Virginia in the Miocene Epoch; 23.0-5.3 million years ago

This map shows how North America appeared 18 million years ago The Atlantic shore line is just west of Richmond The climate was cool and dry compared to the tropical Paleocene and Eocene Epochs, although still warmer than today. Towards the end of the Miocene, the global climate became even cooler and drier because of an expansion of glacial ice sheets on Antarctica The marine soils on which some of the largest buildings of Tidewater and Richmond are founded are deposited; Miocene Clay (Richmond) and Miocene Sand (Tidewater) Apes evolve in Africa

The Yorktown Formation

The east coast subsides and becomes submerged

The Yorktown Formation

The east coast subsides and becomes submerged

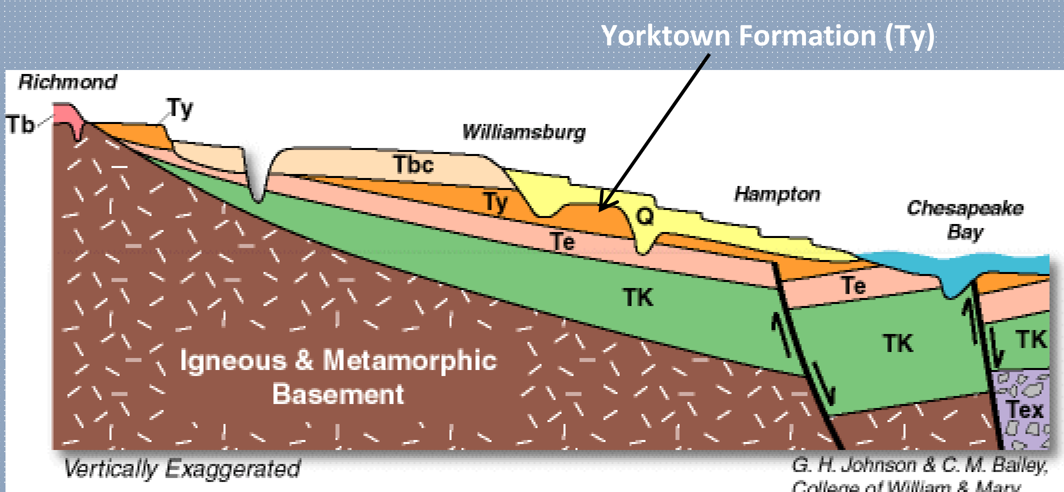
• Deposited in a shallow, tropical sea 5.3 to 3.6 million years ago when eastern Virginia was submerged and the shore line was west of Richmond. Deposited in the late-Miocene mid-Pliocene epochs when mean annual atmospheric temperatures were 2 - 2.5˚ C warmer with greater precipitation than today.

• Comp ised primarily of Silty Sand with Ma ine Shell Fragments and was originally many hundreds of feet thick

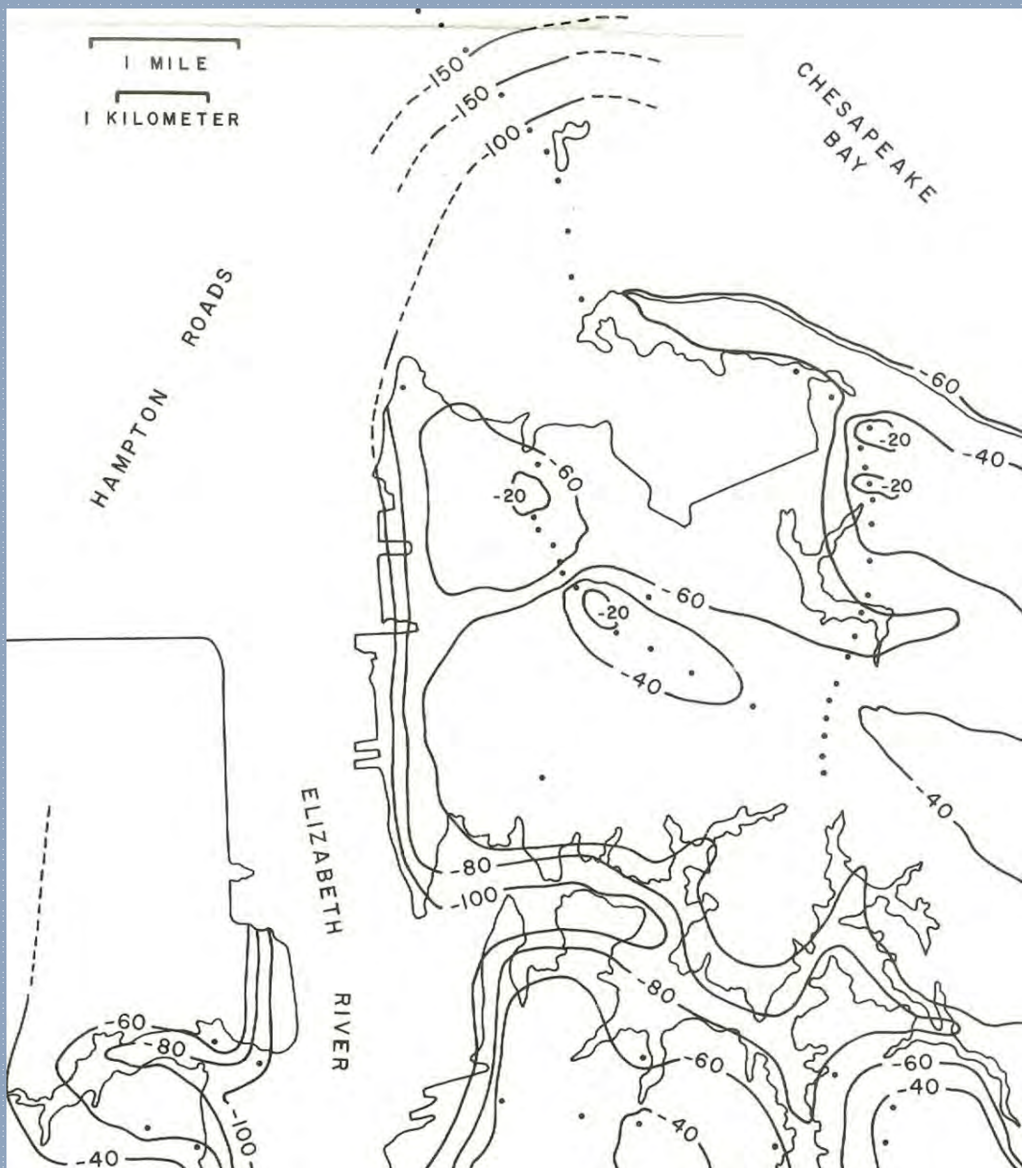
• During a glacial period when sea level fell and exposed Yorktown sediments on the surface, the upper po tion of the Yorktown formation was removed by subsequent erosion, which cut deep channels into its surface These channels are now filled with and buried by recent deposits

