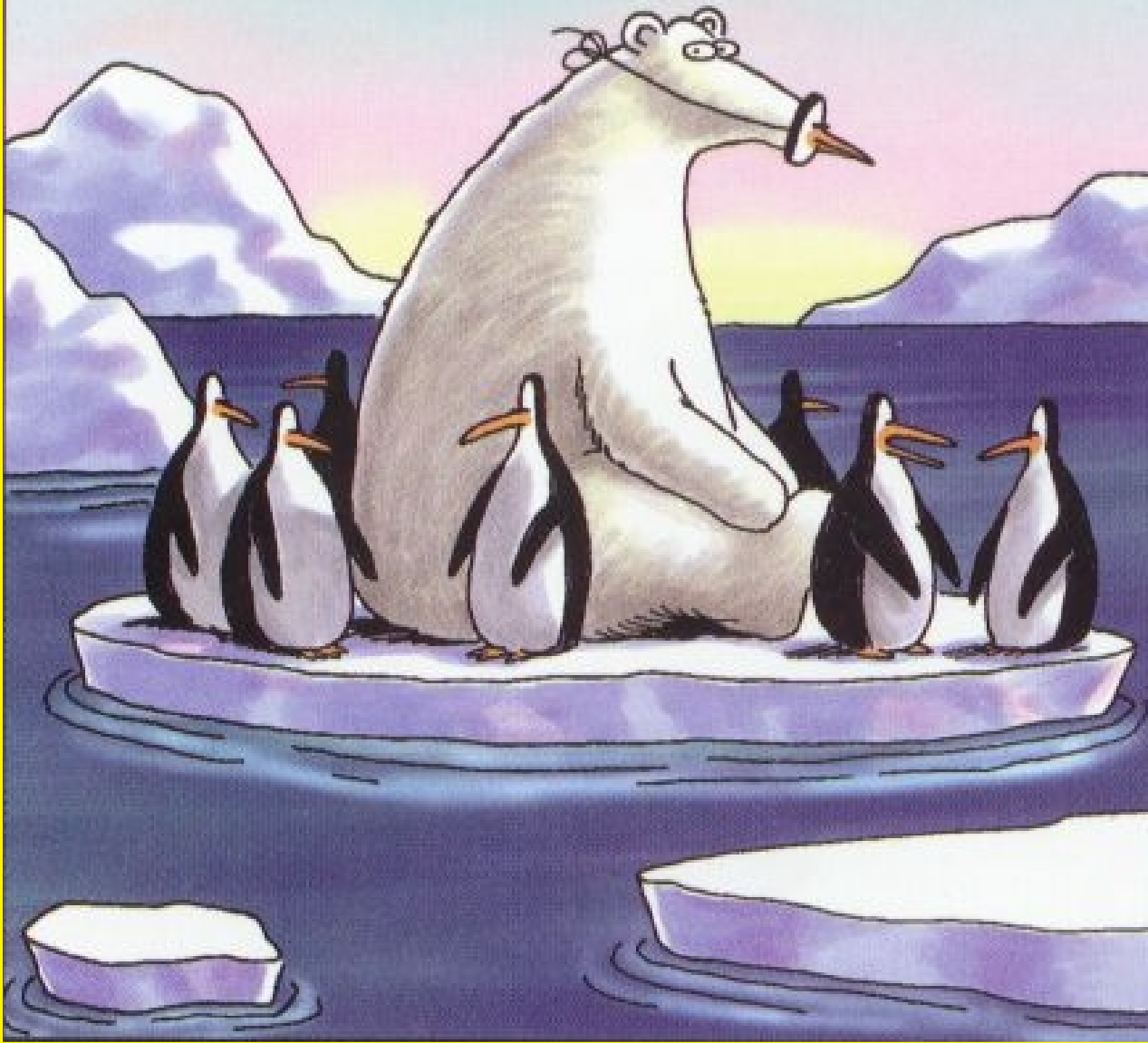


Larson

When penguins and polar bears meet ...

(the occurrence of global ice ages)





INTERNATIONAL STRATIGRAPHIC CHART



International Commission on Stratigraphy

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	age Ma	GSSP		
Phanerozoic	Cenozoic	Neogene	Holocene		0.0115			
			Pleistocene	Upper		0.126		
				Middle		0.781		
				Lower		1.806	🚩	
			Pliocene	Gelasian		2.588	🚩	
				Piacenzian		3.600	🚩	
		Zanclean			5.332	🚩		
		Miocene	Messinian		7.246	🚩		
			Tortonian		11.608	🚩		
			Serravallian		13.65	🚩		
			Langhian		15.97	🚩		
			Burdigalian		20.43	🚩		
			Aquitanian		23.03	🚩		
			Oligocene	Chattian		28.4 ± 0.1	🚩	
				Rupelian		33.9 ± 0.1	🚩	
				Eocene	Priabonian		37.2 ± 0.1	🚩
					Bartonian		40.4 ± 0.2	🚩
					Lutetian		48.6 ± 0.2	🚩
	Paleocene			Ypresian		55.8 ± 0.2	🚩	
		Thanetian		58.7 ± 0.2	🚩			
		Selandian		61.7 ± 0.2	🚩			
	Mesozoic	Cretaceous	Upper	Danian		65.5 ± 0.3	🚩	
				Senonian		70.6 ± 0.6	🚩	
				Santonian		83.5 ± 0.7	🚩	
				Coniacian		85.8 ± 0.7	🚩	
				Turonian		89.3 ± 1.0	🚩	
				Cenomanian		93.5 ± 0.8	🚩	
			Lower	Albian		99.6 ± 0.9	🚩	
				Aptian		112.0 ± 1.0	🚩	
				Barremian		125.0 ± 1.0	🚩	
		Triassic	Upper	Hauterivian		130.0 ± 1.5	🚩	
				Valanginian		136.4 ± 2.0	🚩	
				Berriasian		140.2 ± 3.0	🚩	
			Middle	Maastrichtian		145.5 ± 4.0	🚩	
				Campanian				
				Santonian				
Coniacian								
Turonian								
Cenomanian								

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	age Ma	GSSP	
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian		145.5 ± 4.0	
				Kimmeridgian		150.8 ± 4.0	
				Oxfordian		155.0 ± 4.0	
			Middle	Callovian		161.2 ± 4.0	
				Bathonian		164.7 ± 4.0	
				Bajocian		167.7 ± 3.5	
		Lower	Aalenian		171.6 ± 3.0	🚩	
			Toarcian		175.6 ± 2.0	🚩	
			Pliensbachian		183.0 ± 1.5	🚩	
			Sinemurian		189.6 ± 1.5	🚩	
			Hettangian		196.5 ± 1.0	🚩	
			Rhaetian		199.6 ± 0.6	🚩	
		Triassic	Upper	Norian		203.6 ± 1.5	🚩
				Carnian		216.5 ± 2.0	🚩
				Ladinian		228.0 ± 2.0	🚩
			Middle	Anisian		237.0 ± 2.0	🚩
				Olenekian		245.0 ± 1.5	🚩
				Induan		249.7 ± 0.7	🚩
	Lower		Changhsingian		251.0 ± 0.4	🚩	
			Wuchiapingian		253.8 ± 0.7	🚩	
			Capitanian		253.8 ± 0.7	🚩	
		Wordian		260.4 ± 0.7	🚩		
		Roadian		265.8 ± 0.7	🚩		
		Tremadocian		268.0 ± 0.7	🚩		
	Permian	Upper	Hirnantian		270.6 ± 0.7	🚩	
			Darriwilian		270.6 ± 0.7	🚩	
			Paibian		275.6 ± 0.7	🚩	
		Middle	Kungurian		275.6 ± 0.7	🚩	
			Artinskian		284.4 ± 0.7	🚩	
			Sakmarian		284.4 ± 0.7	🚩	
		Lower	Asselian		294.6 ± 0.8	🚩	
			Gzhelian		299.0 ± 0.8	🚩	
			Kasimovian		299.0 ± 0.8	🚩	
	Carboniferous	Upper	Gzhelian		303.9 ± 0.9	🚩	
			Kasimovian		303.9 ± 0.9	🚩	
			Moscovian		306.5 ± 1.0	🚩	
Middle		Bashkirian		311.7 ± 1.1	🚩		
		Serpukhovian		318.1 ± 1.3	🚩		
		Visean		326.4 ± 1.6	🚩		
Lower		Tournaisian		345.3 ± 2.1	🚩		
				345.3 ± 2.1	🚩		
				359.2 ± 2.5	🚩		

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	age Ma	GSSP
Phanerozoic	Paleozoic	Devonian	Upper	Famennian		359.2 ± 2.5
				Frasnian		374.5 ± 2.6
				Givetian		385.3 ± 2.6
			Middle	Eifelian		391.8 ± 2.7
				Emsian		397.5 ± 2.7
				Pragian		407.0 ± 2.8
		Lower	Lochkovian		411.2 ± 2.8	
			Pridoli		416.0 ± 2.8	
			Ludlow		418.7 ± 2.7	
			Ludfordian		421.3 ± 2.6	
			Gorstian		422.9 ± 2.5	
			Wenlock		426.2 ± 2.4	
		Silurian	Upper	Sheinwoodian		428.2 ± 2.3
				Telychian		436.0 ± 1.9
				Aeronian		439.0 ± 1.8
			Middle	Rhuddanian		443.7 ± 1.5
				Hirnantian		445.6 ± 1.6
				Darriwilian		455.8 ± 1.6
	Lower		Tremadocian		460.9 ± 1.6	
					468.1 ± 1.6	
					471.8 ± 1.6	
	Ordovician	Upper			477.8 ± 1.6	
					478.6 ± 1.7	
					488.3 ± 1.7	
		Middle			488.3 ± 1.7	
					488.3 ± 1.7	
					488.3 ± 1.7	
		Lower			488.3 ± 1.7	
					488.3 ± 1.7	
					488.3 ± 1.7	
	Cambrian	Upper			501.0 ± 2.0	
					501.0 ± 2.0	
					501.0 ± 2.0	
		Middle			513.0 ± 2.0	
					513.0 ± 2.0	
					513.0 ± 2.0	
Lower				513.0 ± 2.0		
				513.0 ± 2.0		
				513.0 ± 2.0		

eonothem Eon	erathem Era	system Period	age Ma	GSSP GSSA
Precambrian	Proterozoic	Eoarchean		542
				542
				542
		Mesoarchean		600
				600
				600
		Neoarchean		850
				850
				850
	Archean	Paleoproterozoic		1000
				1000
				1000
		Meso-proterozoic		1200
				1200
				1200
		Neo-proterozoic		1400
				1400
				1400

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic interval (~542 Ma to Present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP) at its base, whereas the Precambrian Interval is formally subdivided by absolute age, Global Standard Stratigraphic Age (GSSA).

This chart gives an overview of the international chronostratigraphic units, their rank, their names and formal status. These units are approved by the International Commission on Stratigraphy (ICS) and ratified by the International Union of Geological Sciences (IUGS).

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INTERNATIONAL STRATIGRAPHIC CHART



International Commission on Stratigraphy

eonothem	eon	erathem	era	system	period	series	epoch	stage	age	Ma	GSSP													
Phanerozoic	Cenozoic	Neogene	Holocene	Quaternary	Holocene	Holocene	Holocene	Holocene	Holocene	0.0001	GSSP													
												Pleistocene	Quaternary	Pleistocene	Pleistocene	Pleistocene	Pleistocene	Pleistocene	Pleistocene	Pleistocene	Pleistocene	Pleistocene		
																							Upper	Pleistocene
			Pliocene	Neogene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene										
															Lower	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	Pliocene	
			Miocene	Neogene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene										
															Gelasian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Zanclean	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Messinian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Tortonian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Serravallian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Langhian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Burdigalian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Aquitanian	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene	Miocene
															Oligocene	Neogene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene
	Chattian	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene													
	Rupelian	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene	Oligocene													
	Eocene	Neogene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene												
													Priabonian	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene			
													Bartonian	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene	Eocene			
	Paleocene	Neogene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene												
													Lutetian	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene			
													Ypresian	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene	Paleocene		
	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous												
													Thanetian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Selandian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Danian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Maastrichtian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Campanian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Santonian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Coniacian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Turonian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
													Cenomanian	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous	Cretaceous		
	Lower	Cretaceous	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower												
													Albian	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower		
Aptian													Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower			
Barremian													Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower			
Hauterivian													Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower			
Valanginian													Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower			
Berriasian													Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower			

eonothem	eon	erathem	era	system	period	series	epoch	stage	age	Ma	GSSP																								
Phanerozoic	Mesozoic	Jurassic	Upper	Jurassic	Upper	Upper	Upper	Upper	Upper	Upper	Upper																								
												Middle	Jurassic	Middle	Middle	Middle	Middle	Middle	Middle																
																				Lower	Jurassic	Lower	Lower	Lower	Lower										
			Triassic	Mesozoic	Triassic	Triassic	Triassic	Triassic	Triassic	Triassic	Triassic	Triassic	Triassic	Triassic																					
															Upper	Triassic	Upper	Upper	Upper	Upper	Upper	Upper	Upper												
															Middle	Triassic	Middle	Middle	Middle	Middle	Middle	Middle	Middle												
															Lower	Triassic	Lower	Lower	Lower	Lower	Lower	Lower	Lower												
															Permian	Mesozoic	Permian	Permian	Permian	Permian	Permian	Permian	Permian	Permian	Permian	Permian									
																											Lopingian	Permian	Permian	Permian	Permian	Permian	Permian	Permian	Permian
																											Guadalupian	Permian	Permian	Permian	Permian	Permian	Permian	Permian	Permian
															Carboniferous	Paleozoic	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous	Carboniferous									
																											Upper	Carboniferous	Upper	Upper	Upper	Upper	Upper	Upper	Upper
																											Middle	Carboniferous	Middle	Middle	Middle	Middle	Middle	Middle	Middle
			Lower	Carboniferous	Lower	Lower	Lower	Lower	Lower	Lower	Lower																								
			Mississippian	Carboniferous	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian	Mississippian																					
	Upper	Mississippian																									Upper	Upper	Upper	Upper	Upper	Upper			
	Middle	Mississippian																									Middle	Middle	Middle	Middle	Middle	Middle			
	Lower	Mississippian	Lower	Lower	Lower	Lower	Lower	Lower	Lower																										

