

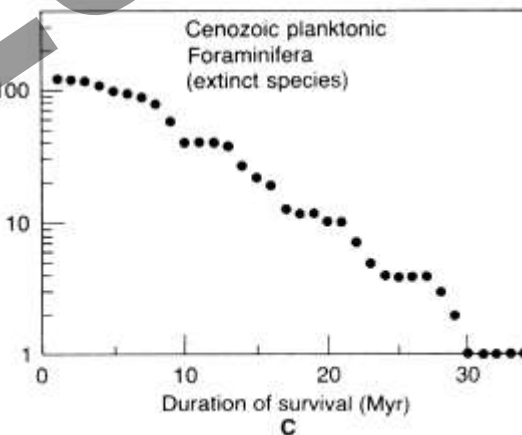
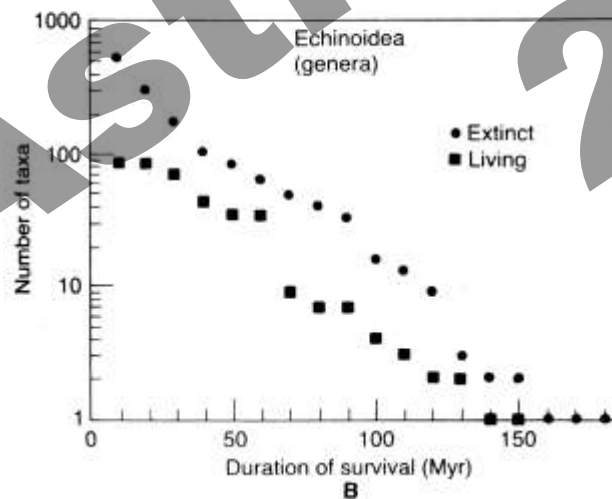
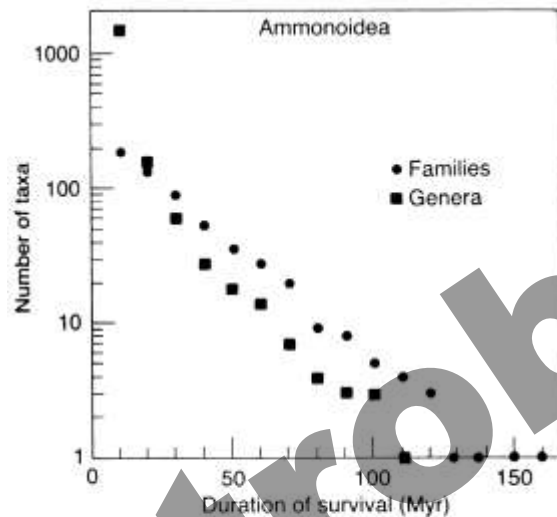


P/Tr granica: najveća katastrofa u fanerozoiku

23. 11. 2012.

Kako funkcioniše (uprosečeno!) izumiranje

- Prosečno trajanje vrste: 1-4 Ma.
- Kompleksnije vrste traju kraće
- Poneki izuzeci („živi fosili“):
coelacanth, ajkule...



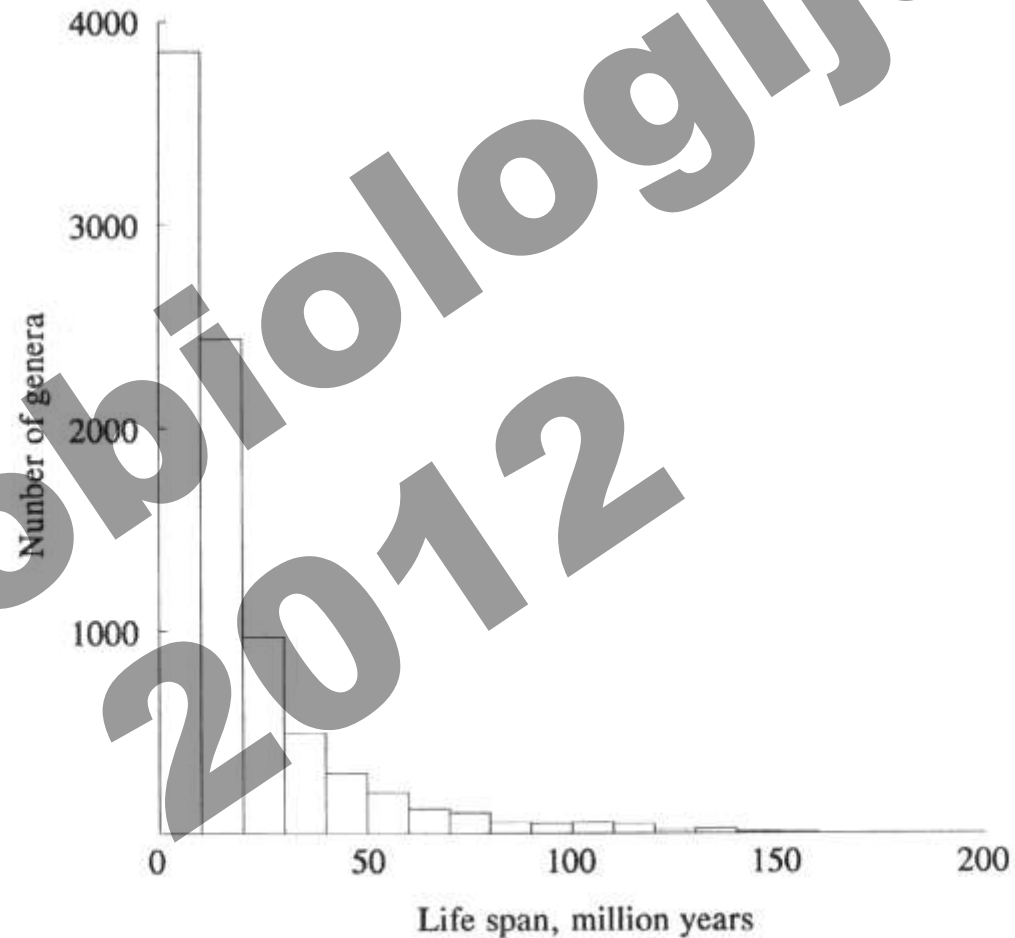


FIGURE 1 Life spans of about 17,500 extinct genera of marine animals (vertebrate, invertebrate, and microfossil) tabulated from data compiled by Sepkoski (1989).