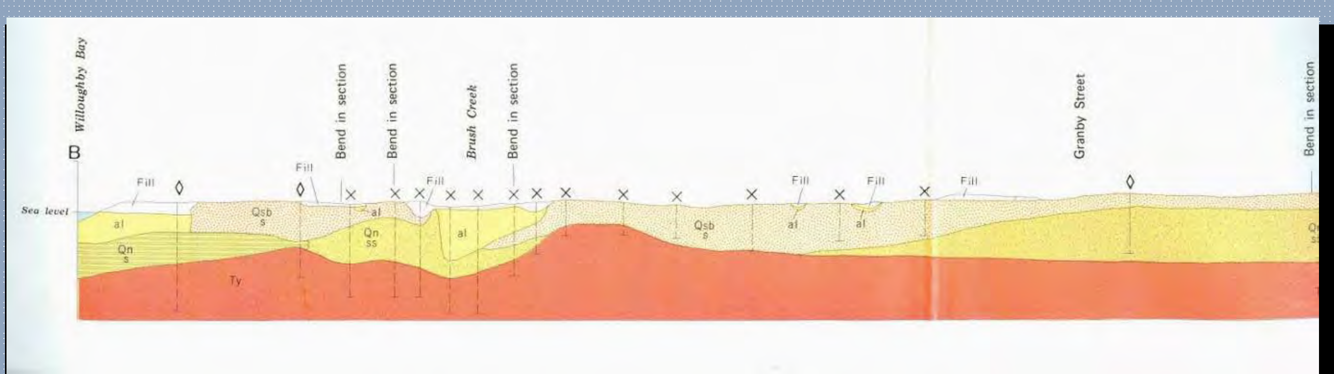
• Highly pre consolidated. Very good foundation support material for deep foundations Tends to liquefy during driven pile installation.

• Surface of Yorktown Formation is within 10 feet of the ground surface at Langley AFB and 30 to 70 feet r more below the surface in Norfolk.



The Yorktown Formation below the Norfolk Naval base





The Yorktown Formation below LAFB

CLIENT	JOB #	BORING #	SHEET	
	10590	B-1	1 OF 2	ECS LLC MID-ATLANTIC
PROJECT NAME: Air Base Wing Headquarters – Joint Basing	ARCHITECT-ENGINEER:			
SITE LOCATION: LAFB, Hampton, Virginia				

CALIBRATED PENETROMETER TONS/FT.^{2} (1, 2, 3, 4, 5+)

PLASTIC LIMIT % (X) — WATER CONTENT % (●) — LIQUID LIMIT % (△)

ROCK QUALITY DESIGNATION & RECOVERY: RQD% — REC.% (20%, 40%, 60%, 80%, 100%)

STANDARD PENETRATION BLOWS/FT. (10, 20, 30, 40, 50+)

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION 100%

SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	STANDARD PENETRATION (BLOWS/FT.)	WATER CONTENT %
0–2	1	SS	24	24	Topsoil Depth 6"	7 (1-3-4-4)	
2–4	2	SS	24	16	FILL – Fine Sandy CLAY, Trace Roots, Dark Brown and Gray, Moist, Stiff, (CL-SC)	13 (4-6-7-8)	
4–6	3	SS	24	14	Fine Sandy, Lean CLAY, Orange, Brown and Gray, Very Moist, Stiff, (CL)	11 (6-6-5-4)	
6–8	4	SS	24	16	Clayey Fine SAND, With Marine Shell Fragments, Orange Brown, Wet, Very Loose, (SC)	4 (2-2-2-2)	36.5
8–10	5	SS	24	24		6 (2-3-3-4)	
10					Silty Fine SAND, Trace Marine Shell Fragments, Dark Gray, Wet, Very Loose, (SM)		
13–15	6	SS	24	24		4 (2-2-2-3)	32.2
18–20	7	SS	24	24		4 (2-2-2-3)	
23–25	8	SS	24	24		4 (2-1-2-3)	33.1
28–30	9	SS	24	24		4 (2-2-2-3)	

CONTINUED ON NEXT PAGE.

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 1 FT — WS OR WD	BORING STARTED 2/22/10	
WL(BCR) — WL(ACR)	BORING COMPLETED 2/22/10	CAVE IN DEPTH N/A
WL	RIG ATV — FOREMAN FDI	DRILLING METHOD Mud

Virginia in the Pliocene Epoch; 5.3-2.6 million years ago

This map shows how North America appeared 3 million years ago. Waves lap on the shores of Louisa County and The Yorktown Formation has been deposited But global sea level begins to drop over 200 feet in the Pliocene because of an increase in glacial ice at the poles. This increase of glacial ice created a global climate that was relatively dry and cool. At the end of the Pliocene further expansion of glacial ice occurs at the poles which leads to another decrease in global temperatures, and a drop in sea level around the world. Virginia s Miocene deposits are exposed and begin to erode. Lucy stands upright 3.4 MYA.

