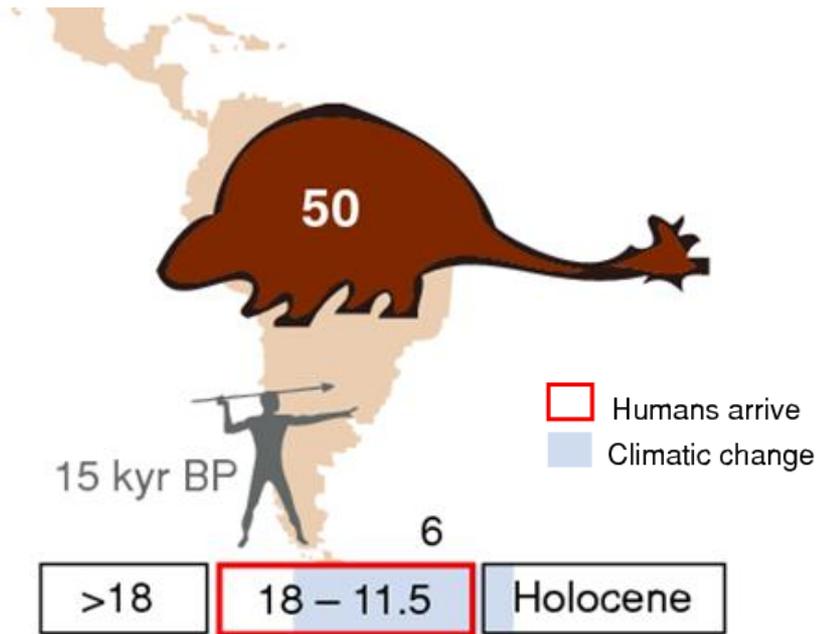
Depois da "big-five"

Irradiação do *Homo sapiens*



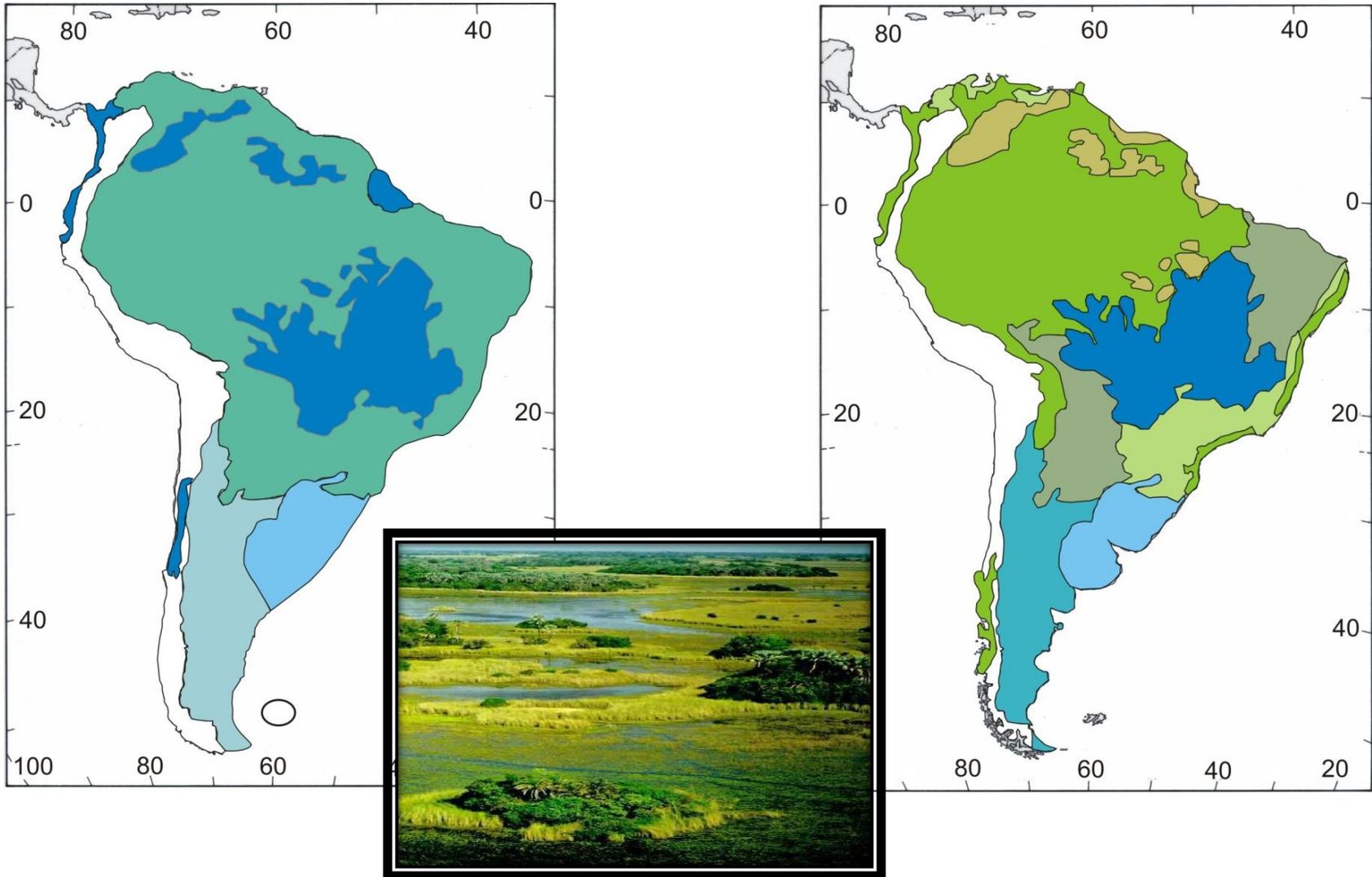
Depois da "big-five"