„Velikih pet“ za koje imamo podatke

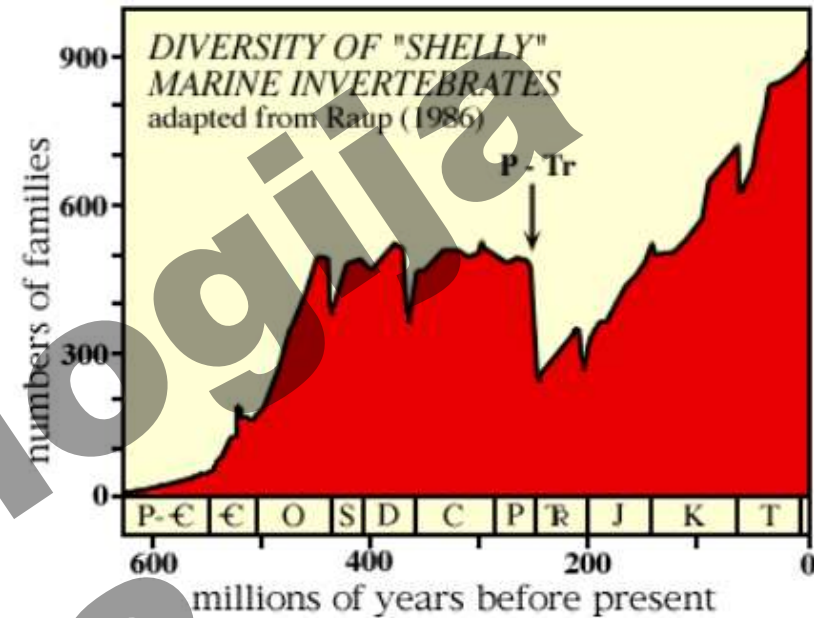
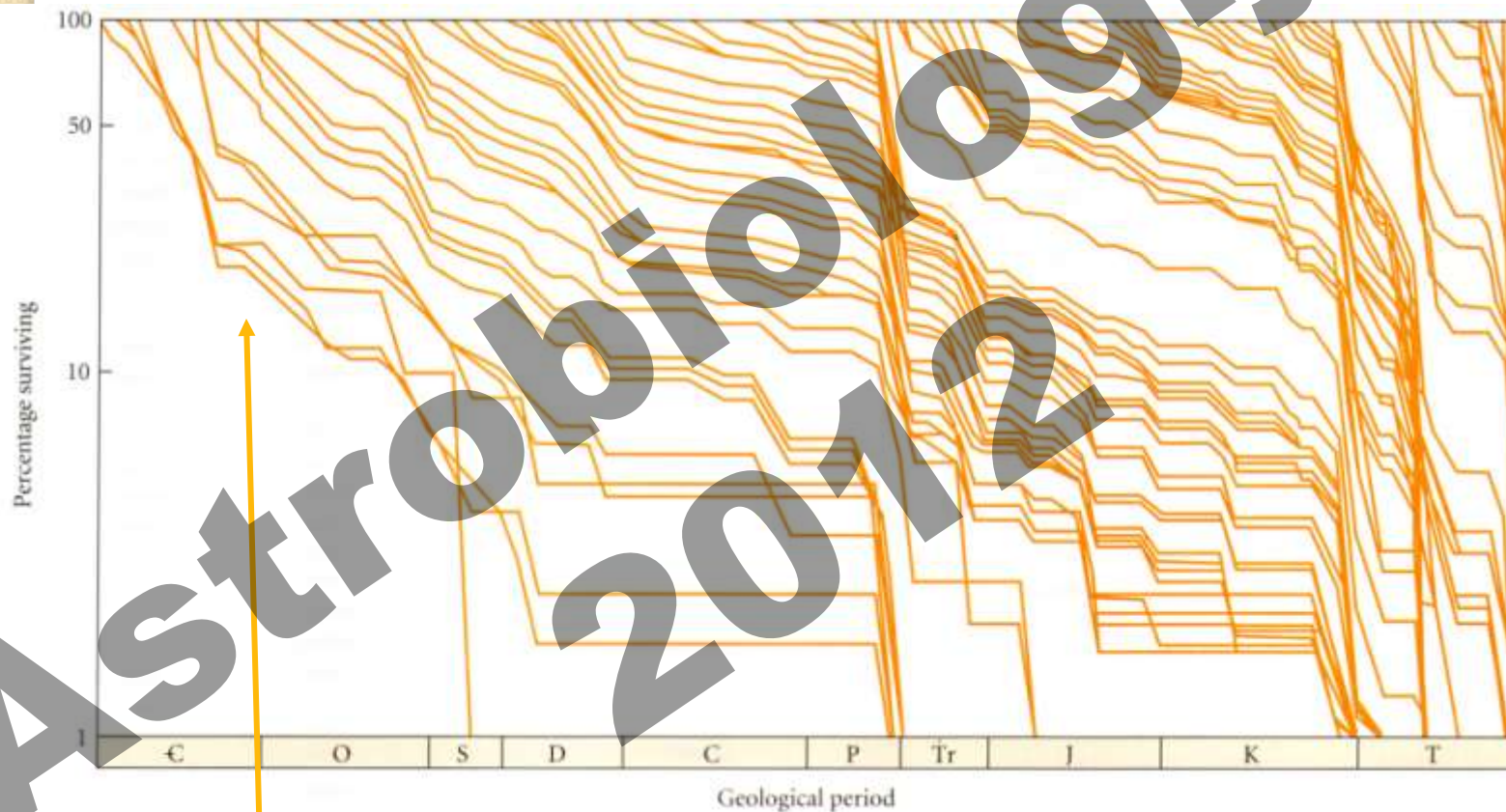


TABLE 1 Comparison of species extinction levels for the Big Five mass extinctions

Extinction episode	Age, Myr before present	Percent extinction
Cretaceous (K-T)	65	76
Triassic	208	76
Permian	245	96
Devonian	367	82
Ordovician	439	85

Extinction data are from Jablonski (1991).