Virginia in the Pleistocene Epoch; 2.6 million to 10,000 years ago

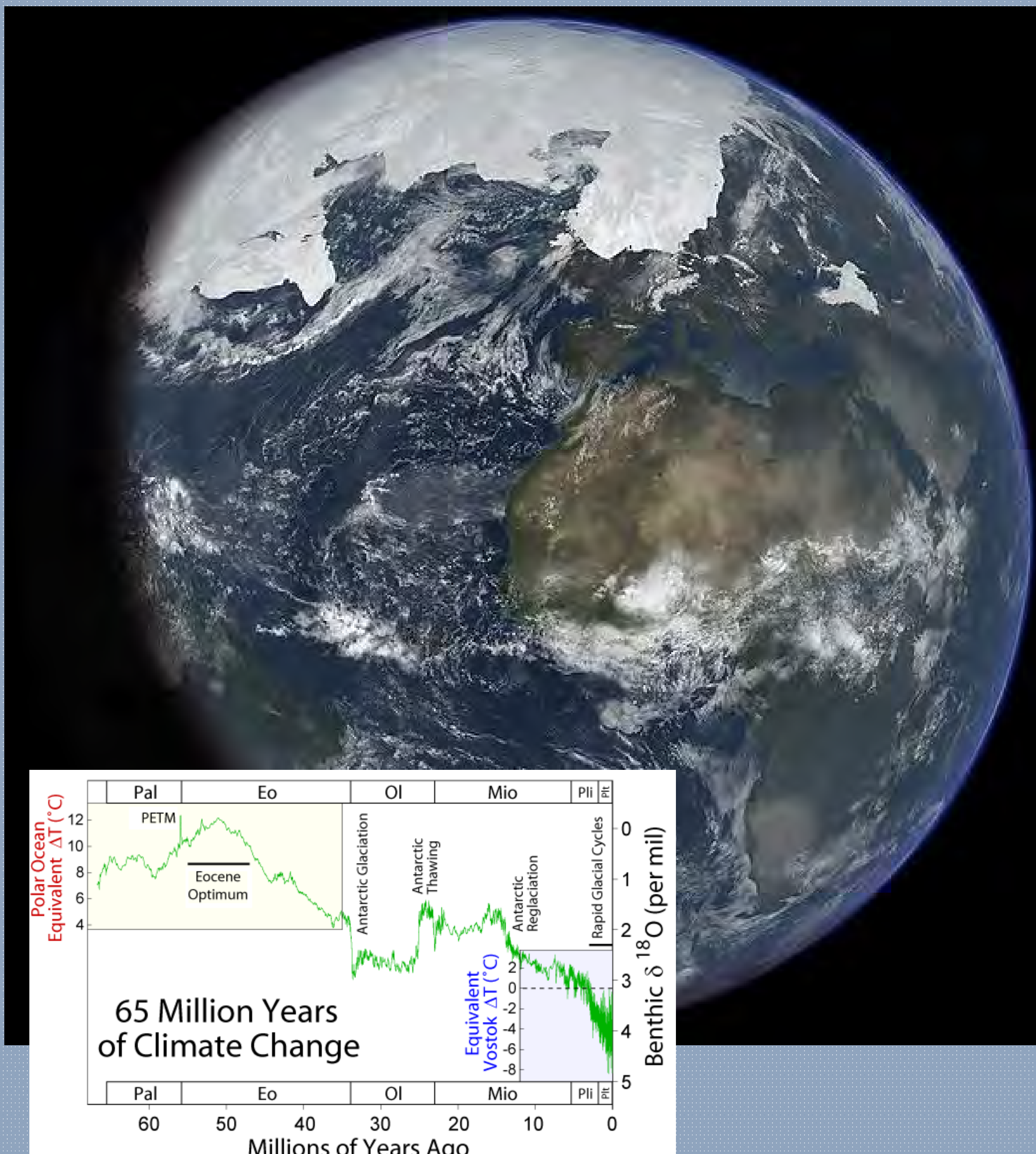
This map shows how North America appeared just over 12 000 years ago During the Pleistocene, repeated glaciations occurred, some of which extended as far south as Pennsylvania. This was the time period that many people have labeled the "Ice Age." The glacial ice that advanced from no thern Canada created many of the features we see on the landscape today such as the Great Lakes and Virginia's Coastal Plain Their melting created the Eastern Shore.

Virginia in the Holocene Epoch;
This very minute

This map shows how North America appears today. The glaciers have receded (we re just <u>between</u> glaciers for now) Drive around The Outer Banks or Virginia Beach and everything is Holocene Drive west on I-64 and it s all Holocene until you pass Nine Mile Road in Richmond where you're thrown back to the Tertiary Period where the decomposing Blue Ridge Mountains shed Gravelly Sand and Clay in a plume across the lanscape over millions of years. These Tertiary deposits cover Miocene deposits which cover Petersburg Granite the basement of Central Virginia

So what happened in Virginia in the Pleistocene and Holocene Epochs that so influenced the landscape?

Glaciation Creates the Coastal Plain morphology over 3 million years.