Last Glacial Maximum

eonothem	eon	erathem	era	system	period	series	epoch	stage	age	Ma	GSSP																							
Phanerozoic	Paleozoic	Devonian	Upper	Devonian	Upper	Upper	Upper	Upper	Upper	Upper	Upper																							
												Middle	Devonian	Middle	Middle	Middle	Middle	Middle																
																			Lower	Devonian	Lower	Lower	Lower											
			Silurian	Paleozoic	Silurian	Silurian	Silurian	Silurian	Silurian	Silurian	Silurian	Silurian	Silurian	Silurian																				
															Upper	Silurian	Upper	Upper	Upper	Upper	Upper	Upper	Upper											
															Middle	Silurian	Middle	Middle	Middle	Middle	Middle	Middle	Middle											
															Lower	Silurian	Lower	Lower	Lower	Lower	Lower	Lower	Lower											
															Ordovician	Paleozoic	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician	Ordovician								
																											Upper	Ordovician	Upper	Upper	Upper	Upper	Upper	Upper
																											Middle	Ordovician	Middle	Middle	Middle	Middle	Middle	Middle
															Lower	Ordovician	Lower	Lower	Lower	Lower	Lower	Lower												
															Cambrian	Paleozoic	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian	Cambrian								
																											Upper	Cambrian	Upper	Upper	Upper	Upper	Upper	Upper
			Middle	Cambrian	Middle	Middle	Middle	Middle	Middle	Middle																								
			Lower	Cambrian	Lower	Lower	Lower	Lower	Lower	Lower																								

eonothem	eon	erathem	era	system	period	age	Ma	GSSP	GSSA															
Precambrian	Proterozoic	Proterozoic	Proterozoic	Proterozoic	Proterozoic	Proterozoic	Proterozoic	Proterozoic	Proterozoic															
										Eoarchean	Proterozoic	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean						
																			Lower limit is not defined	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean
																			Mesoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean
										Paleoarchean	Proterozoic	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean						
																			Siderian	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean
																			Rhyacian	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean	Paleoarchean
										Neoproterozoic	Proterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic						
																			Statherian	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic
																			Orosirian	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic	Neoproterozoic
										Meso-proterozoic	Proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic						
																			Calymmian	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic
																			Ectasian	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic	Meso-proterozoic
										Tonian	Proterozoic	Tonian	Tonian	Tonian	Tonian	Tonian	Tonian	Tonian						
																			Stenian	Tonian	Tonian	Tonian	Tonian	Tonian
Cryogenian	Tonian	Tonian	Tonian	Tonian	Tonian																			
Eoarchean	Proterozoic	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean																
									Ediacaran	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean										
									542	Eoarchean	Eoarchean	Eoarchean	Eoarchean	Eoarchean										

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International Commission on Stratigraphy

eonothem Eon	erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP	
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		Zanclean			5.332	🚩	
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			Langhian		15.97	🚩	
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	Rupelian				33.9 ± 0.1	🚩	
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		Ypresian		55.8 ± 0.2	🚩		
		Thanetian		58.7 ± 0.2	🚩		
	Paleocene	Selandian		61.7 ± 0.2	🚩		
		Danian		65.5 ± 0.3	🚩		
		Maastrichtian		70.6 ± 0.6	🚩		
	Cretaceous	Upper	Campanian		83.5 ± 0.7	🚩	
			Santonian		85.8 ± 0.7	🚩	
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				Oxfordian		155.0 ± 4.0
			Middle	Callovian		161.2 ± 4.0
				Bathonian		164.7 ± 4.0
				Bajocian		167.7 ± 3.5
		Lower	Aalenian		171.6 ± 3.0	🚩
			Toarcian		175.6 ± 2.0	🚩
			Pliensbachian		183.0 ± 1.5	🚩
			Sinemurian		189.6 ± 1.5	🚩
			Hettangian		196.5 ± 1.0	🚩
		Triassic	Upper	Rhaetian		199.6 ± 0.6
				Norian		203.6 ± 1.5
			Middle	Carnian		216.5 ± 2.0
	Ladinian				228.0 ± 2.0	
	Lower		Anisian		237.0 ± 2.0	
			Olenekian		245.0 ± 1.5	
			Innian		249.7 ± 0.7	
			Induan		251.0 ± 0.4	🚩
	Permian	Guadalupian	Lopingian		253.8 ± 0.7	
			Wuchiapingian		260.4 ± 0.7	
			Capitanian		265.8 ± 0.7	
			Wordian		268.0 ± 0.7	
			Roadian		270.6 ± 0.7	
		Cisuralian	Kungurian		275.6 ± 0.7	
			Artinskian		284.4 ± 0.7	
			Sakmarian		294.6 ± 0.8	
			Asselian		299.0 ± 0.8	
Gzhelian				303.9 ± 0.9		
Carboniferous	Pennsylvanian	Upper		306.5 ± 1.0		
		Middle		311.7 ± 1.1		
		Lower		318.1 ± 1.3		
		Bashkirian		326.4 ± 1.6		
	Mississippian	Upper		326.4 ± 1.6		
		Middle		345.3 ± 2.1		
		Lower		359.2 ± 2.5		
		Tournaisian		359.2 ± 2.5		

eonothem Eon	erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP
Phanerozoic	Paleozoic	Devonian	Upper	Famennian		359.2 ± 2.5
				Frasnian		374.5 ± 2.6
				Givetian		385.3 ± 2.6
			Middle	Eifelian		391.8 ± 2.7
				Emsian		397.5 ± 2.7
				Pragian		407.0 ± 2.8
		Lower	Lochkovian		411.2 ± 2.8	
			Pridoli		416.0 ± 2.8	
			Ludlow		418.7 ± 2.7	
			Ludfordian		421.3 ± 2.6	
			Gorstian		422.9 ± 2.5	
		Silurian	Wenlock	Homerian		426.2 ± 2.4
				Sheinwoodian		428.2 ± 2.3
			Llandovery	Telychian		436.0 ± 1.9
	Aeronian				439.0 ± 1.8	
	Ordovician	Upper	Rhuddanian		443.7 ± 1.5	
			Irrnastian		446.1 ± 1.9	
		Middle	Carthilillian		455.8 ± 1.6	
			Barrovillian		469.0 ± 2.0	
			Tremadocian		468.1 ± 1.6	
		Lower	Furongian		478.6 ± 1.7	
			Paibian		488.3 ± 1.7	
			Paibian		501.0 ± 2.0	
	Cambrian	Middle			513.0 ± 2.0	
					513.0 ± 2.0	
		Lower			541.0 ± 1.0	
					542.0 ± 1.0	

eonothem Eon	erathem Era	System Period	Age Ma	GSSP GSSA
Precambrian	Proterozoic	Eoarchean	Lower limit is not defined	
			Siderian	2300
			Rhyacian	2050
		Paleo-proterozoic	Statherian	1600
			Ectasian	1400
			Calymmian	1200
	Archean	Mesoarchean	Tonian	850
			Cryogenian	600
		Neo-proterozoic	Ediacaran	542

251.0 Ma ← **Permian Extinction (end of the flesh-ripping trilobites)**

542.0 Ma ← **Cambrian explosion**

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic interval (~542 Ma to Present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP) at its base, whereas the Precambrian Interval is formally subdivided by absolute age, Global Standard Stratigraphic Age (GSSA).

This chart gives an overview of the international chronostratigraphic units, their rank, their names and formal status. These units are approved by the International Commission on Stratigraphy (ICS) and ratified by the International Union of Geological Sciences (IUGS).

The discipline of the CS (Cohen et al., 1996, Episodes, 19: 77-81) regulate the selection and definition of the international units of geologic time. Many GSSP's actually have a 'golden spike' (🚩) and Stage and/or System name plaque mounted at the boundary level in the primary stratigraphic type section. In this GSSA is an abstract age without reference to a specific level in a rock section of Earth. Descriptions of each GSSP and GSSA are summarized in Episodes, 25: 204-208 (2002) and posted on the ICS website (www.stratigraphy.org).

Some stages within the Ordovician and Cambrian will be formally named upon international agreement on their GSSP limits. Most intra-stage boundaries (e.g., Middle and Upper Aptian) are not formally defined. Numerical ages of the unit boundaries in the Phanerozoic are subject to revision. Colors are according to the Commission for the Geological Map of the World (www.cgmw.org). The listed numerical ages are from 'A Geologic Time Scale 2004', by Gradstein, Ogg, Smith, et al. (2004; Cambridge University Press).

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This chart was drafted and printed with funding generously provided for the GTS Project 2004 by ExxonMobil, Statoil Norway, ChevronTexaco and BP. The chart was produced by Gabi Ogg.



INTERNATIONAL STRATIGRAPHIC CHART



International Commission on Stratigraphy

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	Age Ma	GSSP	
Phanerozoic	Cenozoic	Neogene	Holocene		0.0115		
			Pleistocene	Upper			
				Middle		0.126	
				Lower		0.781	
			Pliocene	Gelasian		1.806	
				Piacenzian		2.588	
		Zanclean			3.600		
		Miocene	Messinian		5.332		
			Tortonian		7.246		
			Serravallian		11.608		
			Langhian		13.65		
			Burdigalian		15.97		
			Aquitanian		20.43		
			Oligocene	Chattian		23.03	
				Rupelian		28.4 ± 0.1	
				Priabonian		33.9 ± 0.1	
				Bartonian		37.2 ± 0.1	
		Eocene	Lutetian		40.4 ± 0.2		
	Ypresian			48.6 ± 0.2			
	Thanetian			55.8 ± 0.2			
	Paleocene	Selandian		58.7 ± 0.2			
		Danian		61.7 ± 0.2			
	Cretaceous	Upper	Maastrichtian		70.6 ± 0.6		
			Campanian		83.5 ± 0.7		
			Santonian		85.8 ± 0.7		
			Coniacian		89.3 ± 1.0		
			Turonian		93.5 ± 0.8		
			Cenomanian		99.6 ± 0.9		
		Lower	Albian		112.0 ± 1.0		
			Aptian		125.0 ± 1.0		
			Barremian		130.0 ± 1.5		
			Hauterivian		136.4 ± 2.0		
			Valanginian		140.2 ± 3.0		
			Berriasian		145.5 ± 4.0		

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	Age Ma	GSSP
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian		145.5 ± 4.0
				Kimmeridgian		150.8 ± 4.0
				Oxfordian		155.0 ± 4.0
			Middle	Callovian		161.2 ± 4.0
				Bathonian		164.7 ± 4.0
				Bajocian		167.7 ± 3.5
		Lower	Aalenian		171.6 ± 3.0	
			Toarcian		175.6 ± 2.0	
			Pliensbachian		183.0 ± 1.5	
			Sinemurian		189.6 ± 1.5	
			Hettangian		196.5 ± 1.0	
			Rhaetian		199.6 ± 0.6	
		Triassic	Upper	Norian		203.6 ± 1.5
				Carnian		216.5 ± 2.0
				Ladinian		228.0 ± 2.0
			Middle	Anisian		237.0 ± 2.0
				Olenekian		245.0 ± 1.5
				Induan		249.7 ± 0.7
	Permian	Upper	Changhsingian		251.0 ± 0.4	
			Lopingian		253.8 ± 0.7	
			Wuchiapingian		260.4 ± 0.7	
			Capitanian		265.8 ± 0.7	
			Wordian		268.0 ± 1.0	
			Roadian		270.6 ± 0.7	
		Lower	Kungurian		270.6 ± 0.7	
			Artinskian		275.6 ± 0.7	
			Cisuralian		284.4 ± 0.7	
			Sakmarian		294.6 ± 0.8	
			Asselian		299.0 ± 0.8	
			Gzhelian		299.0 ± 0.8	
	Carboniferous	Pennsylvanian	Upper		303.9 ± 0.9	
			Middle		306.5 ± 1.0	
			Lower		311.7 ± 1.1	
		Mississippian	Upper		318.1 ± 1.3	
			Middle		326.4 ± 1.6	
			Lower		345.3 ± 2.1	
Paleozoic	Cambrian	Tournaisian		352.0 ± 2.5		

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	Age Ma	GSSP
Phanerozoic	Paleozoic	Devonian	Upper	Famennian		359.2 ± 2.5
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				Emsian		397.5 ± 2.7
				Pragian		407.0 ± 2.8
		Lower	Lochkovian		411.2 ± 2.8	
			Pridoli		416.0 ± 2.8	
			Ludlow		418.7 ± 2.7	
		Silurian	Llandovery	Ludfordian		421.3 ± 2.6
				Gorstian		422.9 ± 2.5
				Homerian		426.2 ± 2.4
			Wenlock	Sheinwoodian		428.2 ± 2.3
				Telychian		436.0 ± 1.9
				Aeronian		439.0 ± 1.8
		Ordovician	Upper	Rhuddanian		443.7 ± 1.5
				Hirnantian		445.6 ± 1.6
				Darriwilian		445.8 ± 1.6
	Middle		Tremadocian		460.9 ± 1.6	
					468.1 ± 1.6	
					471.8 ± 1.6	
	Cambrian	Lower			478.6 ± 1.7	
					488.3 ± 1.7	
			Furongian		488.3 ± 1.7	
		Middle	Paibian		501.0 ± 2.0	
					513.0 ± 2.0	
					513.0 ± 2.0	
	Paleozoic	Cambrian	Lower			542.0 ± 1.0

eonothem Eon	erathem Era	system Period	Age Ma	GSSP GSSA		
Phanerozoic	Proterozoic	Ediacaran	542			
			Neo-proterozoic	600		
				Cryogenian	850	
		Tonian		1000		
		Meso-proterozoic	1200			
			Stenian	1400		
			Ectasian	1600		
		Paleo-proterozoic	1800			
			Statherian	2050		
			Orosirian	2300		
		Rhyacian	2500			
		Siderian	2500			
		Archean	Neoarchean	2800		
				Mesoarchean	3200	
				Paleoarchean	3600	
			Eoarchean	Lower limit is not defined		

65.6 Ma ←

Dinosaurs discover internal combustion engine

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic interval (~542 Ma to Present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP) at its base, whereas the Precambrian Interval is formally subdivided by absolute age, Global Standard Stratigraphic Age (GSSA).