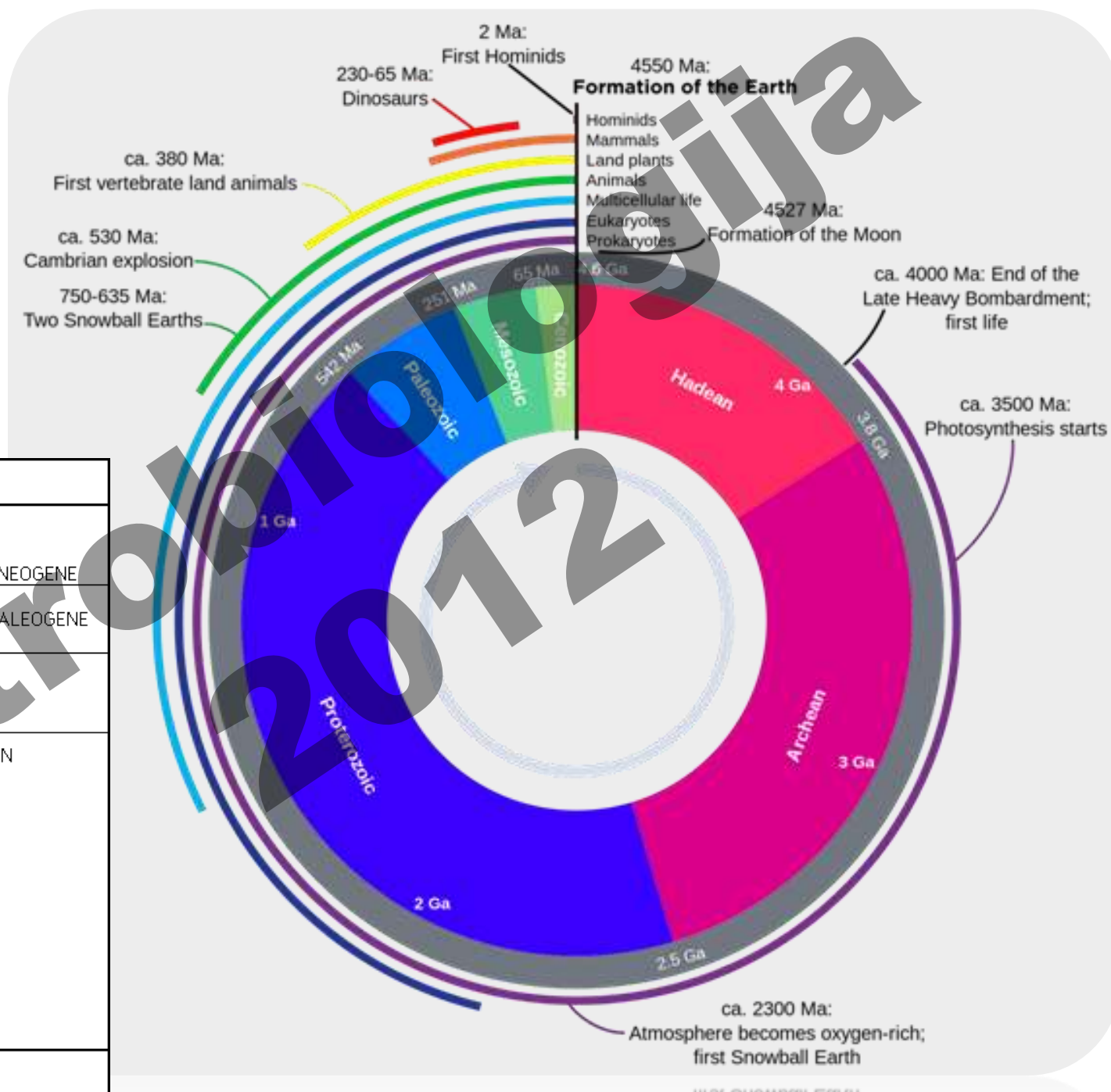
Pozadinsko vs. epizodno izumiranje među marinskim vrstama



POZADINSKO
IZUMIRANJE

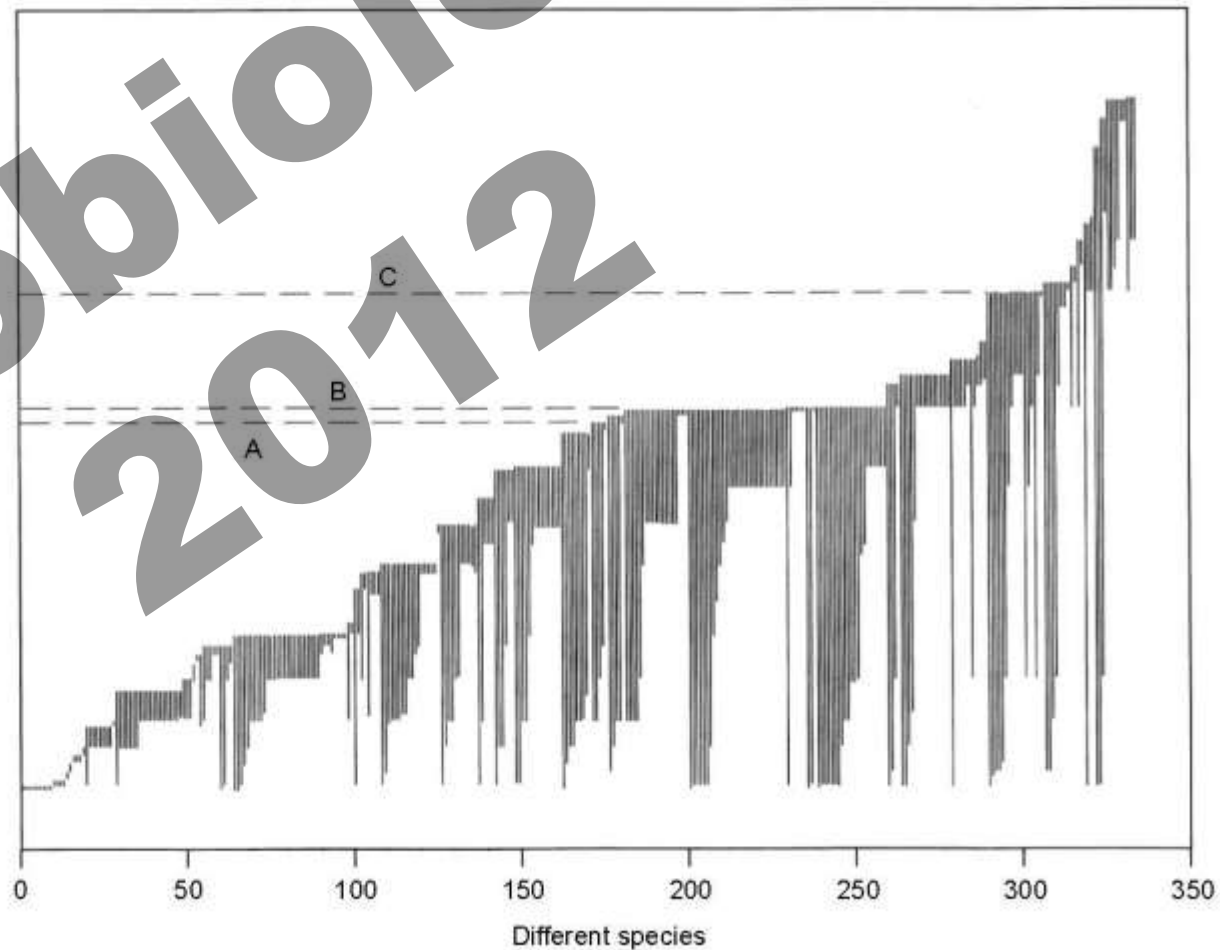
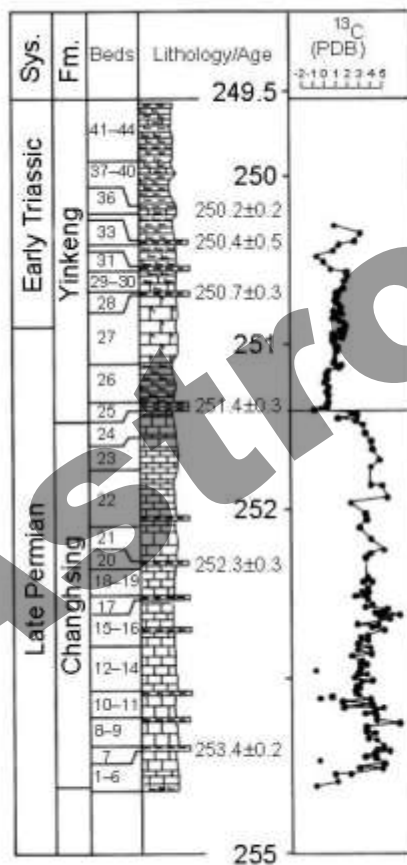
MASOVNA IZUMIRANJA