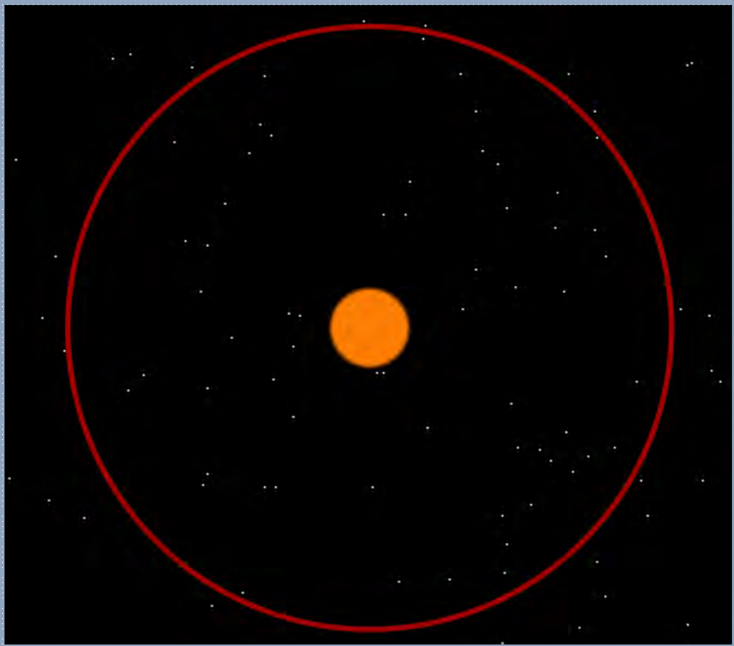


Why does global temperature change?

Milankovitch Cycles

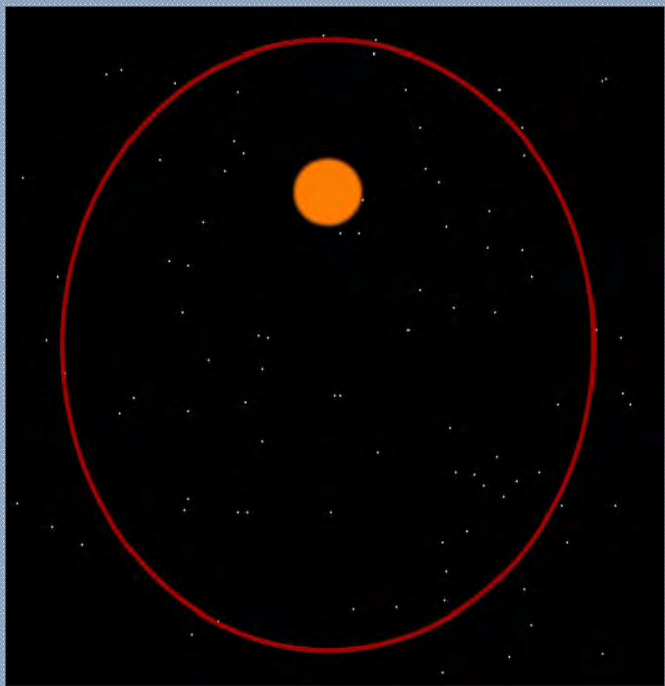
Milankovitch Theory describes the collective effects of changes in the Earth's movements upon its climate.

1. Orbital shape (eccentricity)



The Earth's orbit is an ellipse. The eccentricity is a measure of the departure of this ellipse from circularity. The Earth's eccentricity varies primarily due to interactions with the gravitational fields of Jupiter and Saturn.

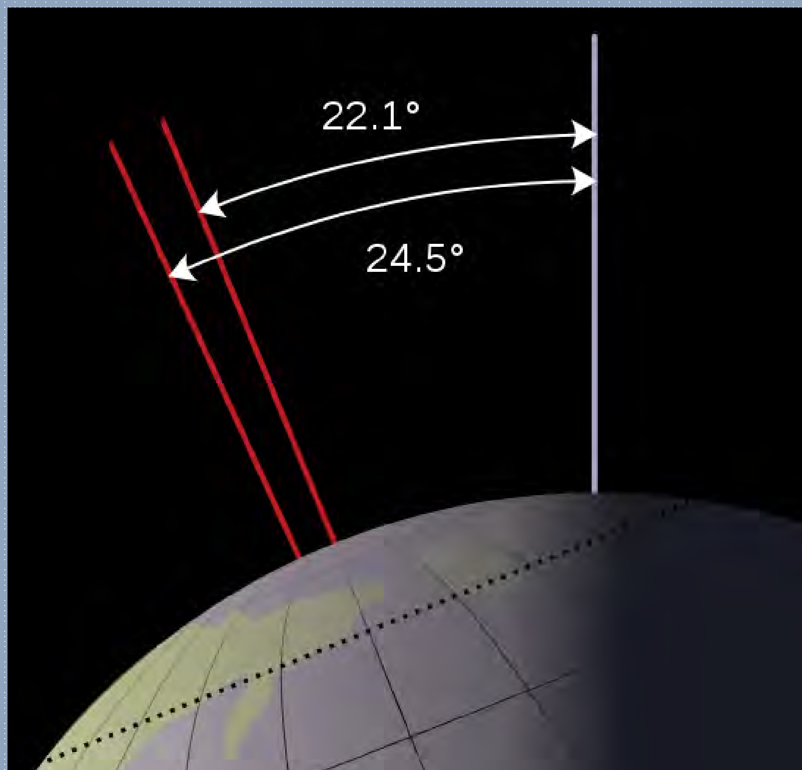
The shape of the Earth's orbit varies in time between being nearly circular (low eccentricity of 0.005) and being mildly elliptical (high eccentricity of 0.058) and has a mean eccentricity of 0.028. The major component of these variations occurs on a period of 413,000 years.