Irradiação do *Homo sapiens*



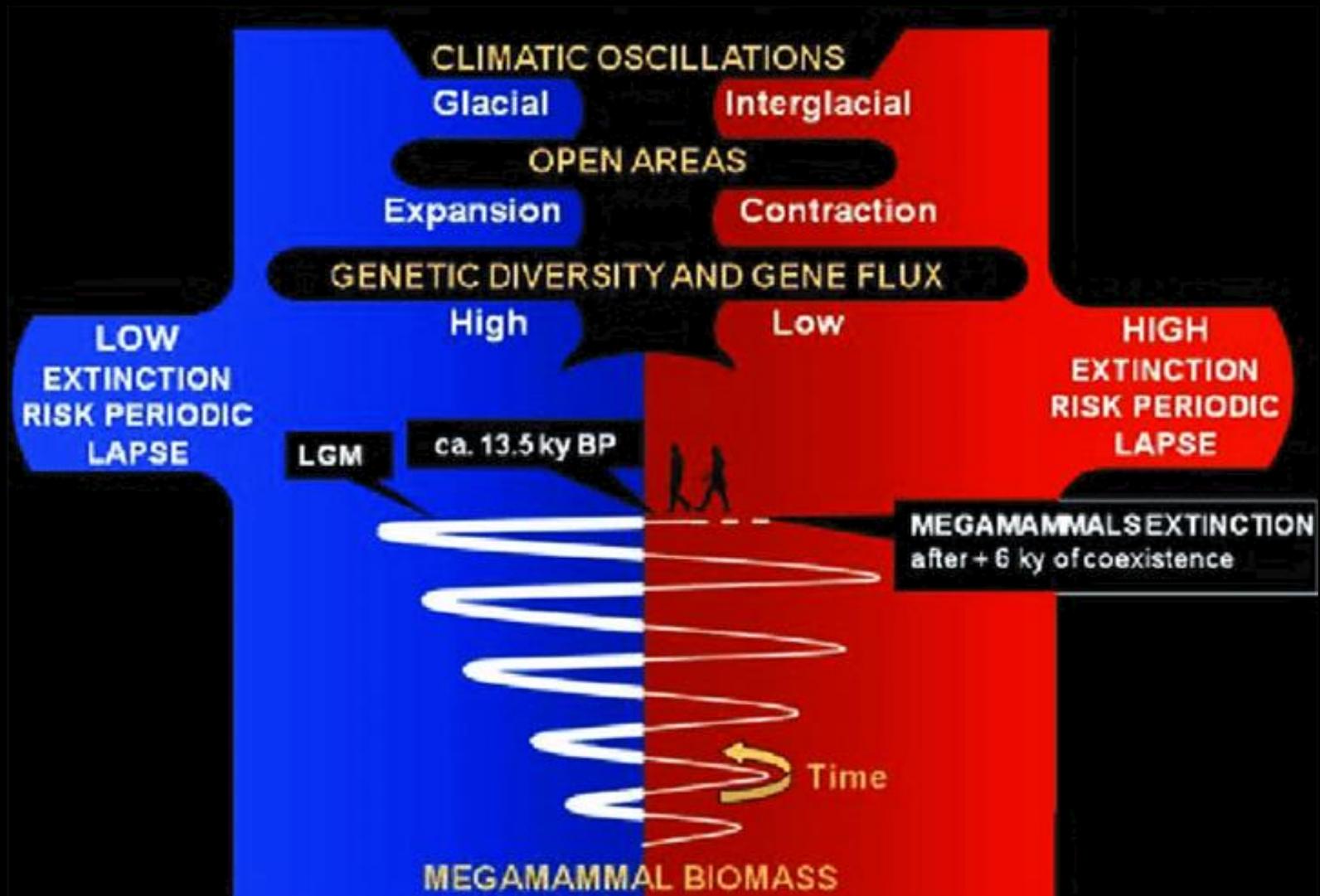
Depois da "big-five"