Da se
podsetimo...



ERA	my	PERIOD	EPOCH
CENOZOIC	2	QUATERNARY	HOLOCENE
			PLEISTOCENE
	65	TERTIARY	PLIOCENE
			NEOGENE
			MIOCENE
MESOZOIC	140	CRETACEOUS	OLIGOCENE
			PALEOGENE
			Eocene
	210	JURASSIC	
	250	TRIASSIC	
PALEOZOIC	280	PERMIAN	PENNSYLVANIAN
	320	CARBONIFEROUS	MISSISSIPPIAN
	360		
	400	DEVONIAN	
	440	SILURIAN	
	500	ORDOVICIAN	
	570	CAMBRIAN	
PRECAMBRIAN			

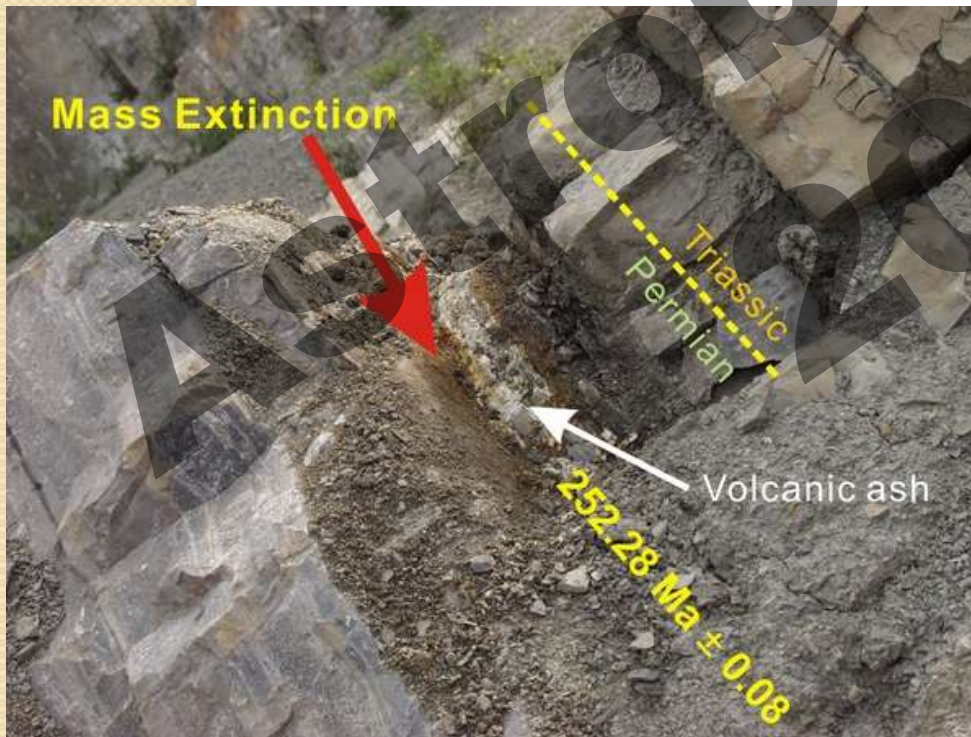
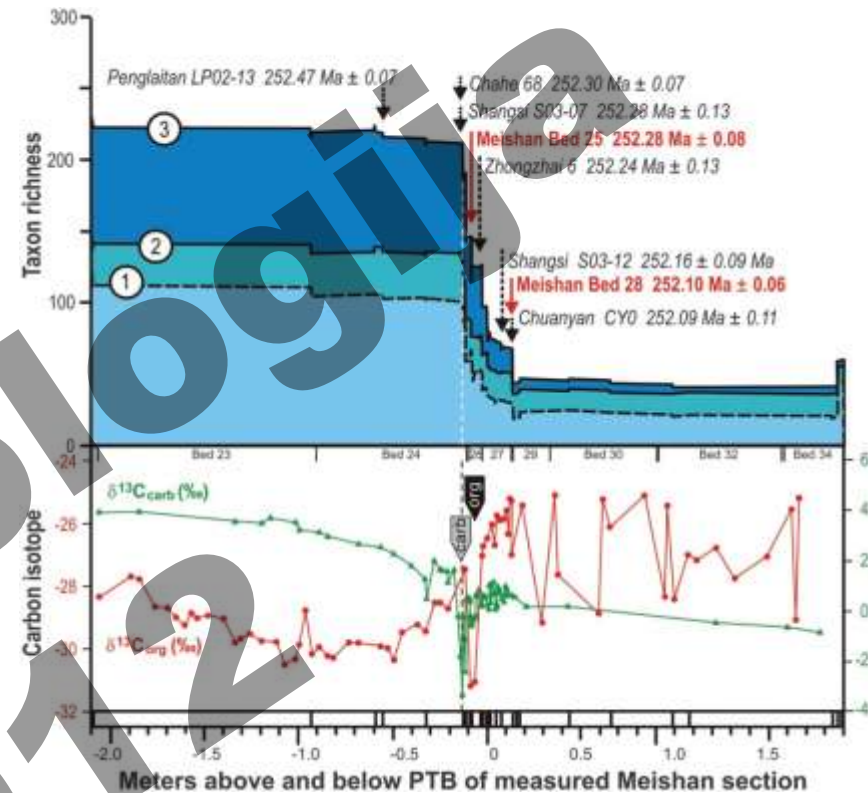
Novo precizno datiranje P/Tr prelaza i 3 nivoa



Postojbina sečuanske hrane – i najkvalitetnija P/Tr granica...