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The Guidelines of the ICS (Remane et al., 1996, Episodes, 19: 77-81) regulate the selection and

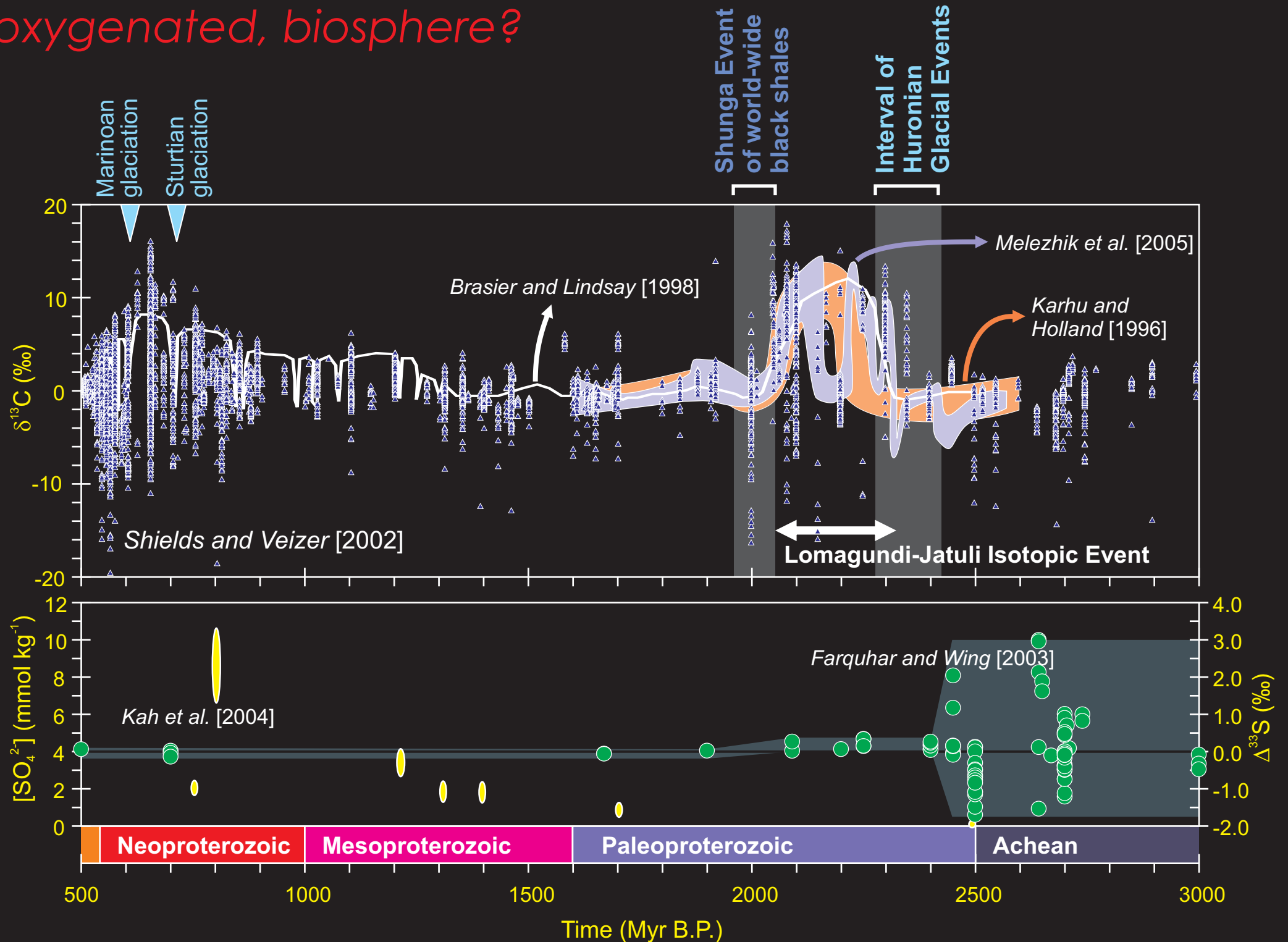
definition of the international units of geologic time. Many GSSP's actually have a 'golden spike' (📌) and Stage and/or System name plaque mounted at the boundary level in the boundary stratotype section, whereas a GSSA is an abstract age without reference to a specific level in a rock section on Earth. Descriptions of each GSSP and GSSA are summarized in *Episodes*, 25: 204-208 (2002) and posted on the ICS website (www.stratigraphy.org).

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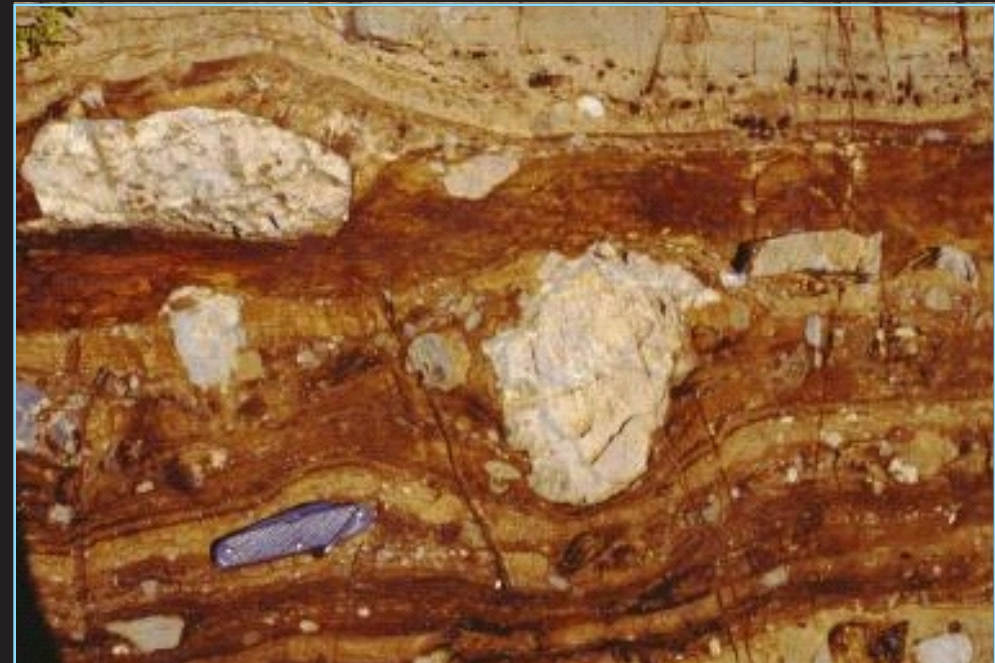
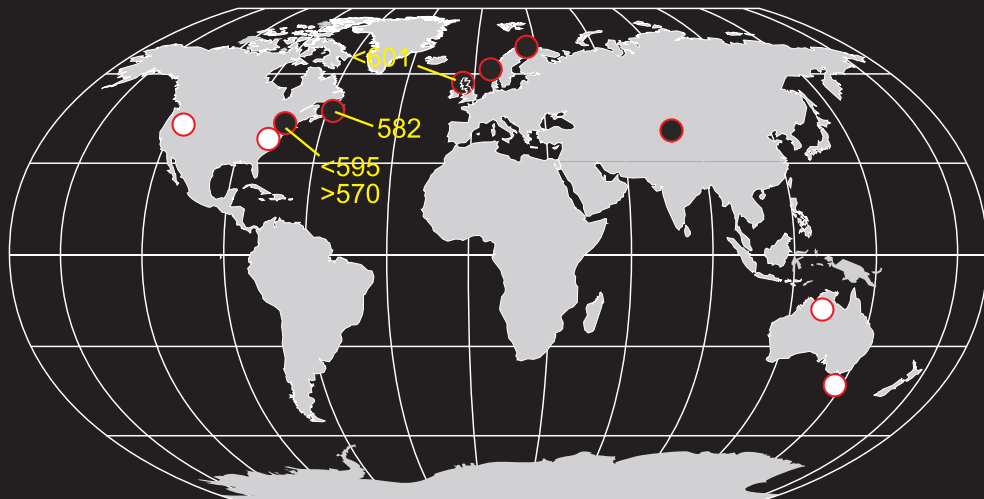
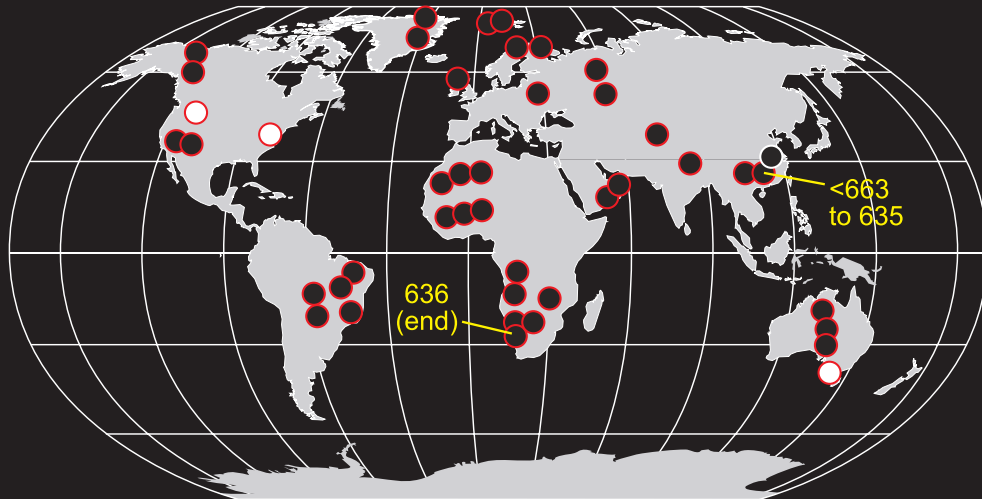
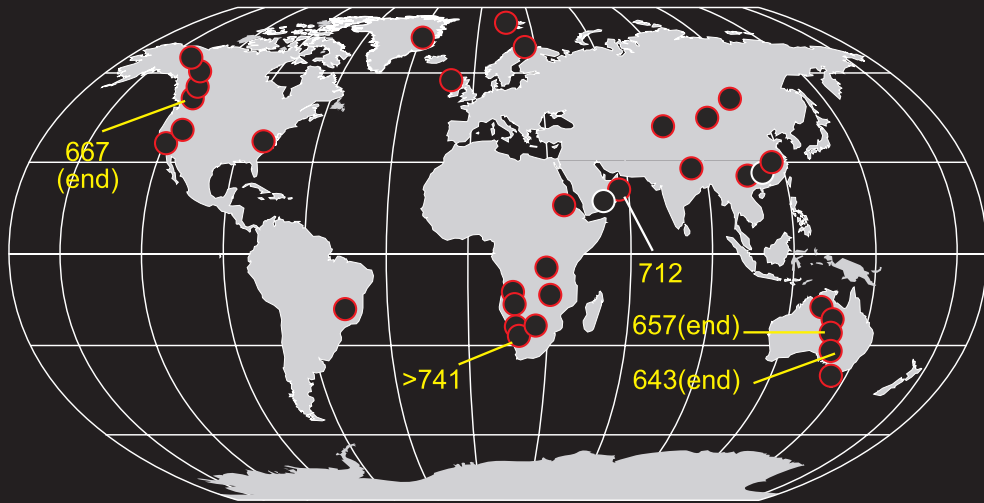
This chart was drafted and printed with funding generously provided for the GTS Project 2004 by ExxonMobil, Statoil Norway, ChevronTexaco and BP. The chart was produced by Gabi Ogg.