Glaciation

Milankovitch Cycles

2. Axial tilt (obliquity)

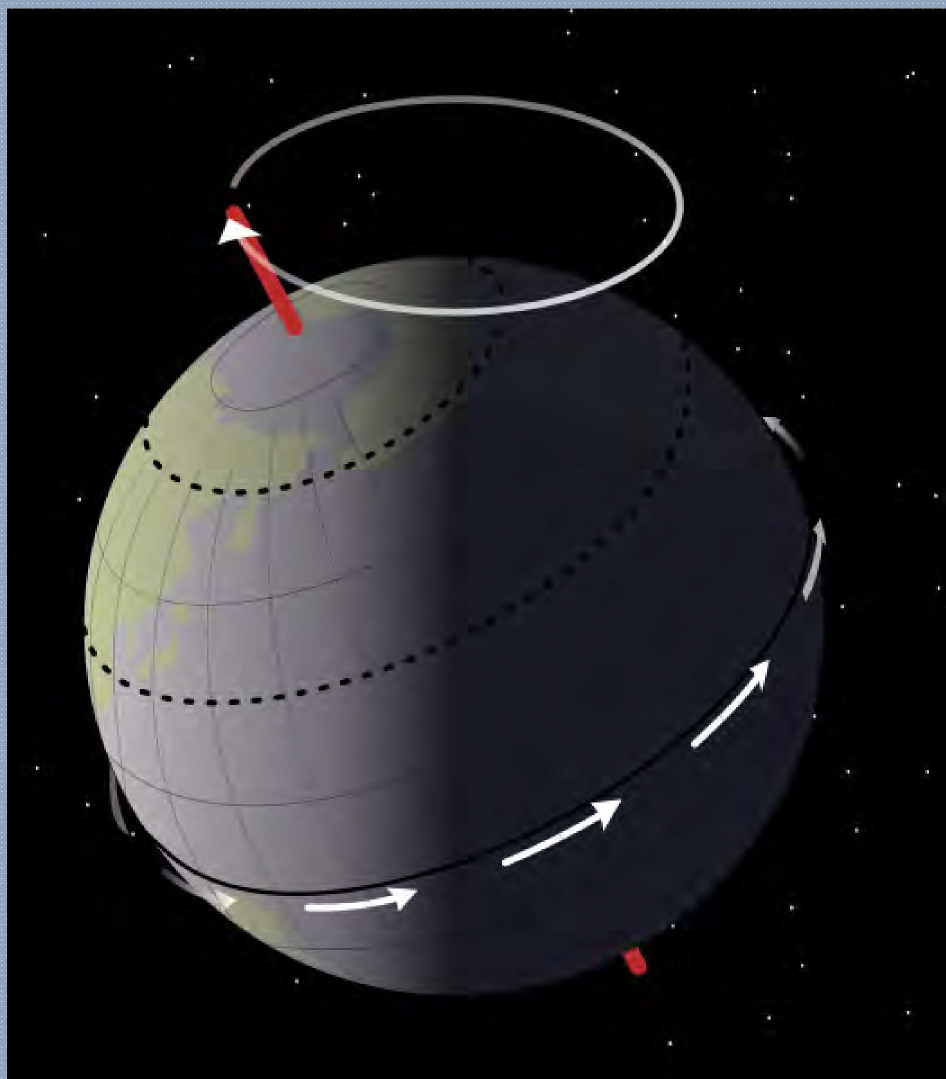


The angle of the Earth's axial tilt (obliquity) varies with respect to the plane of the Earth's orbit. These slow 2.4° obliquity variations are roughly periodic, taking approximately 41,000 years to shift between a tilt of 22.1° and 24.5° and back again. Cooler summers are suspected of encouraging the start of an ice age by melting less of the previous winter's ice and snow. Currently the Earth is tilted at 23.44 degrees from its orbital plane, roughly half way between its extreme values. The tilt is in the decreasing phase of its cycle, and will reach its minimum value around the year 10,000 C.E. This trend, by itself, would tend to make winters warmer and summers colder.