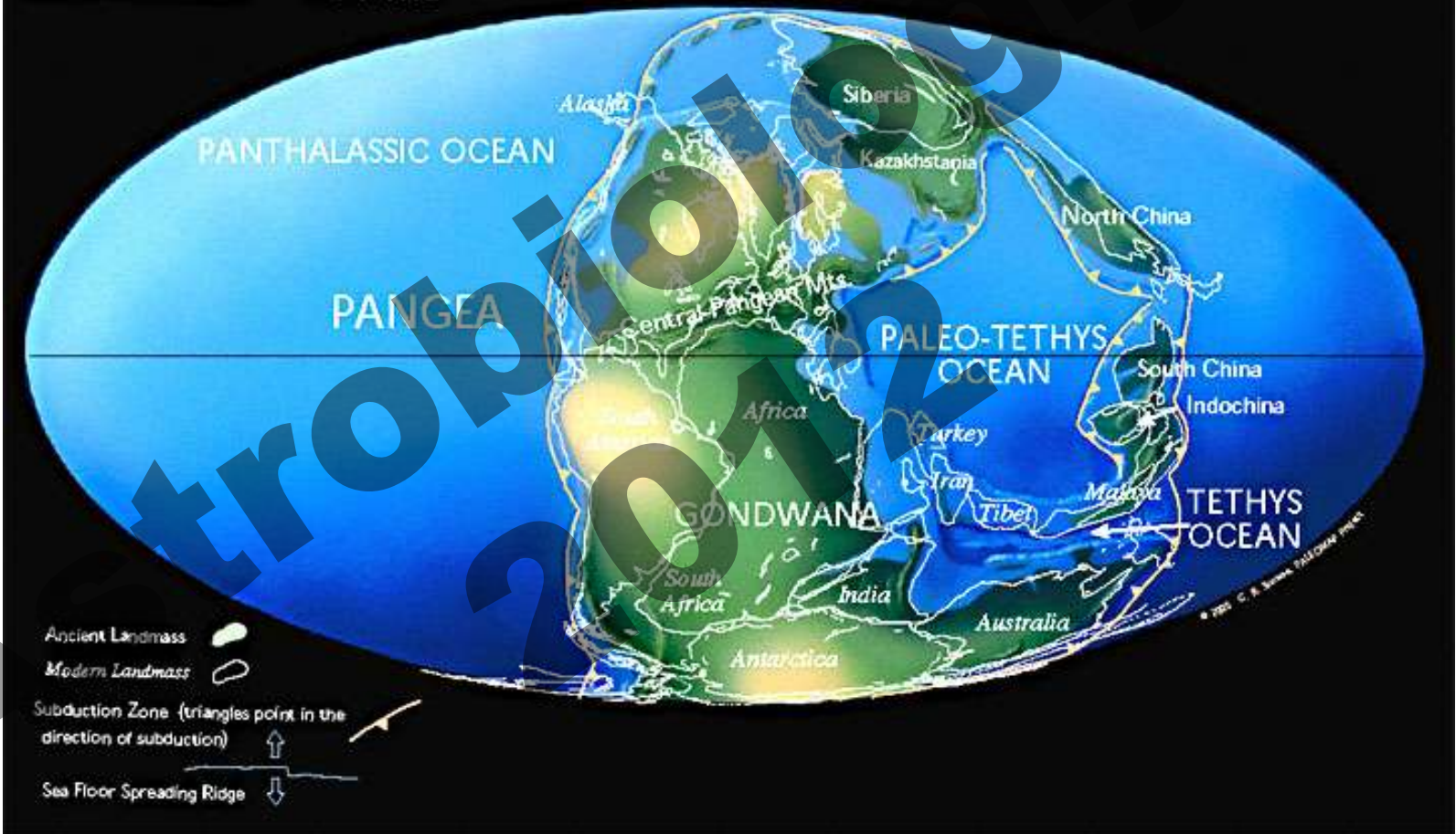


- Nivo B: -251.4 ± 0.3 Ma
- Shuzhong et al. (2011)



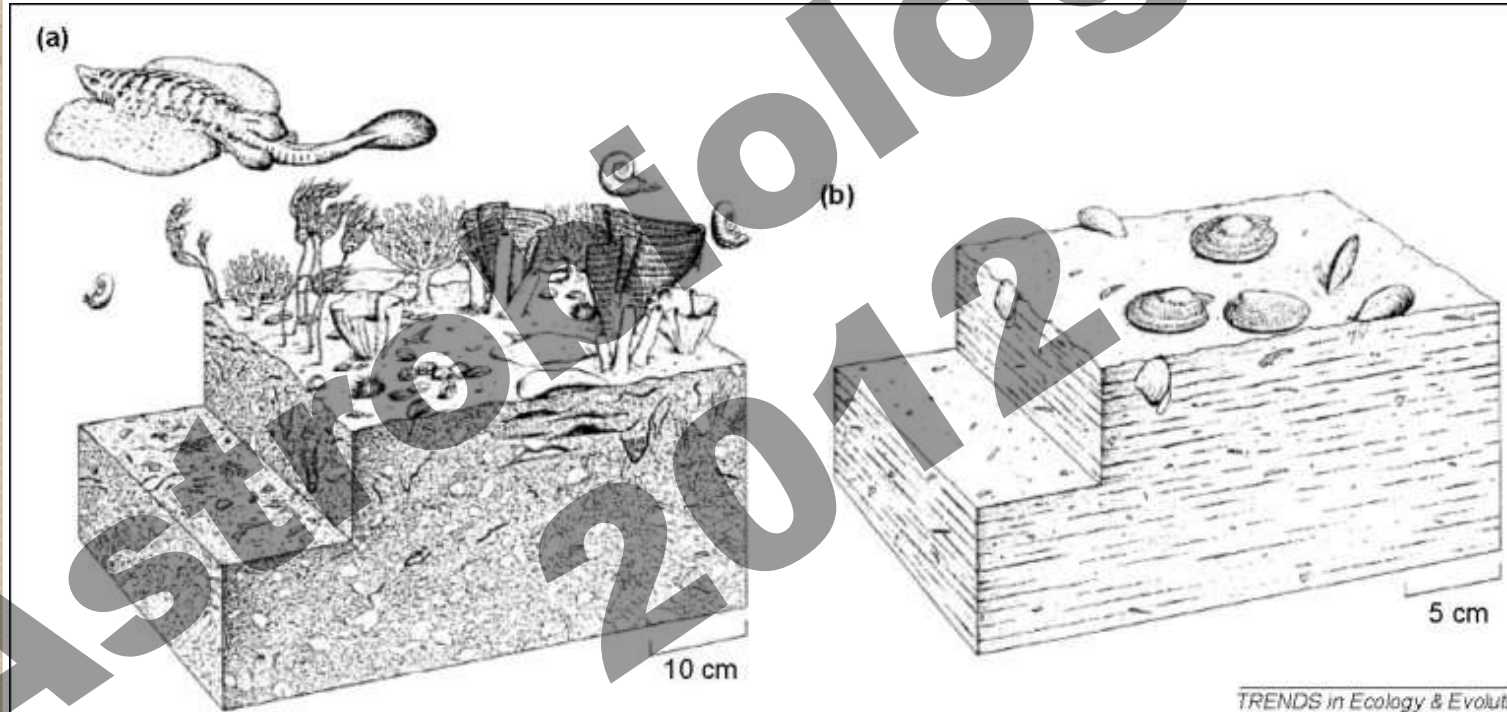
Izumiranje
definitivno
bilo naglo ($< 1 \text{ Ma}$)