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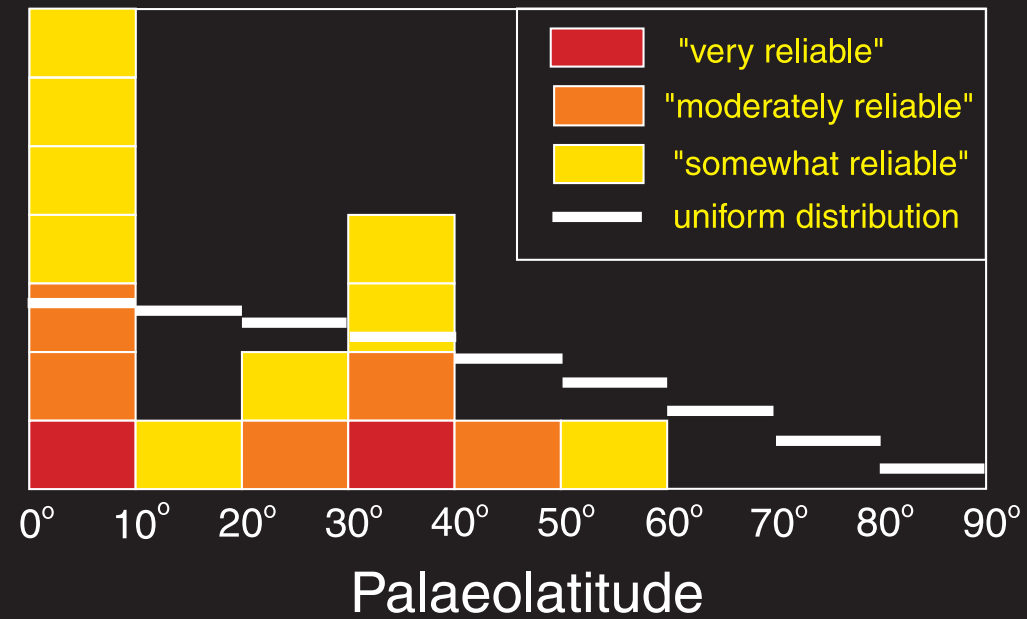
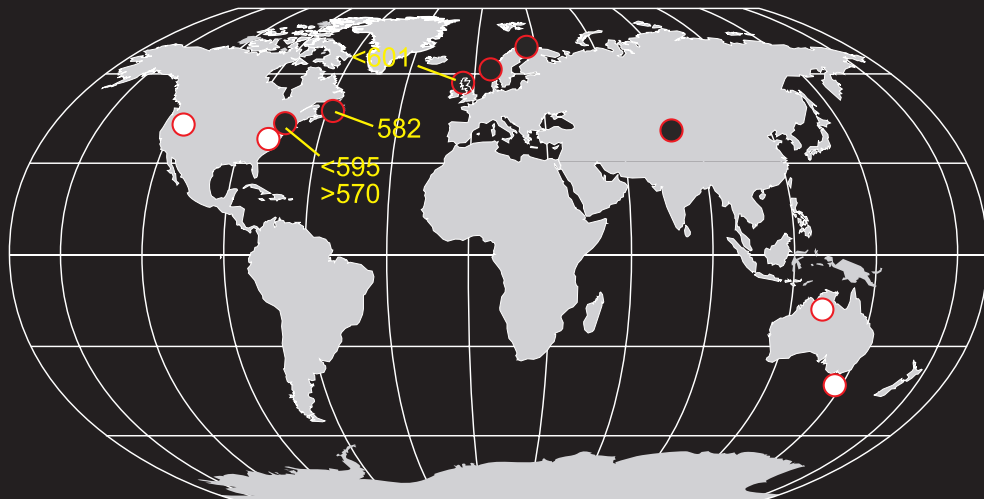
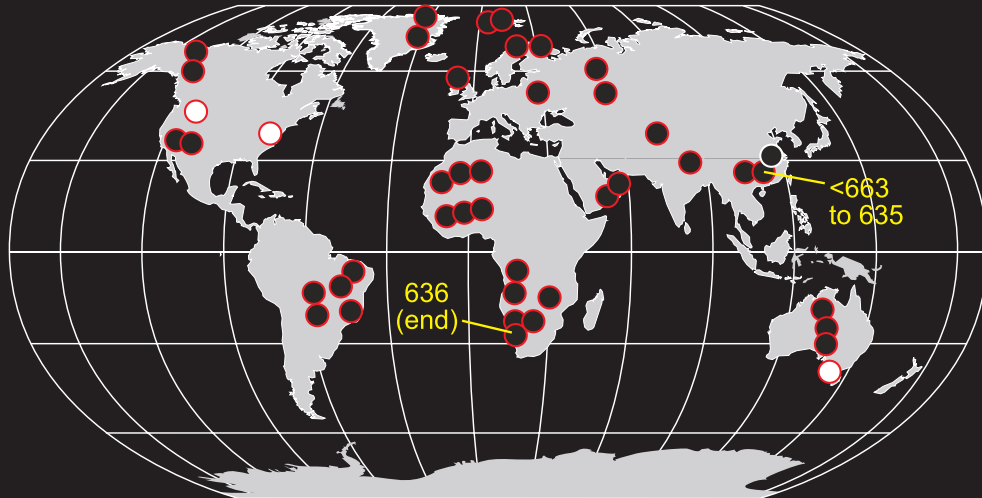
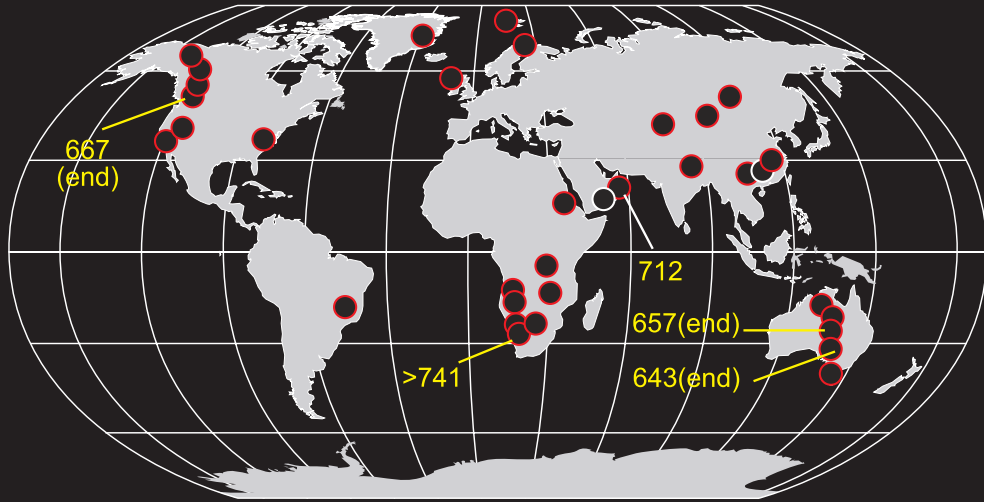
The Proterozoic: Gateway to an metazoan-dominated, oxygenated, biosphere?



Evidence for glaciation



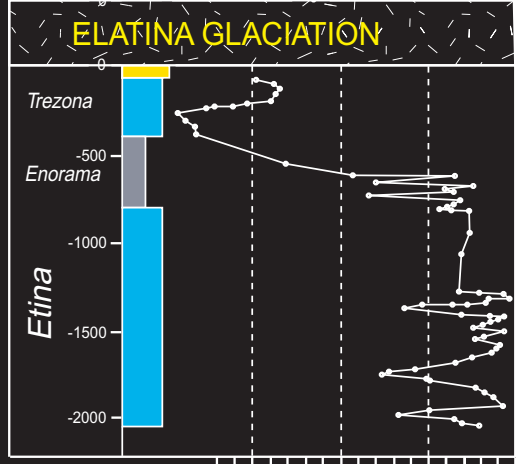
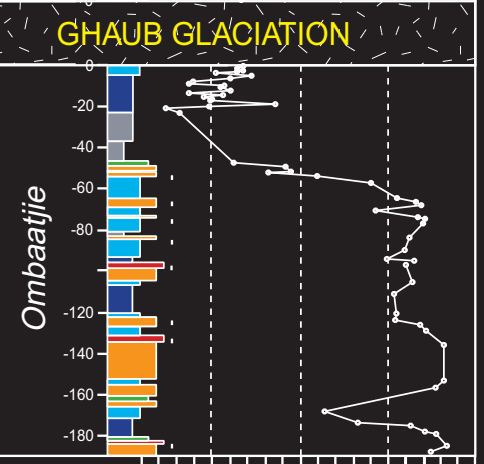
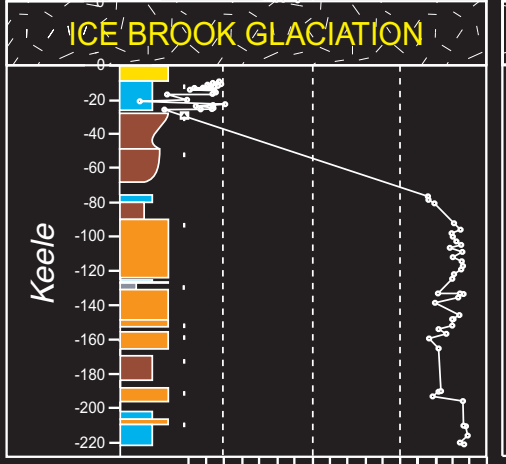
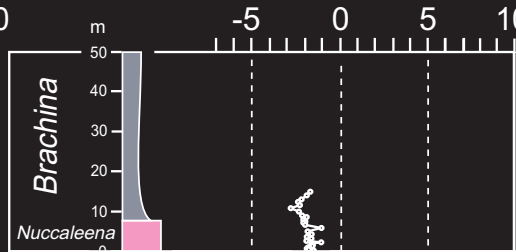
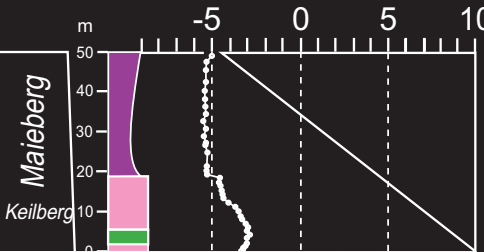
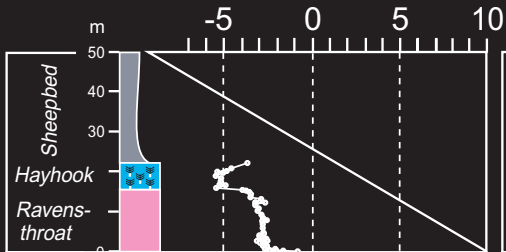
Evidence for glaciation



CANADA

NAMIBIA

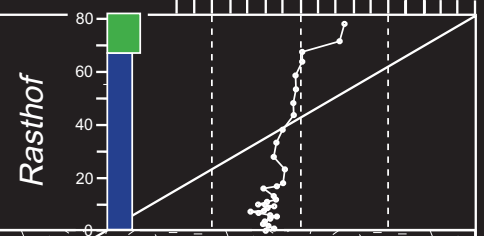
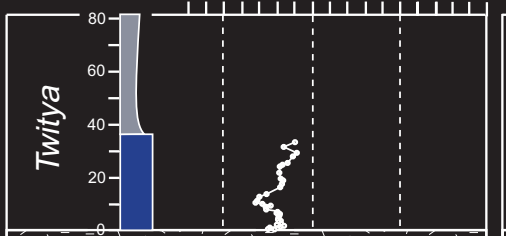
AUSTRALIA



SECTION NOT SHOWN

SECTION NOT SHOWN

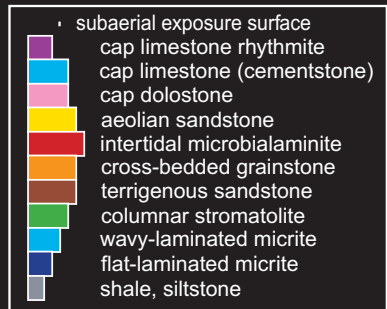
SECTION NOT SHOWN



RAPITAN GLACIATION

CHUOS GLACIATION

STURTIAN G

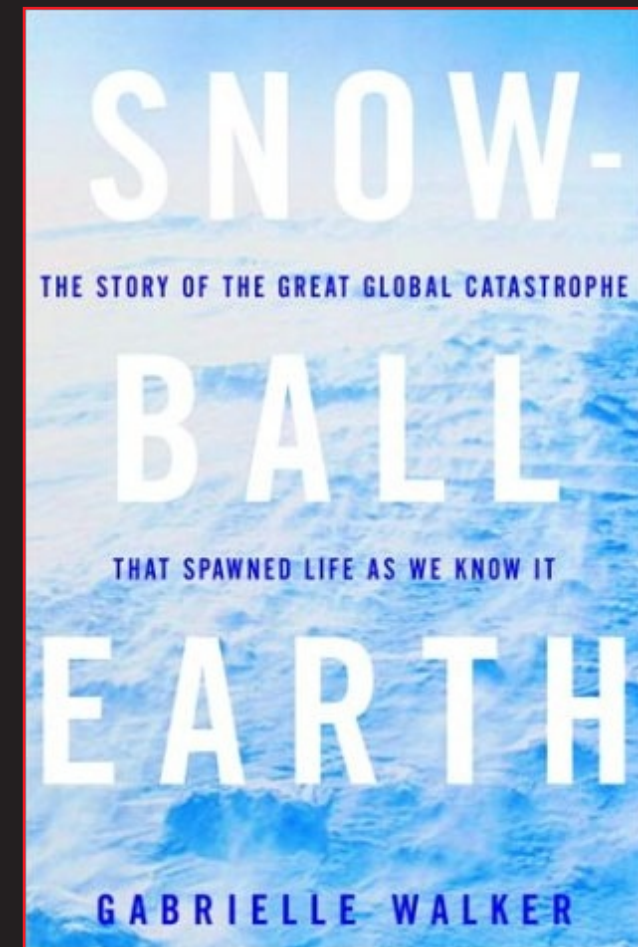


$\delta^{13}\text{C}$ (‰ VPDB)