Glaciation

Milankovitch Cycles

3. Axial Precession

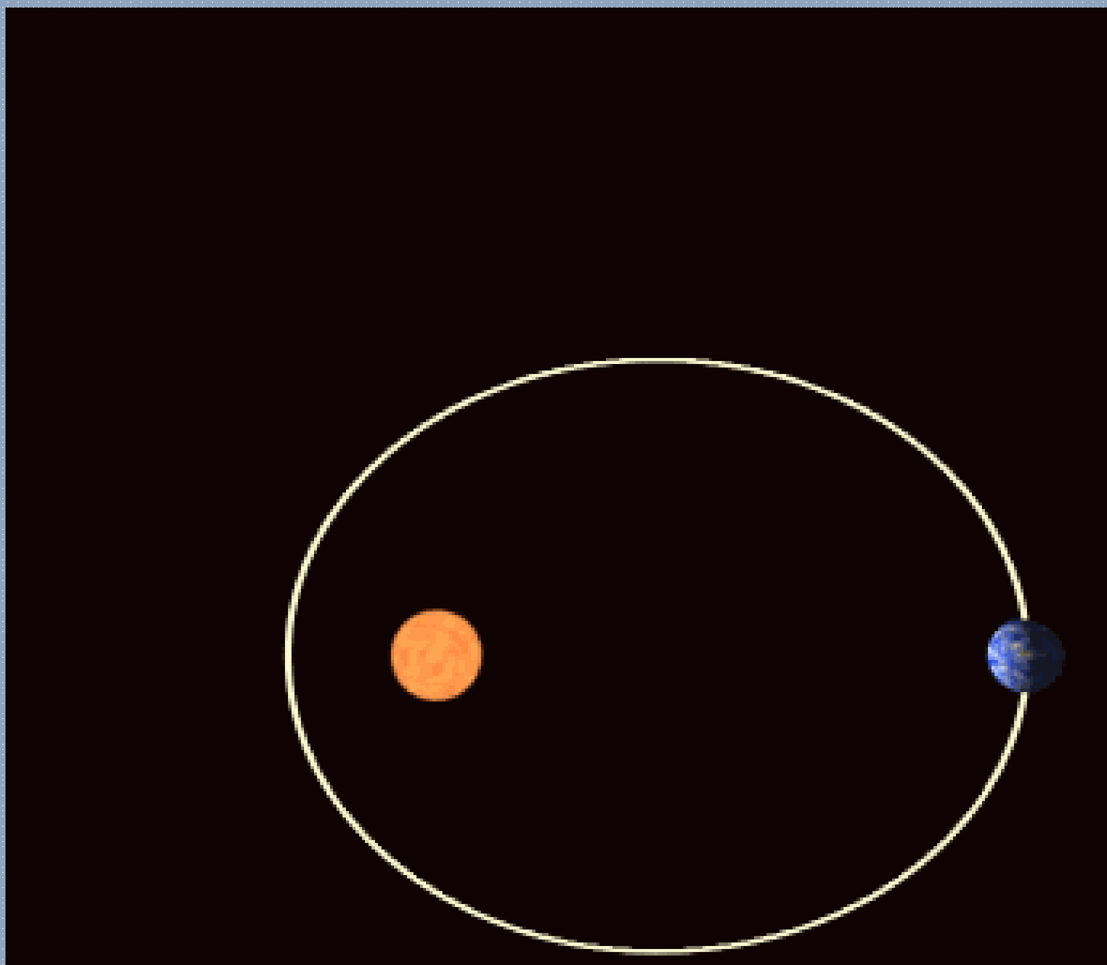


Precession is the change in the direction of the Earth's axis of rotation relative to the fixed stars, with a period of roughly 26,000 years. This gyroscopic motion is due to the tidal forces exerted by the sun and the moon on the solid Earth, associated with the fact that the Earth is an oblate spheroid shape and not a perfect sphere. The sun and moon contribute roughly equally to this effect. When the axis is aligned so it points toward the Sun during perihelion, one polar hemisphere will have a greater difference between the seasons while the other hemisphere will have milder seasons.

Glaciation

Milankovitch Cycles

4. Apsidal Precession

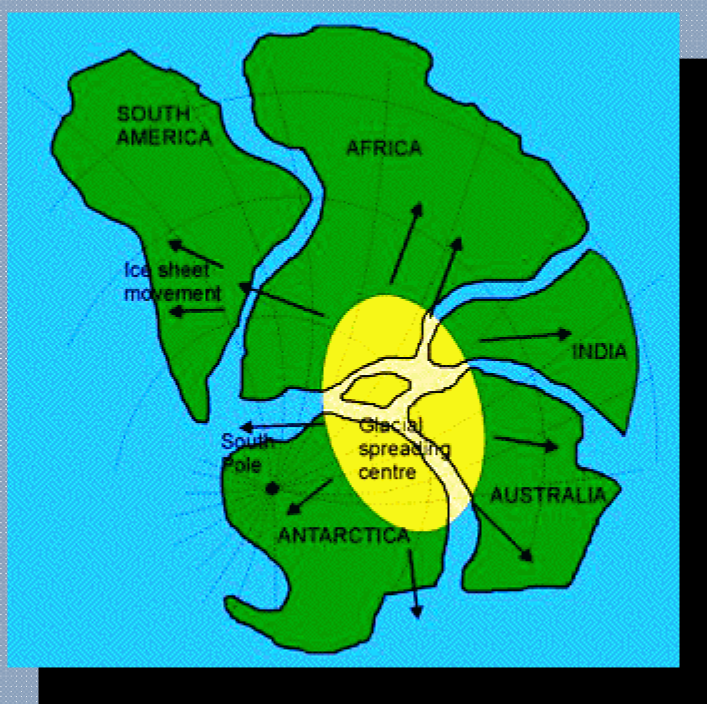


Planets orbiting the Sun follow elliptical (oval) orbits that rotate gradually over time (apsidal precession). The orbital ellipse itself precesses in space, primarily as a result of interactions with Jupiter and Saturn. This orbital precession is in the same sense to the gyroscopic motion of the axis of rotation, shortening the period of the precession of the equinoxes (extreme seasonal altitudes of the sun) with respect to the perihelion (point in orbit nearest the sun) from 25,771.5 to ~21,636 years.