Late Permian 255 Ma



PANGAEA = LAURASIA (severni) + **GONDWANA** (južni)

Pre i posle...



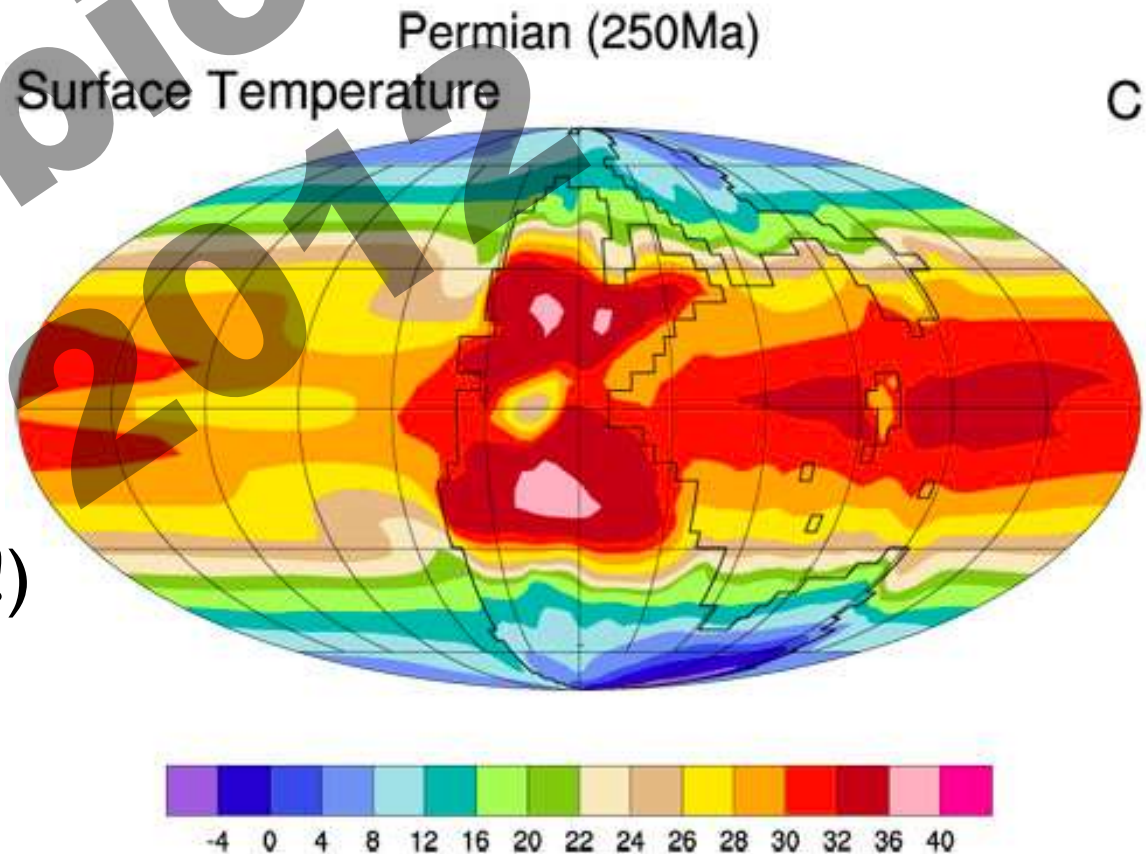
Žrtve P/Tr događaja

- Trilobiti (!)
- Korali (98%)
- Echinoderma
- Brahiopodi
- Foraminifera
- Izgleda da su kičmenjaci bili slabije pogođeni nego beskičmenjaci (mada to može biti i selekcionni efekat)...



Dramatične klimatske promene

- Značajno povišena globalna temperatura
- Okeanska anoksija
- Okeanska temperatura raste
- Nagle promene nivoa mora (u oba smeru!)



Okeanska anoksija

- Kako u šelfovima, tako i u dubokom moru.
- Više temperature vode → manje kiseonika!
- Manja temperaturna razlika polovi-ekvator.
- Poremećaj (ili prestanak!) okeanskih struja.
- Živa bića se ne mogu na to prilagoditi (bar ne brzo)
- Naslage crnog škriljca