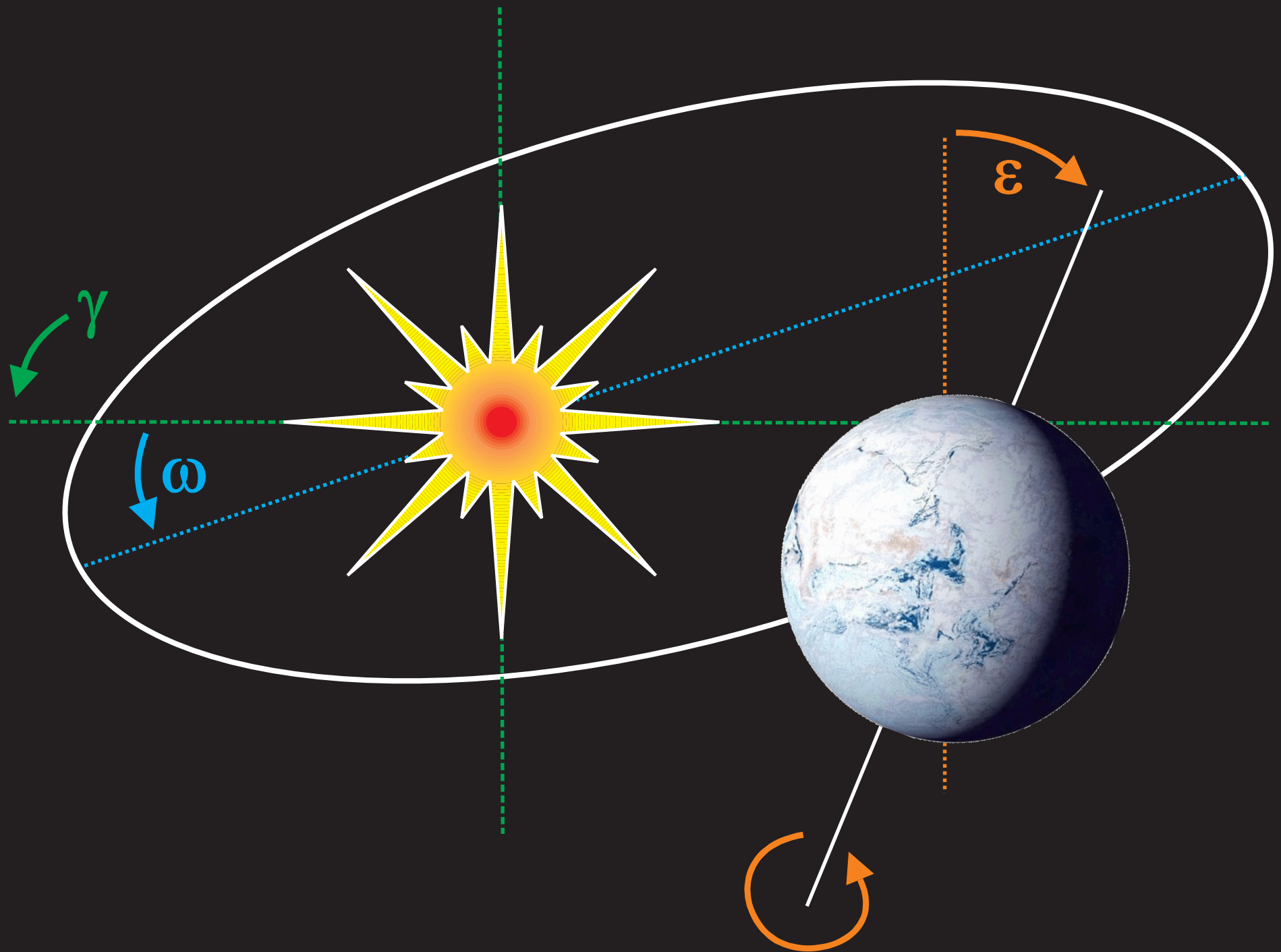


'snowball Earth'

Hoffman et al. [1998] (*Science* **281**)



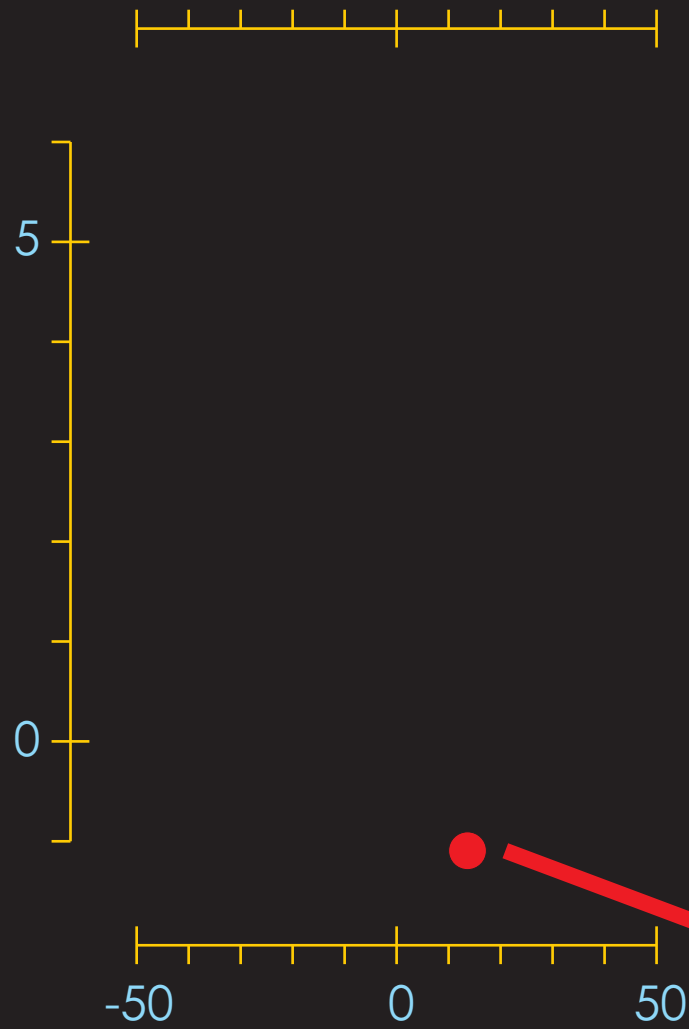
'snowball Earth'



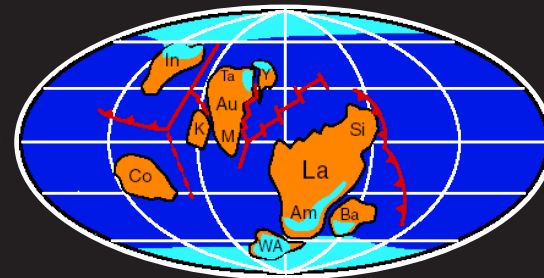
The snowball Earth hypothesis

[Hoffman and Schrag, 2002] (*Terra Nova* **14**, 129-155)

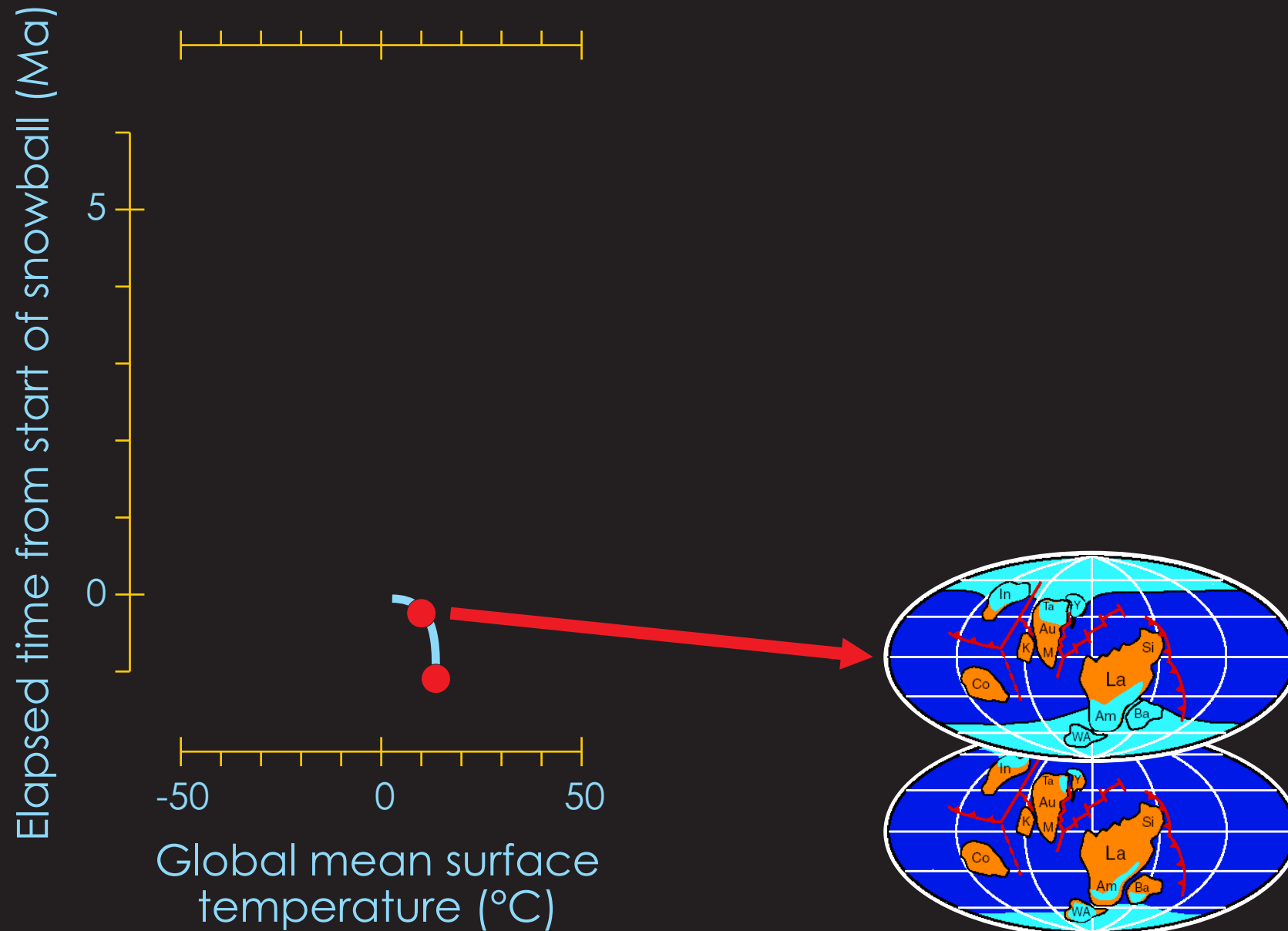
Elapsed time from start of snowball (Ma)