Glaciation

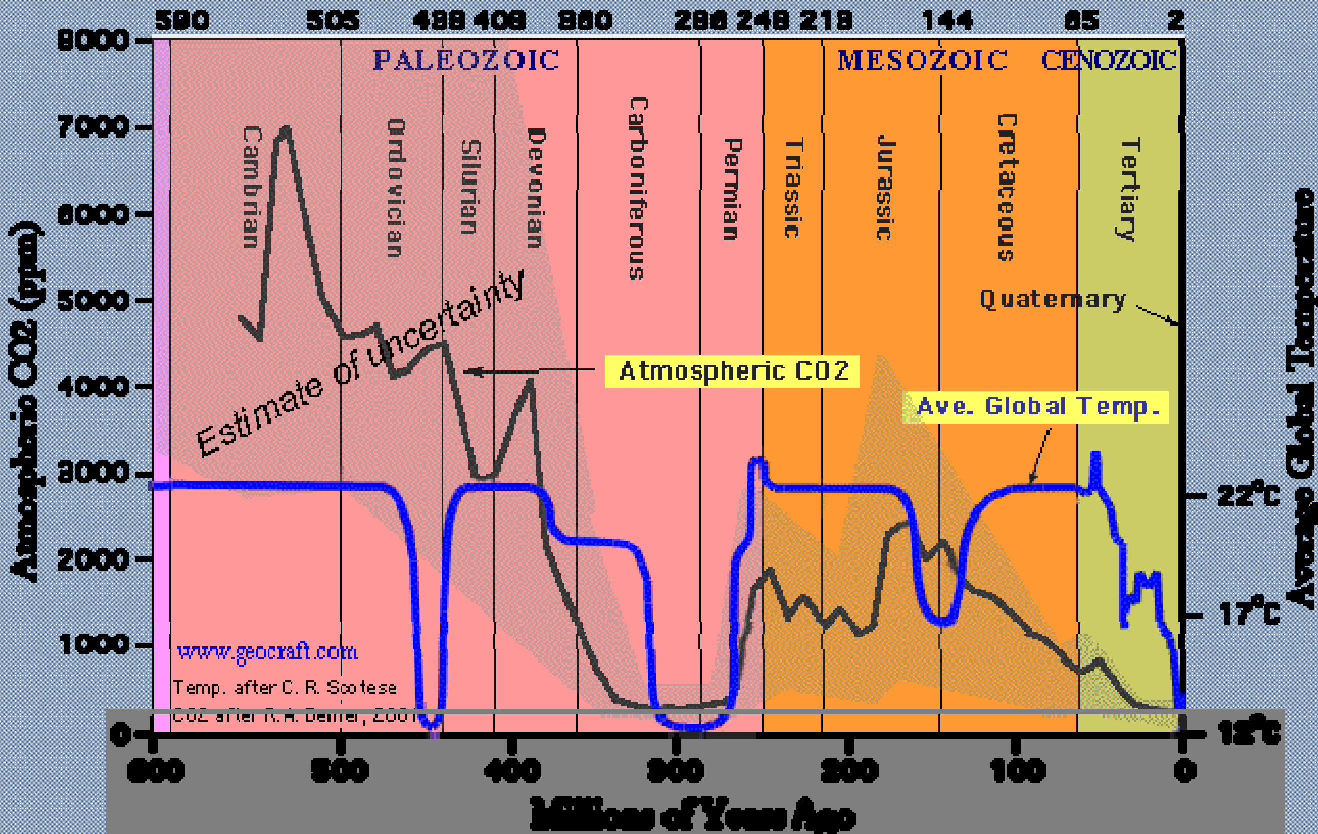
And what about solar cycles and rearrangement of continental landmasses over geologic time by the processes of continental drift? And man's contribution? The sun consumes 600,000,000 tons of hydrogen every second and sends some of that energy to us. What does man produce?

We are actually in an **ice age** climate today. However, for the last 10,000 years or so we have enjoyed a warm but temporary interglacial vacation. We know from geological records like ocean sediments and ice cores from permanent glaciers that for at least the last 750,000 years interglacial periods happen at 100,000 year intervals, lasting about 15,000 to 20,000 years before returning to an icehouse climate. We are currently about 18,000 years into Earth's present interglacial cycle. These cycles have been occurring for at least the last 2-4 million years, and the Earth has been cooling gradually for the last 30 million years.