Irradiação do *Homo sapiens*



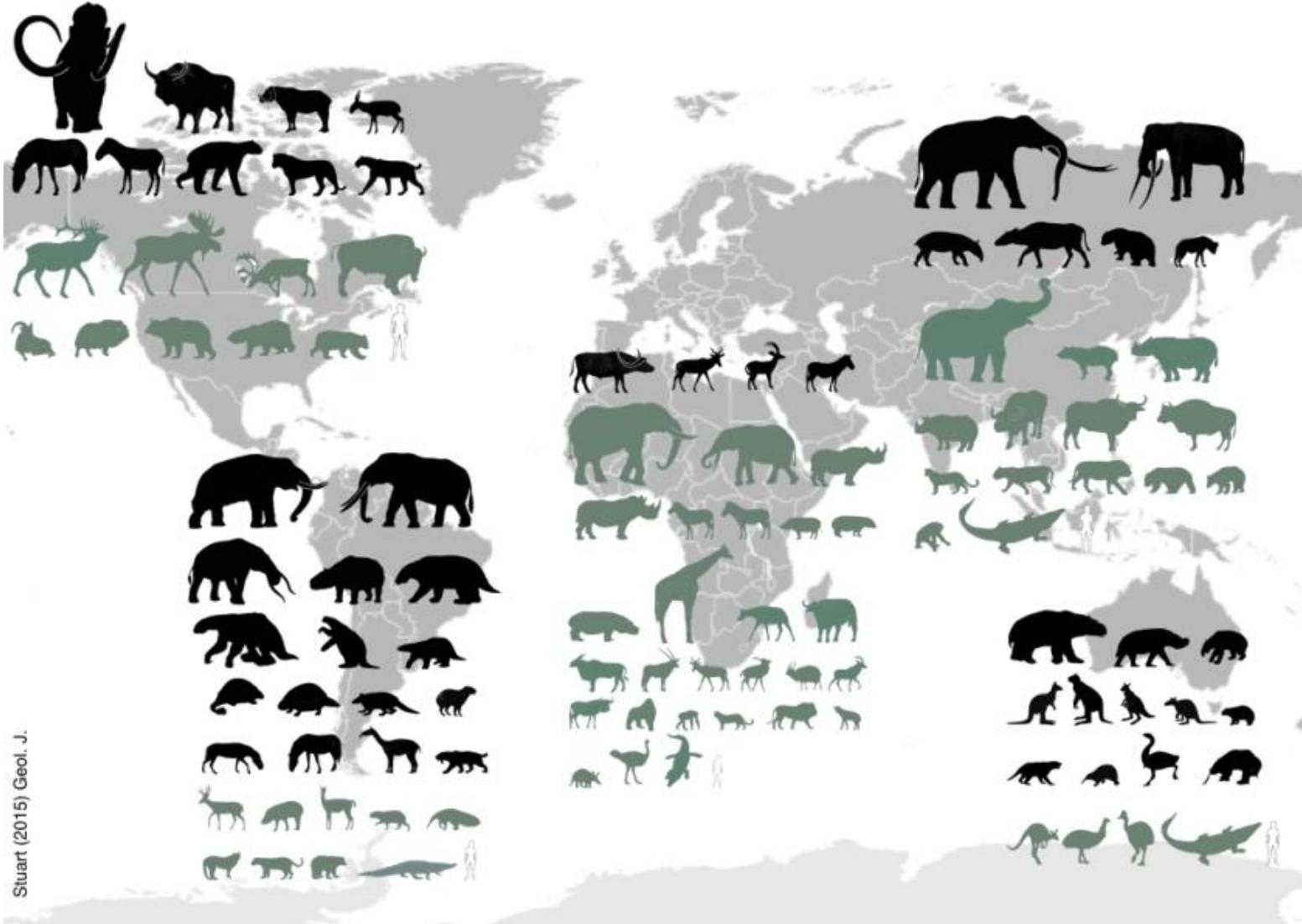
Depois da "big-five"