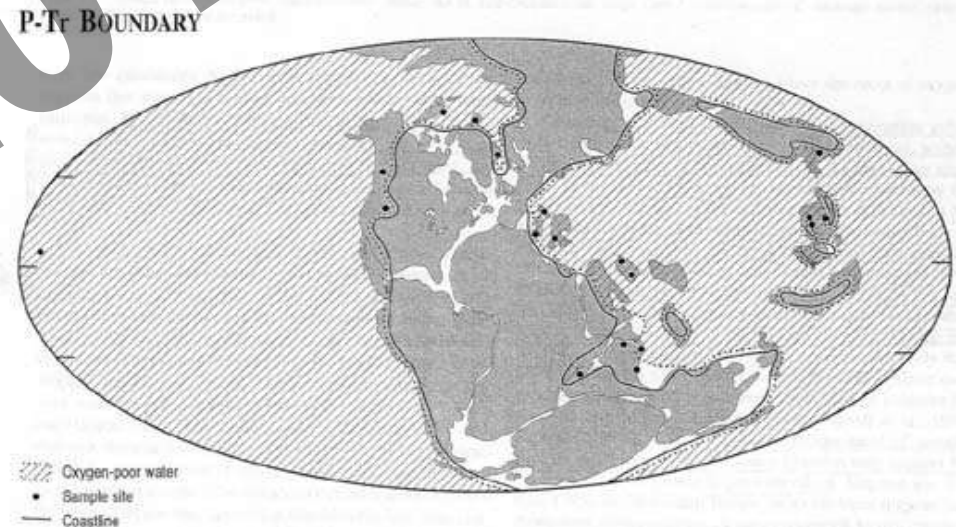
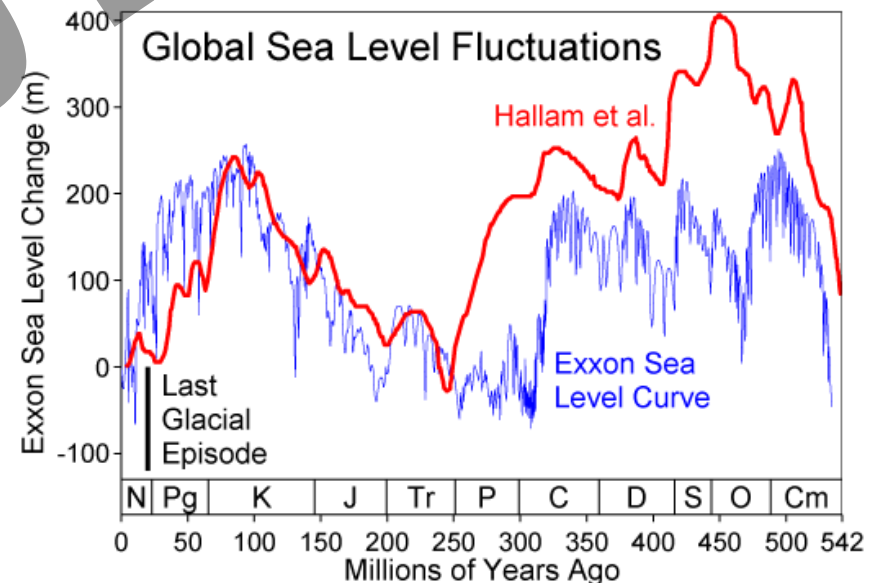


Figure 10. Extent of oxygen-poor shallow-marine conditions in Permian-Triassic (P-Tr) boundary interval (late *C. changxingensis*–*H. parvus* conodont zones). Note that only on southern margins of Neo-Tethys, in Perigondwanan region, did oxic deposition persist at this time.

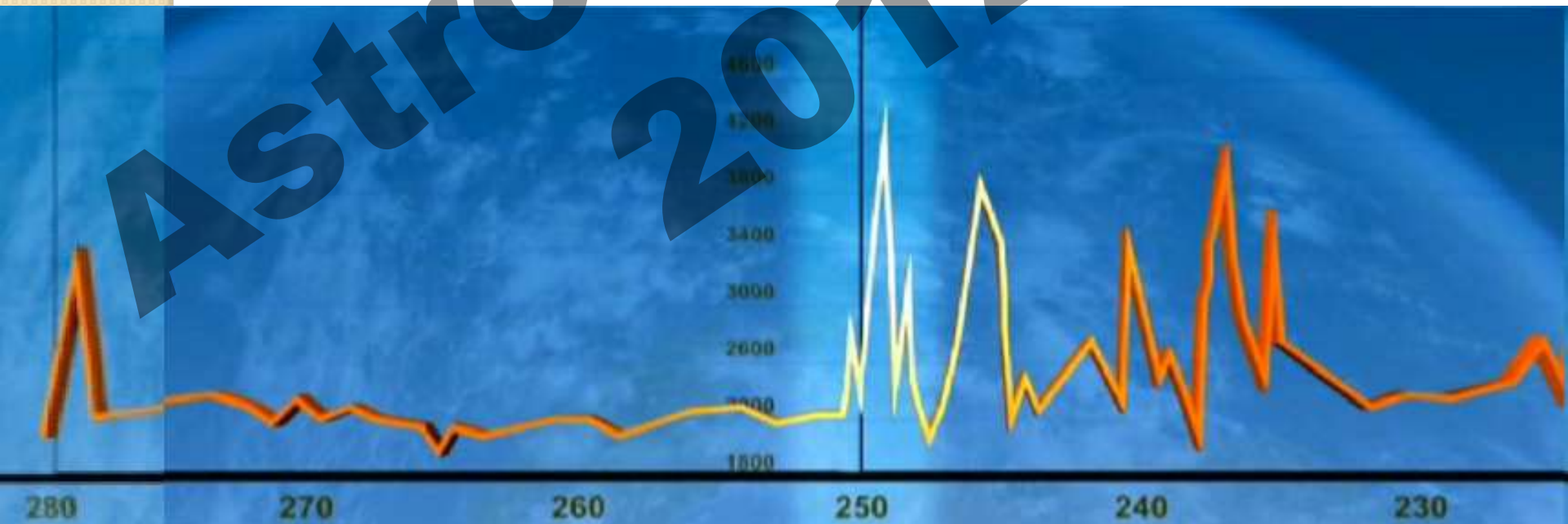
Promene nivoa globalnog mora

- Tragovi u stenama ukazuju na dramatični pad pri kraju perma (više stotina metara).
- Nivo bi se spustio potpuno ispod šelfova.
- To se **nije** desilo! (*something fishy is going on...*)
- Opadanje (od cca. 50 m) je bilo praćeno naglim usponom odmah iza P/Tr granice.



Povratak metanskih hidrata...

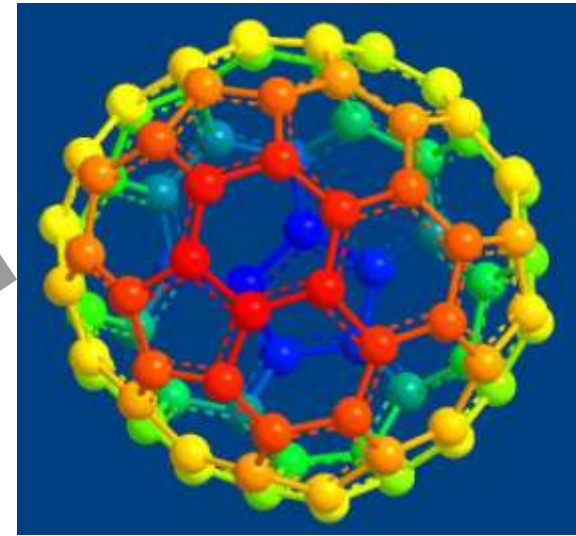
- Povećanje okeanske temperature izaziva otpuštanje metana
- Promene okeanske cirkulacije → toplije dno okeana
- Pozitivna povratna sprega!
- Učešće u celokupnom mehanizmu katastrofe...