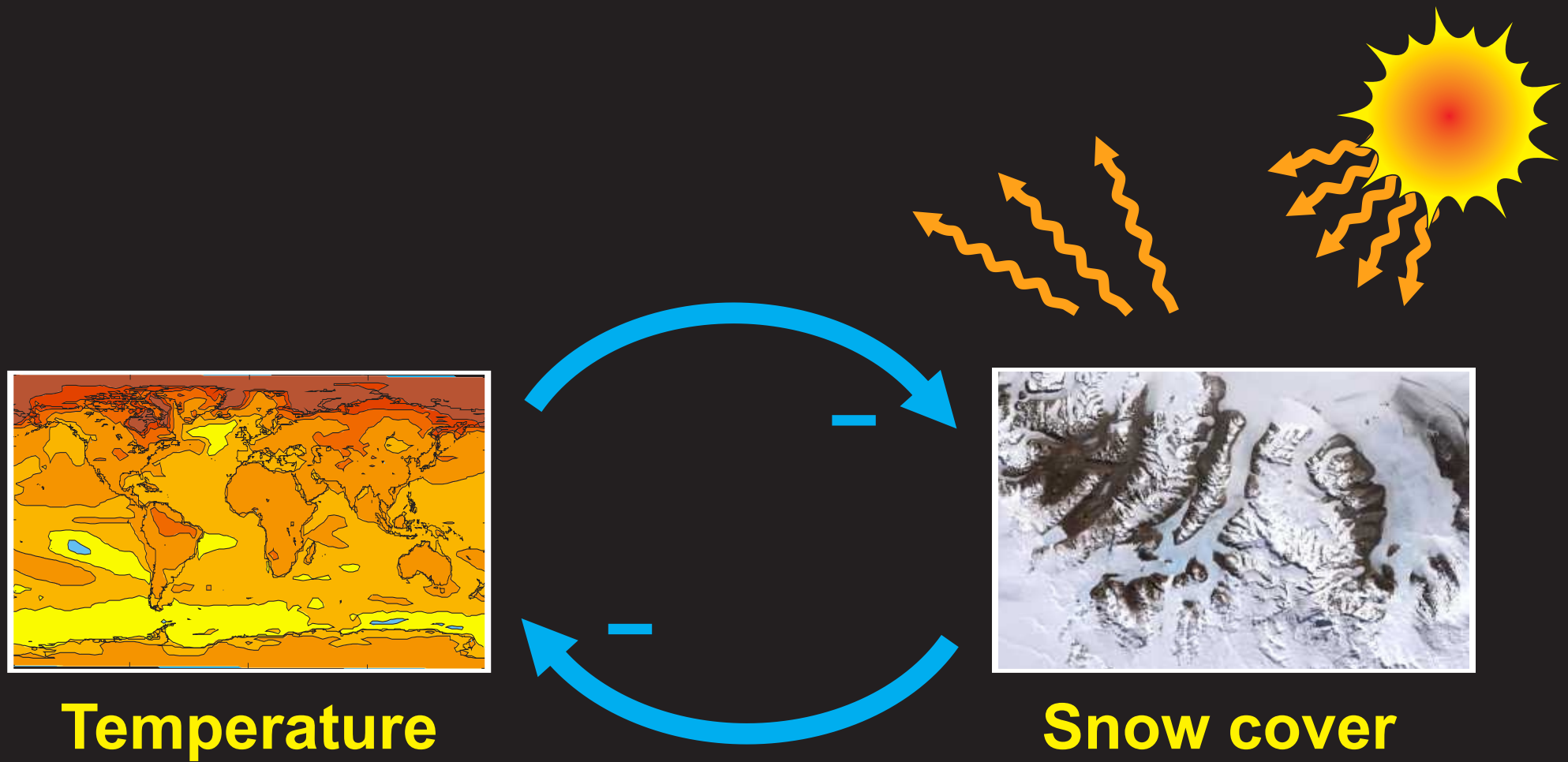
Global mean surface temperature (°C)



The snowball Earth hypothesis

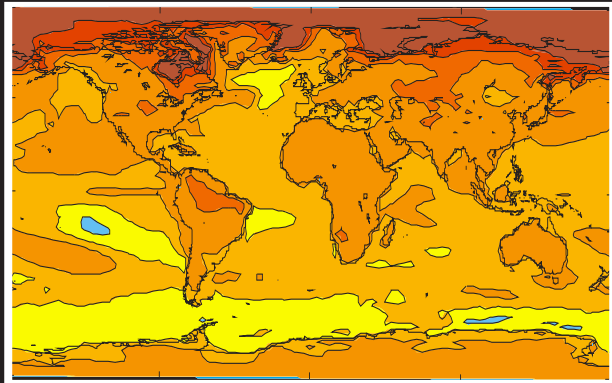
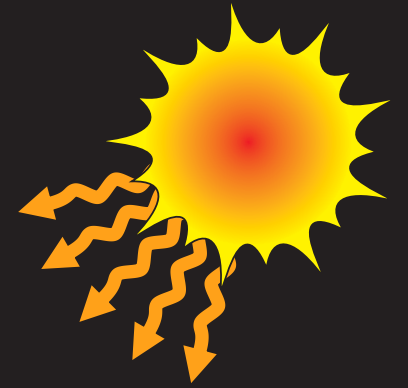


'Feedbacks'

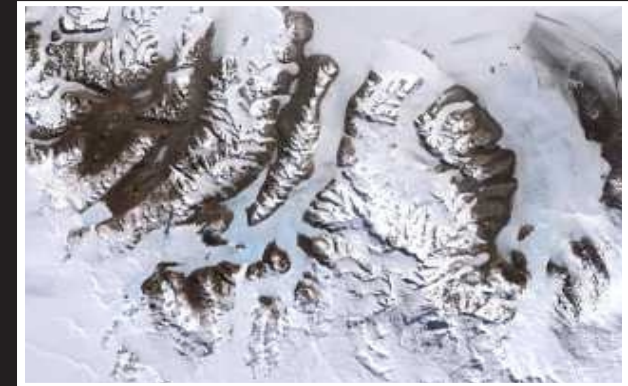


positive "ice-albedo" feedback

'Feedbacks'



Temperature

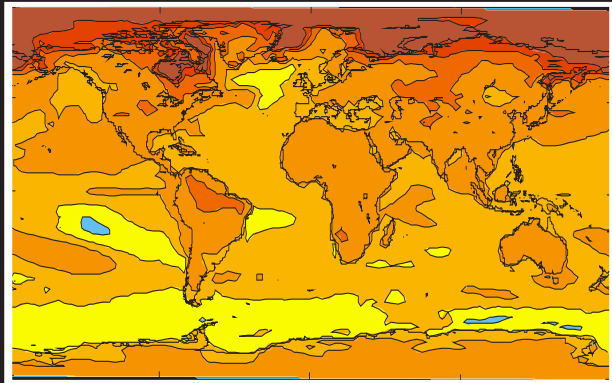


Snow cover



= $-1/2^{\circ}\text{C}$

'Feedbacks'



Temperature

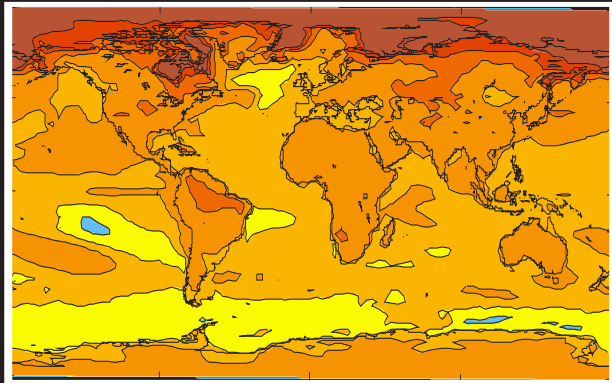
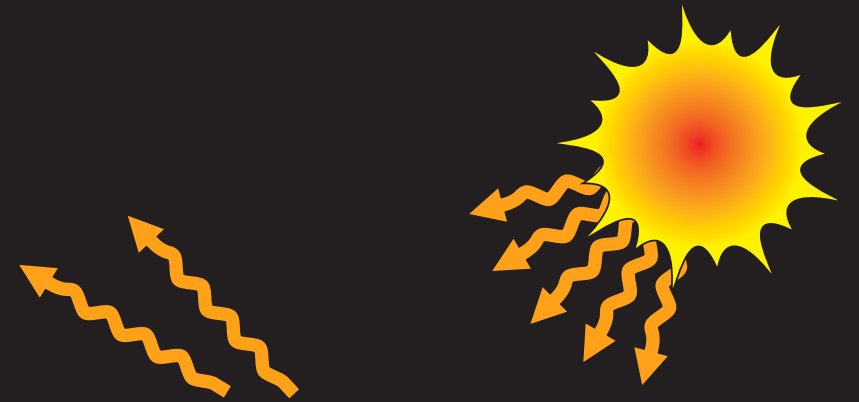


Snow cover

TOTAL CHANGE = $-1/2^{\circ}\text{C}$



'Feedbacks'



Temperature

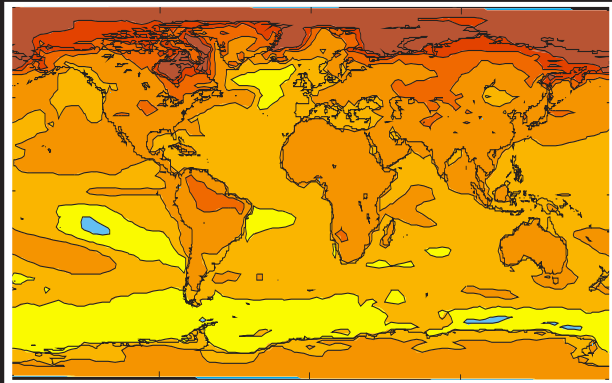


Snow cover



$$\text{TOTAL CHANGE} = -1/2^{\circ}\text{C} - 1/4^{\circ}\text{C}$$

'Feedbacks'

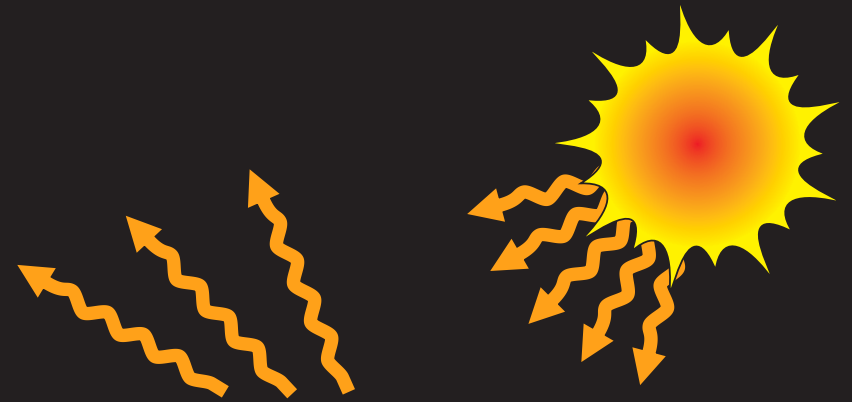


Temperature

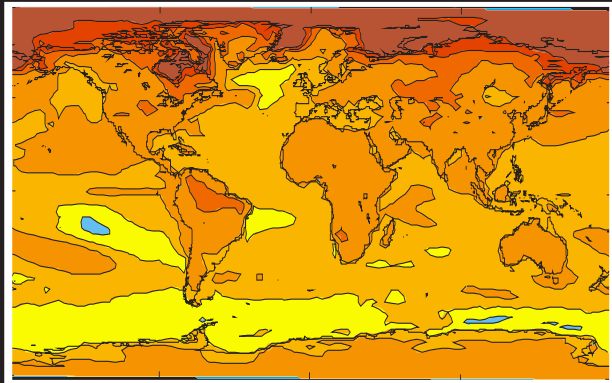


Snow cover

TOTAL CHANGE = $-1/2^{\circ}\text{C}$ - $1/4^{\circ}\text{C}$



'Feedbacks'



Temperature

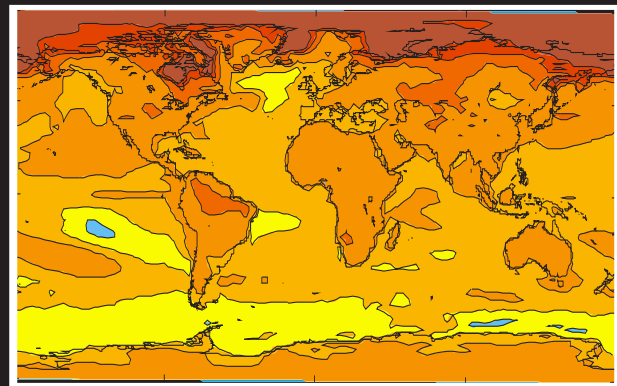


Snow cover

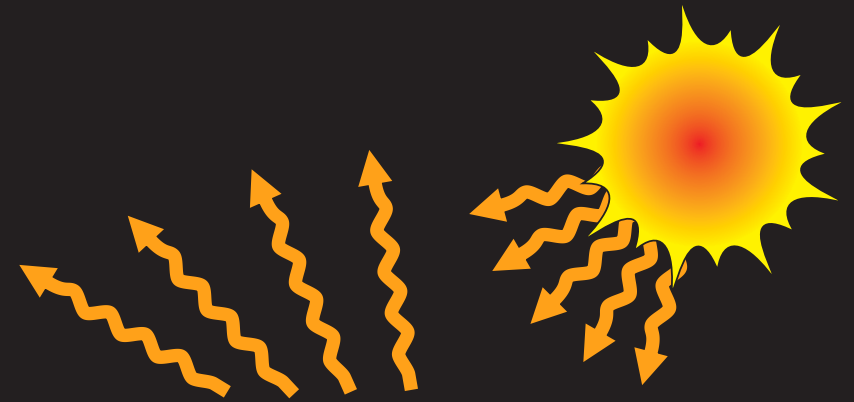


$$\text{TOTAL CHANGE} = -1/2^{\circ}\text{C} - 1/4^{\circ}\text{C} - 1/8^{\circ}\text{C}$$

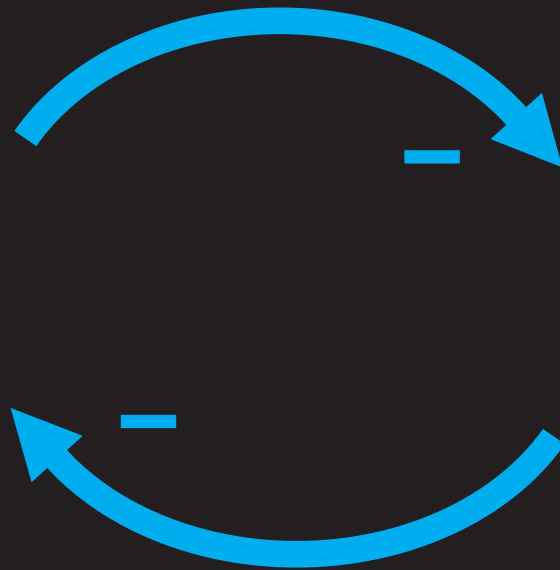
'Feedbacks'