Irradiação do *Homo sapiens*



Depois da "big-five"

Irradiação do *Homo sapiens*



Depois da "big-five"

Irradiação do *Homo sapiens*

THE SIXTH EXTINCTION

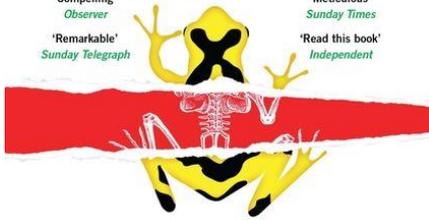
AN UNNATURAL HISTORY

'Compelling'
Observer

'Meticulous'
Sunday Times

'Remarkable'
Sunday Telegraph

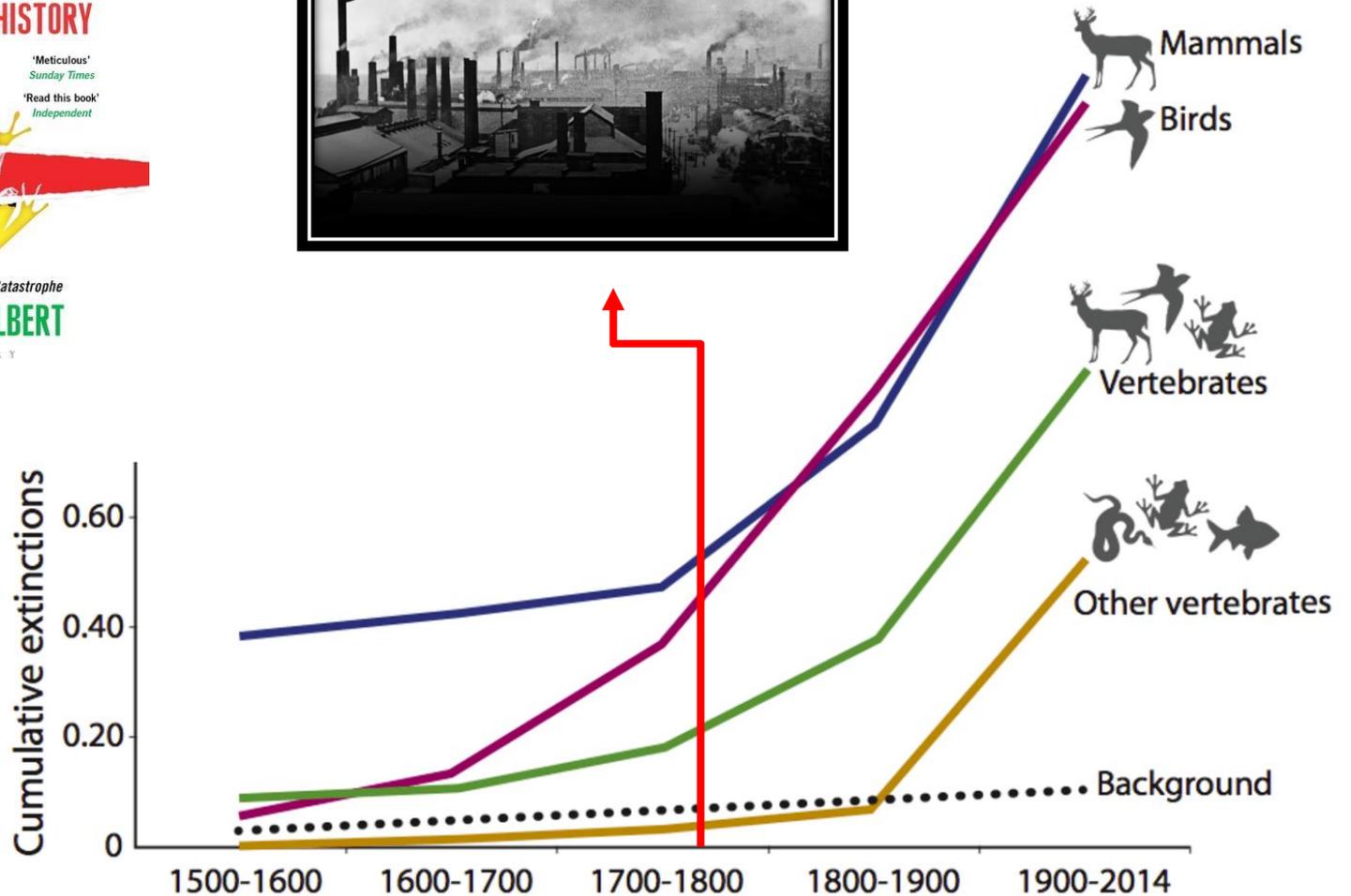
'Read this book'
Independent



Author of *Field Notes from a Catastrophe*

ELIZABETH KOLBERT

BLOOMSBURY

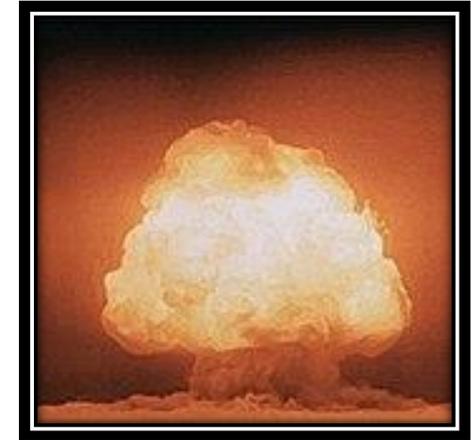


Depois da "big-five"

Irradiação do Homo sapiens

Quaternary	Anthropocene ¹			
	Holocene		1945	
	Pleistocene	Upper		0.0117
		Middle		0.126
		Calabrian		0.781
		Gelasian		1.806
			2.588	

Trinity test



System & Period	Series & Epoch	Subseries & Subepoch	Stage & Age	GSSP
Quaternary	Holocene	Upper & Late	Meghalayan	present
		Middle	Northgrippian	4250 years b2k
		Lower & Early	Greenlandian	8236 years b2k
	Pleistocene	Upper & Late	Unnamed	11,700 years b2k
		Middle	Unnamed	~126 ka
		Lower & Early	Calabrian	~0.773 Ma
			Gelasian	1.80 Ma
			2.58 Ma	