Dakle, koji je fizički mehanizam
izazvao sav ovaj kaos?

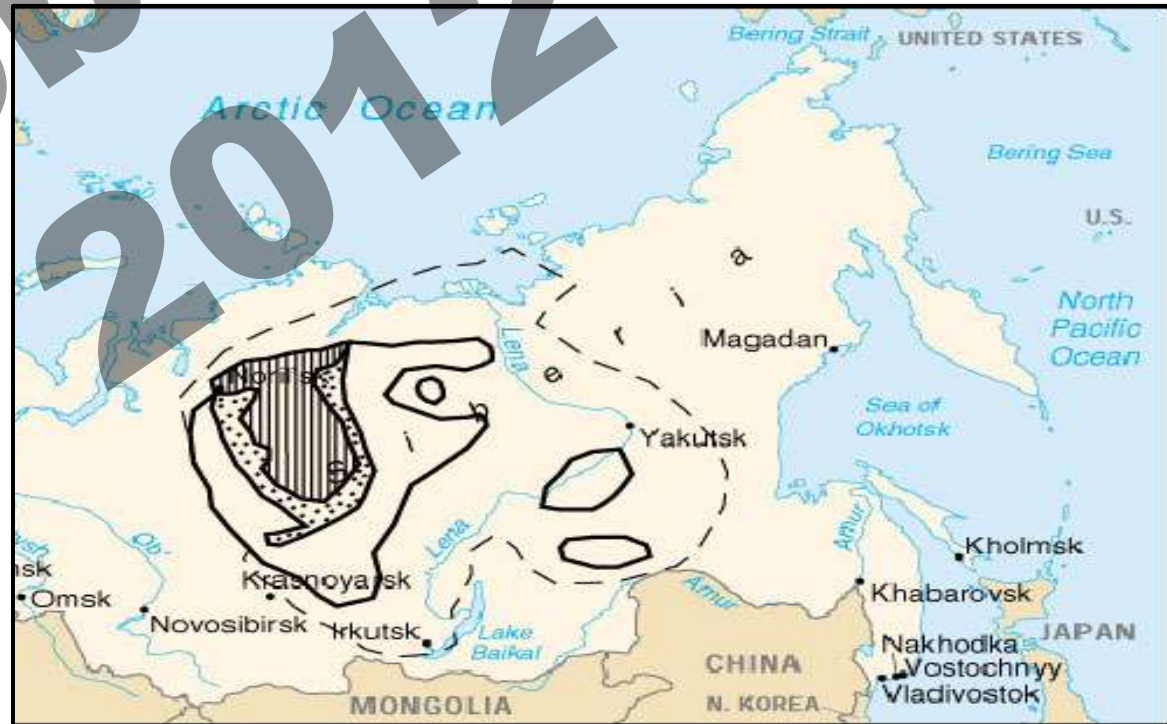
Sudar?

- Većina permskih kratera su mali (ništa ni blizu Čikšulubu)
- Sudar može izazvati hlađenje („sudarna zima“), ali kako objasniti globalno zagrevanje?
- Becker et al. (2001): sporna hemijska evidencija iz fulerena.
- Sporni tektiti (udarna stakla)
- Intenzivno proučavan scenario.
- Kombinacija sudara i vulkanizma (vrlo kontroverzno)?



Sibirski supervulkanizam

- Sibirski trapovi (švedski „stepenice“)
- Površina oko 2.000.000 km² (površina veća od Evrope!)
- Erupcije trajale punim intenzitetom nekoliko stotina hiljada godina



Efekti supervulkanizma

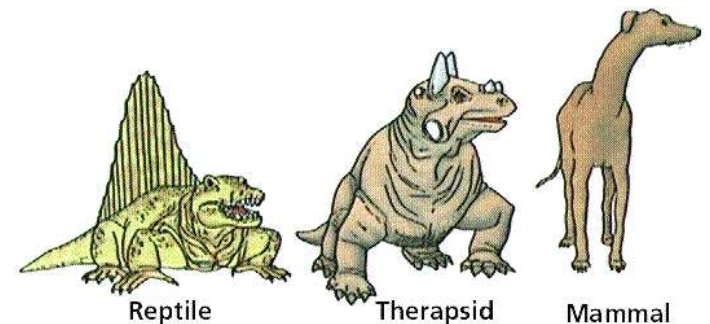
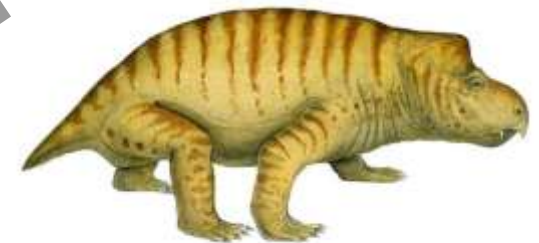
- Supervulkani emituju prašinu i gasove staklene bašte.
- U početku sumporni aerosoli i vulkanska prašina blokiraju Sunčevu svetlost, izazivajući brzo hlađenje („vulkanska zima“).
- Ash and sulfur aerosols can remain in the upper atmosphere for 100's to 1000's of years which would be enough to cause a significant glaciation.
- At the end of the Permian period the biggest ever drop in sea level in history occurred, indicating large scale glaciation.

Volcanism

- Greenhouse gases warm the climate by allowing sunlight to pass through
- Heat reflected by the Earth itself cannot penetrate the atmosphere so is retained.
- Greenhouse gases stay in the atmosphere much longer so their climate changing effects can last for millions of years.

Preživeli?

- Therapsidi: rodjaci i dinosaura i sisara
- ...
- Apsolutni šampion: *lystrosaurus* (90% svih fosila iz trijasa)





Posledice?

- P/Tr događaj omogućio pojavu taksona kao što su dinosauri i sisari...
- ...ali i usporio stopu povećanja EQ (razvoj „inteligencije“)
- Oporavak biosfere trajao 5-10 Ma (biodiverzitet se vratio na prethodni nivo tek u 30 Ma!).