Temperature

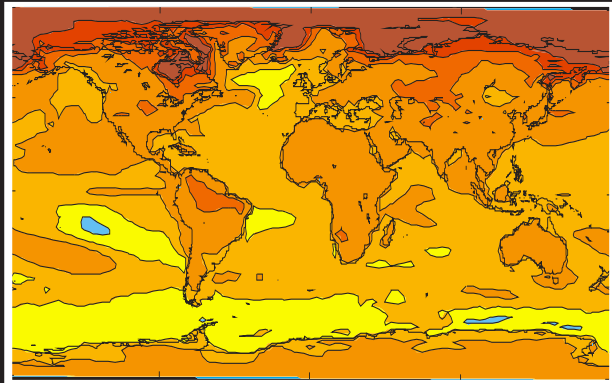
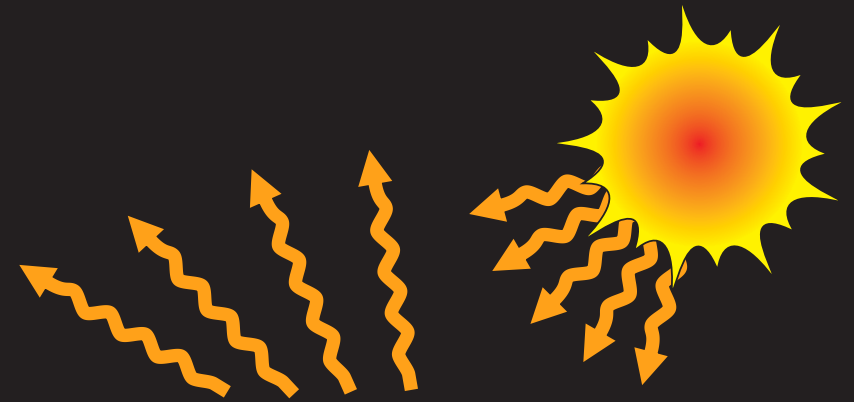


Snow cover

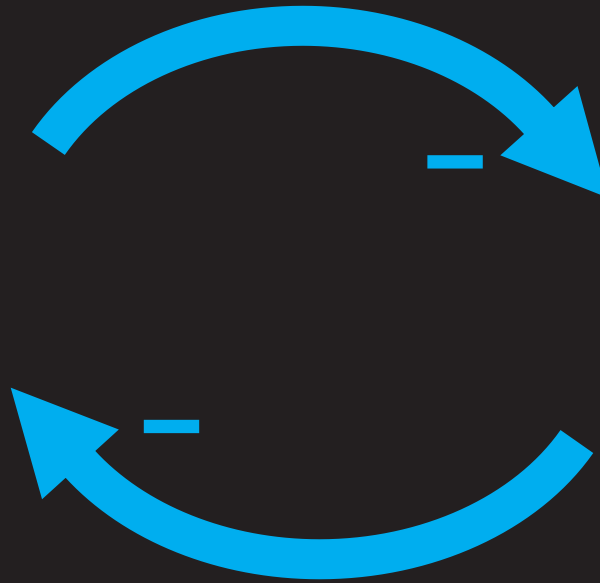


$$\text{TOTAL CHANGE} = -1/2^\circ\text{C} - 1/4^\circ\text{C} - 1/8^\circ\text{C} - 1/16^\circ\text{C} - \dots$$

'Feedbacks' ('runaway')



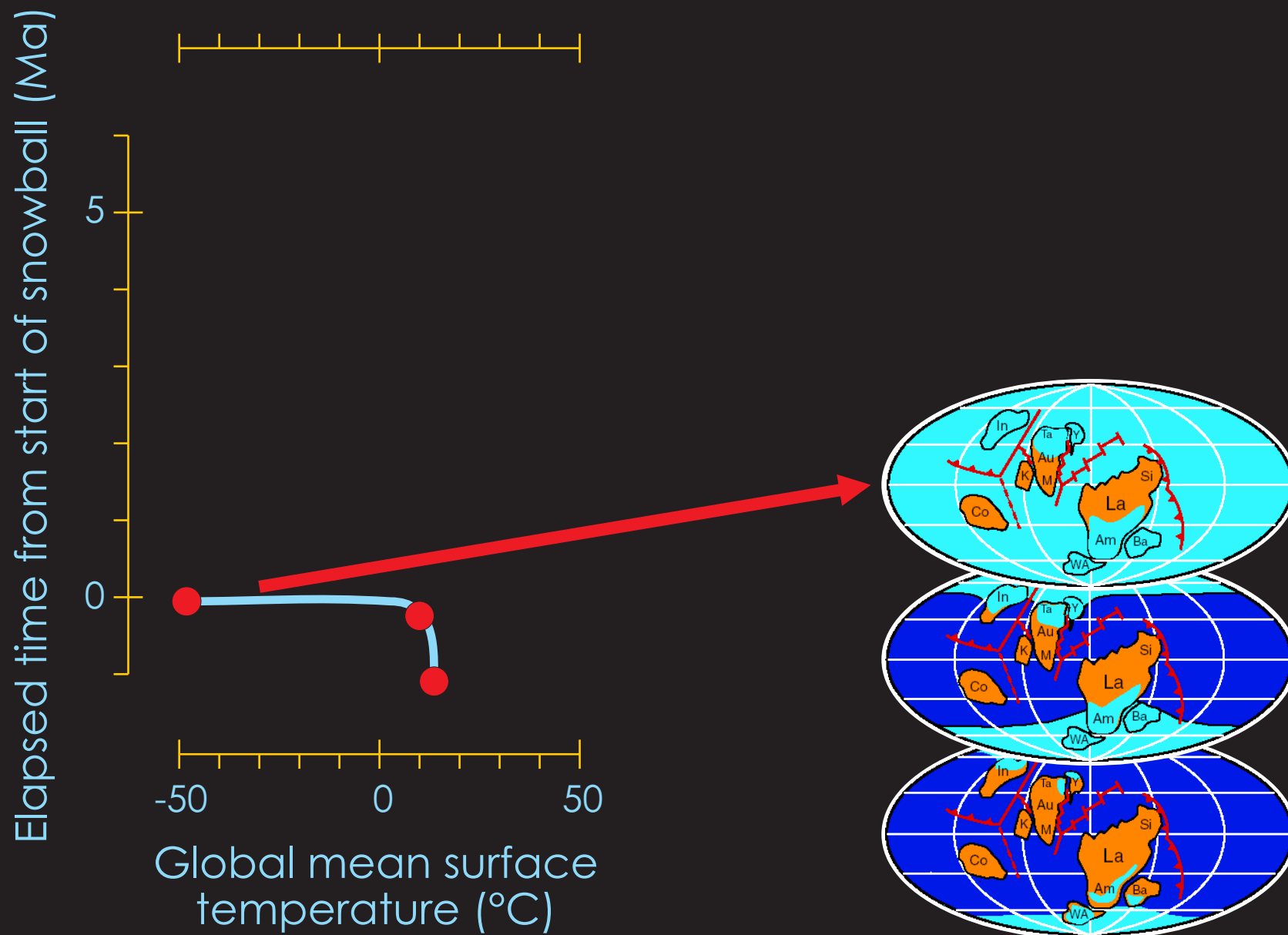
Temperature



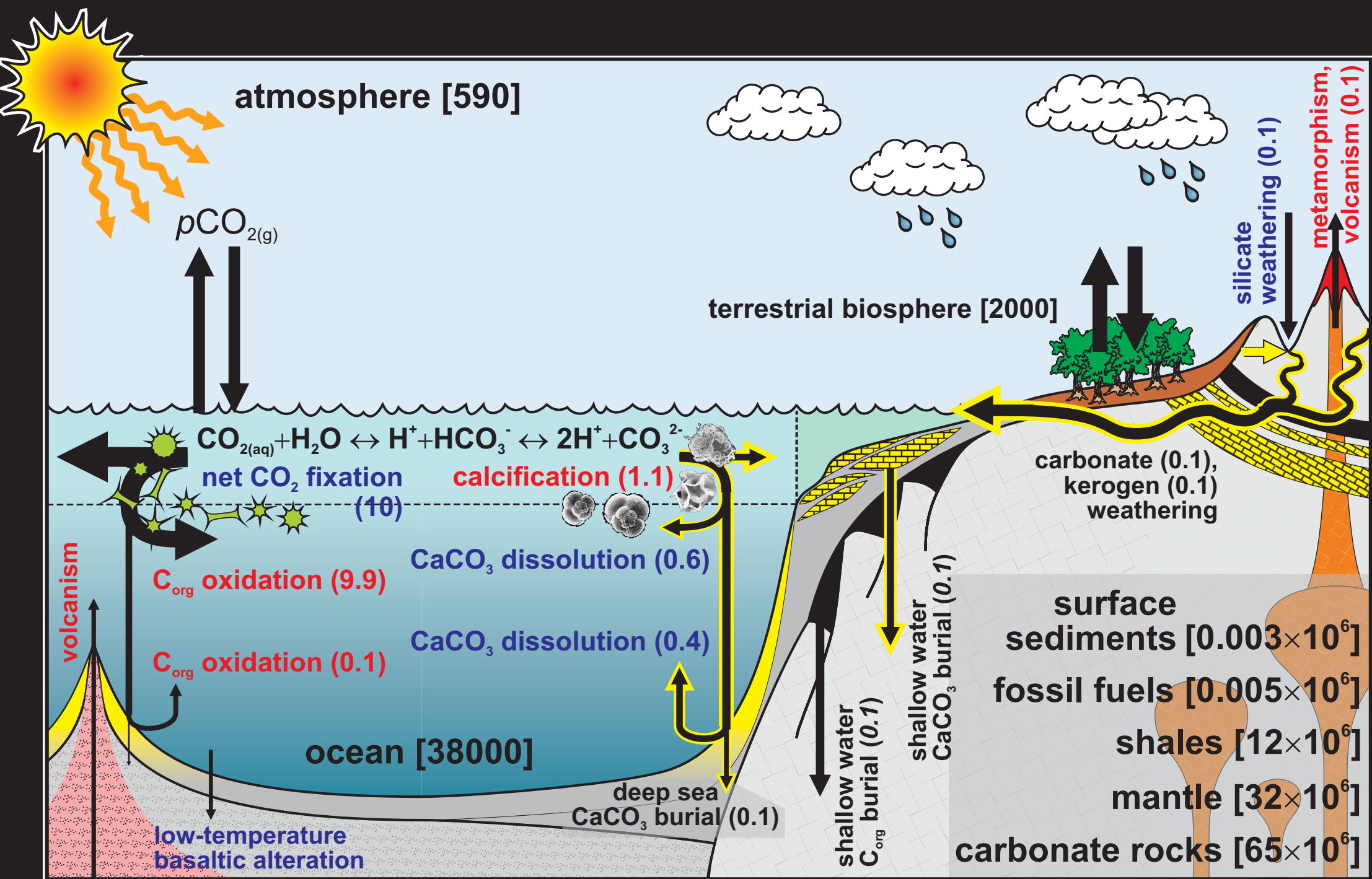
Snow cover

TOTAL CHANGE = $-1^{\circ}\text{C} - 2^{\circ}\text{C} - 4^{\circ}\text{C} - 8^{\circ}\text{C}$
-

The snowball Earth hypothesis



The global carbon cycle (modern)



Long-term controls on atmospheric $p\text{CO}_2$

Terrestrial weathering can be (approximately equally) divided into carbonate (CaCO_3) and calcium-silicate (' CaSiO_3 ') weathering:



Ultimately, the (alkalinity: Ca^{2+}) weathering products must be removed through carbonate precipitation and burial in marine sediments:



It can be seen that in (2) + (3), that the CO_2 removed (from the atmosphere) during weathering, is returned upon carbonate precipitation (and burial). In (1) + (3) (silicate weathering) CO_2 is permanently removed to the geological reservoir. This CO_2 must be balanced by mantle (/volcanic) out-gassing on the very long term.

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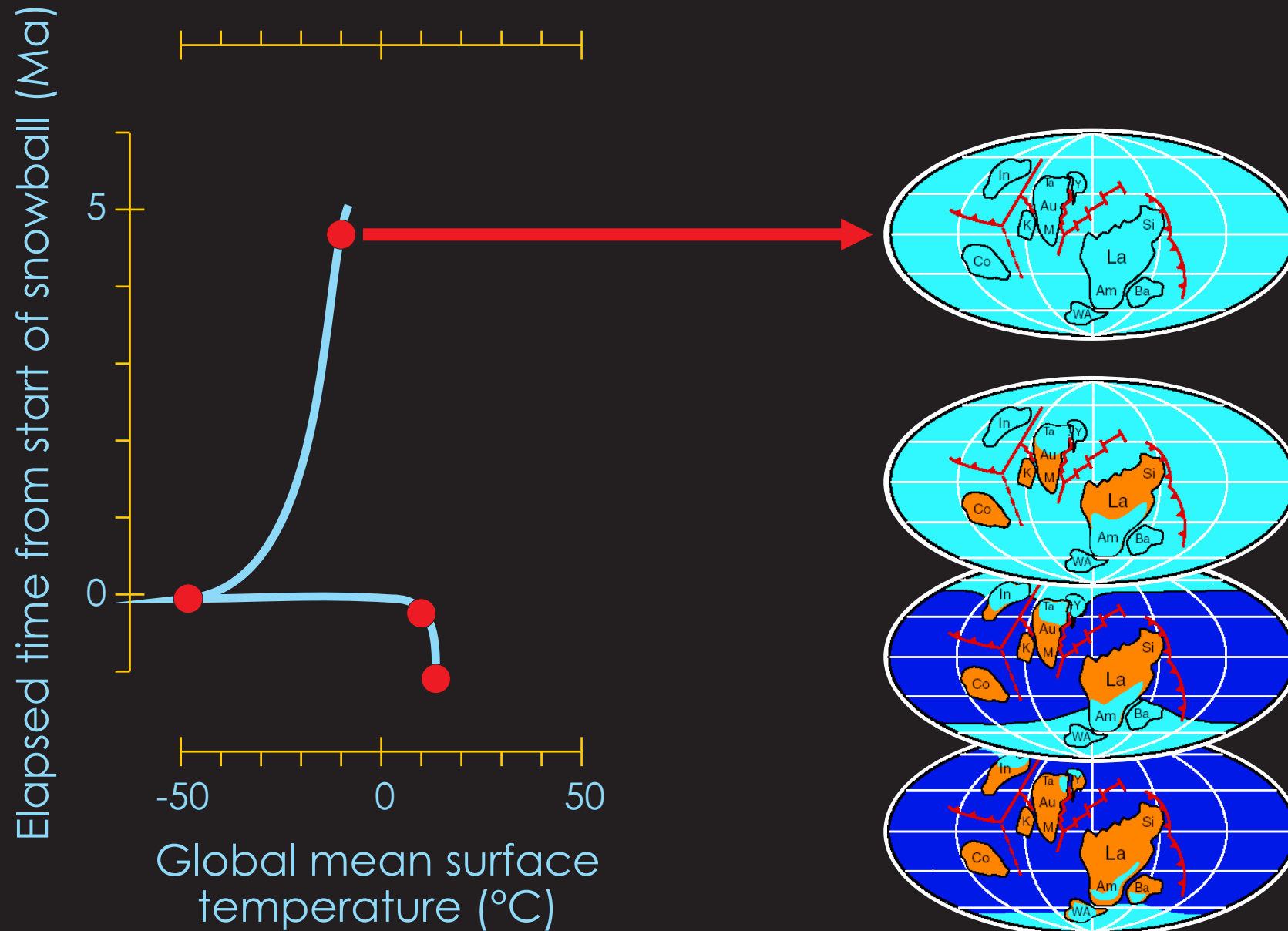


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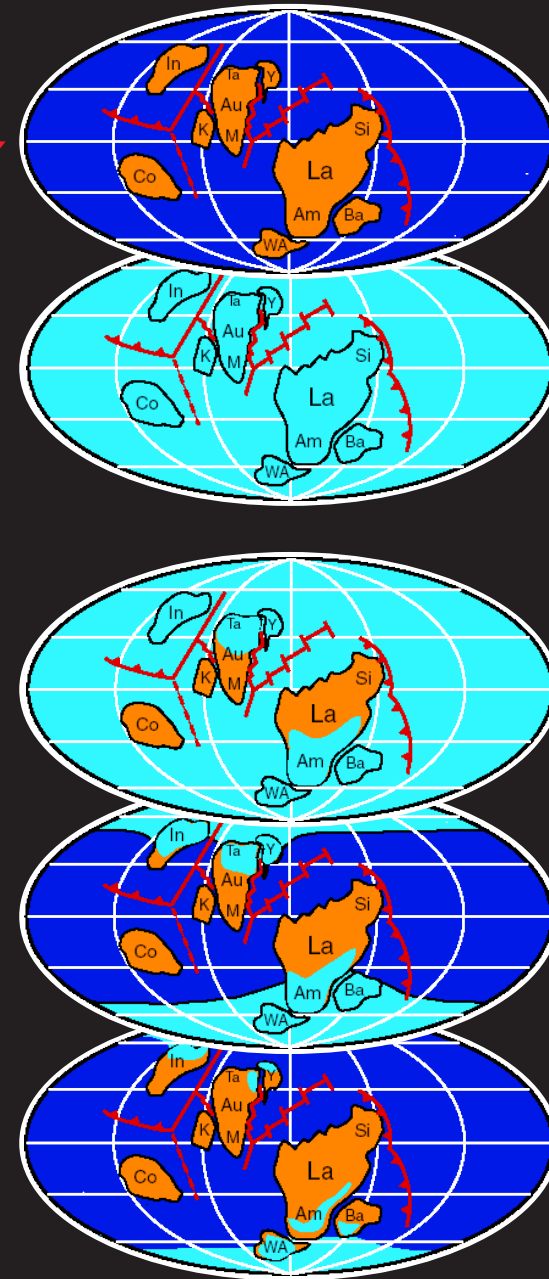
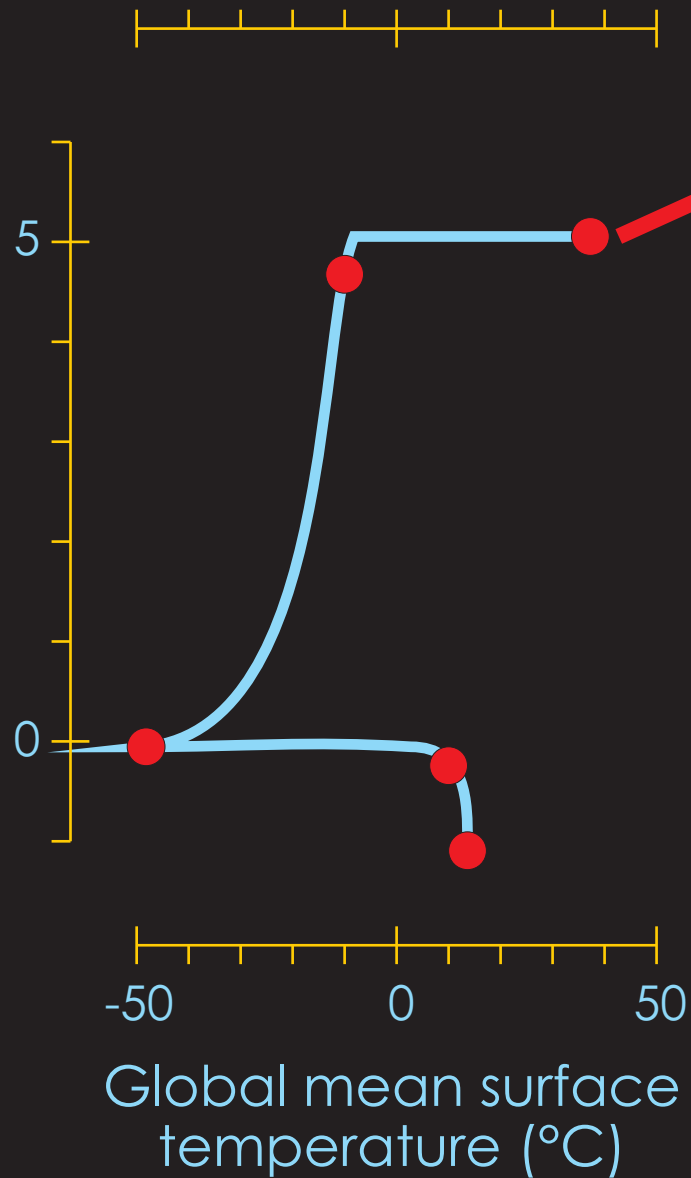
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The snowball Earth hypothesis

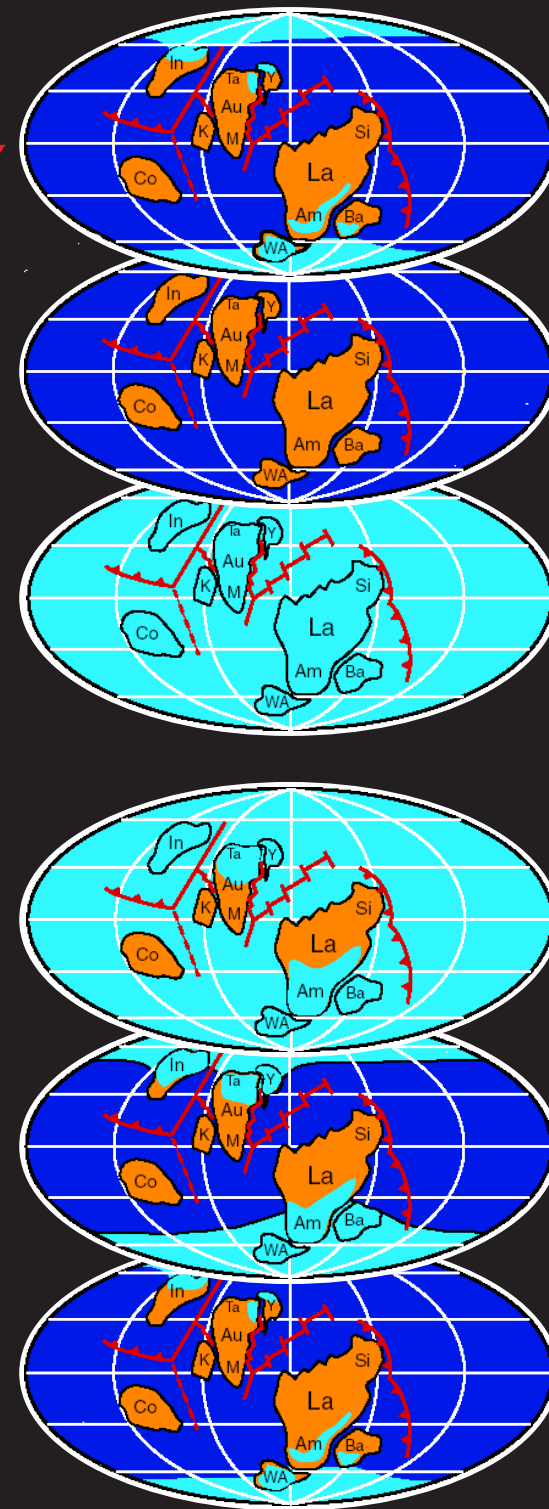
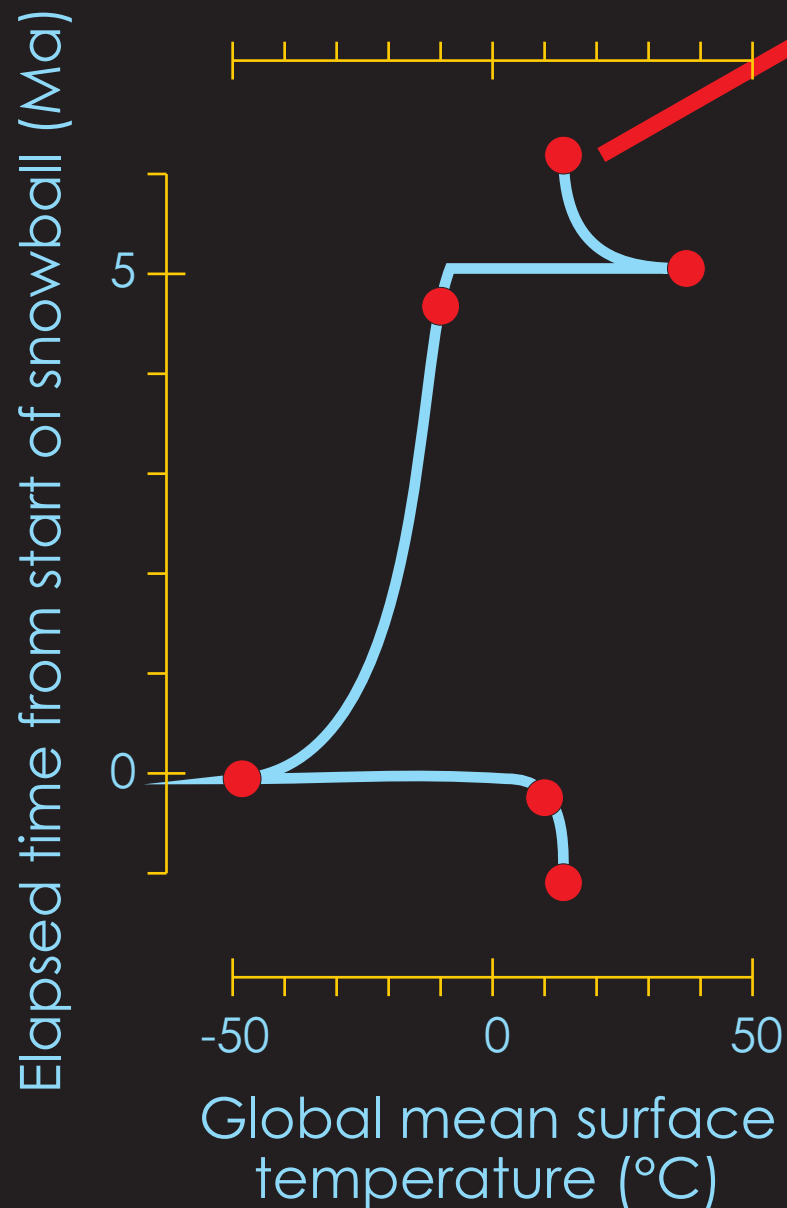


The snowball Earth hypothesis

Elapsed time from start of snowball (Ma)



The snowball Earth hypothesis



adapted from; Hoffman and Schrag [2002]

Alternative explanations for the glacial observations