Glaciation

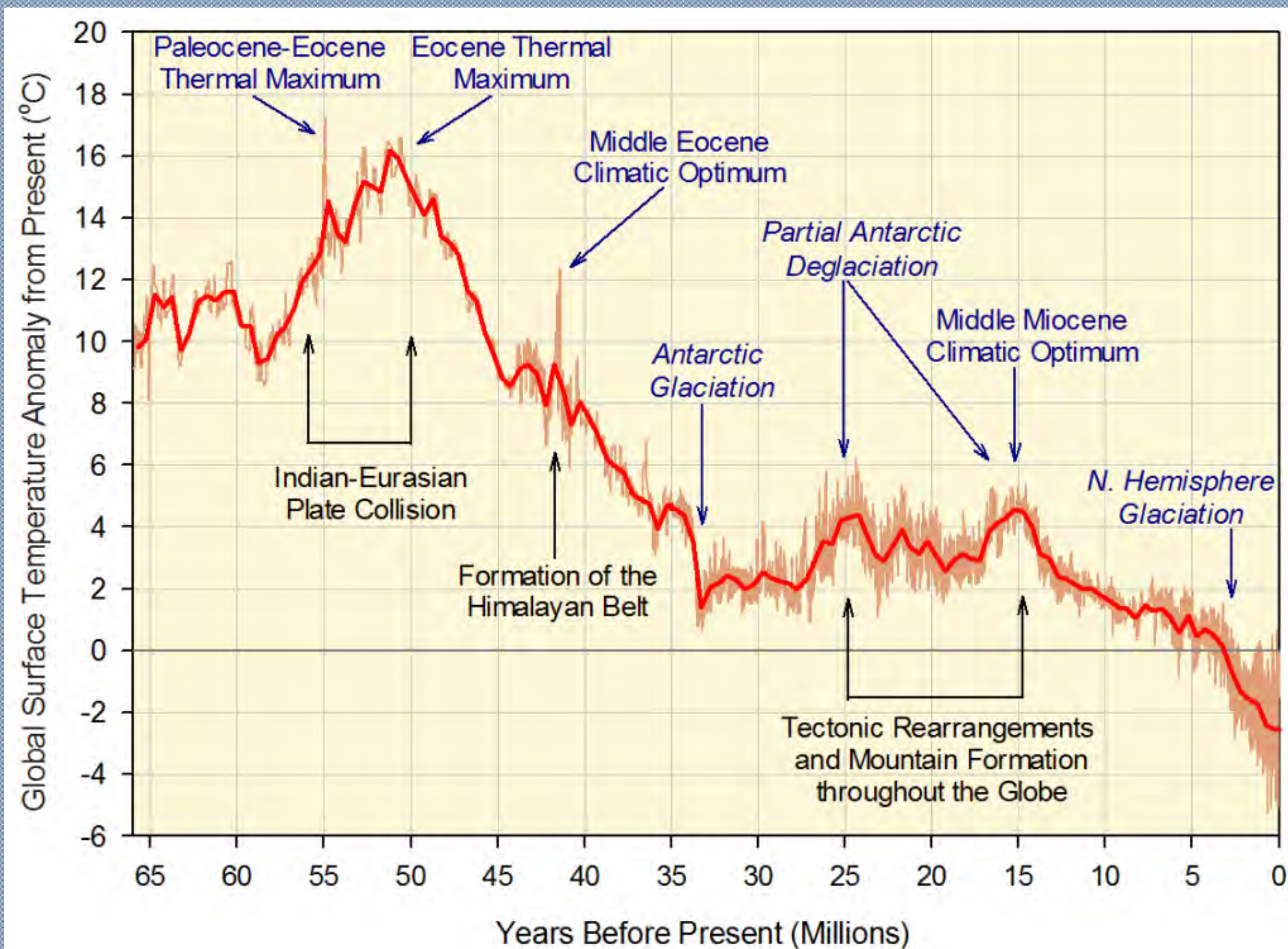
Temperature variations over time



Late Carboniferous to **Early Permian** time (315 mya to 270 mya) is the only time period in the last 600 million years when **both** atmospheric **CO^2** and **temperatures** were as low as they are today (Quaternary Period). There has historically been much more CO2 in our atmosphere than exists today. The **Carboniferous Period** and the **Ordovician Period** were the only geological periods during the Paleozoic Era when **global temperatures were as low as they are today**. To the consternation of global warming proponents, the Late Ordovician Period was also an **Ice Age** while at the same time CO^2 concentrations then were nearly 12 times higher than today-- **4400 ppm**. According to greenhouse theory, Earth should have been exceedingly hot. Instead, global temperatures were no warmer than today. Clearly, other factors besides atmospheric carbon influence earth temperatures and global warming.

Glaciation

Temperature variations over 65 million years



Dinosaur Extinction

Miocene Epoch

Yorktown Formation

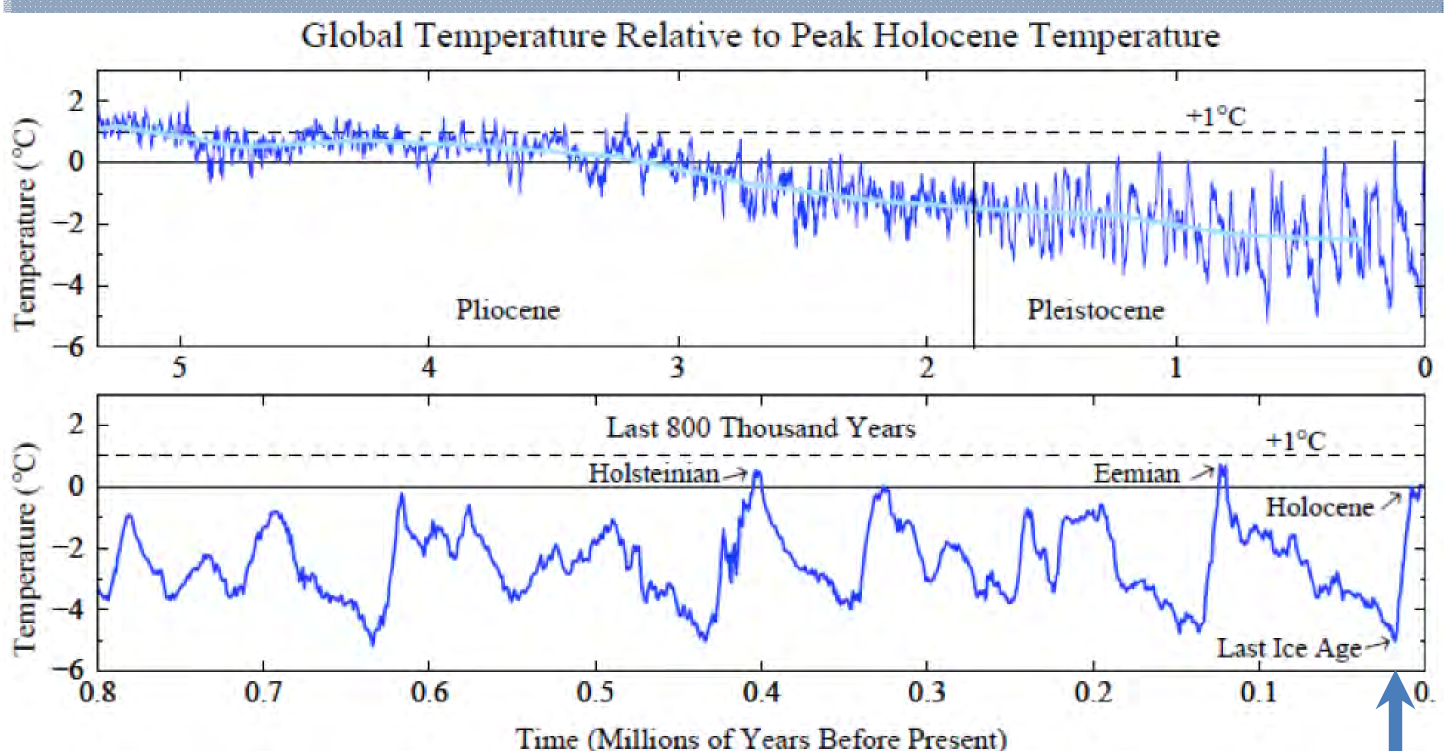
Glaciation

Temperature variations over 5 million years and zoom in to last 800 thousand years

Miocene Epoch

Pleistocene Epoch

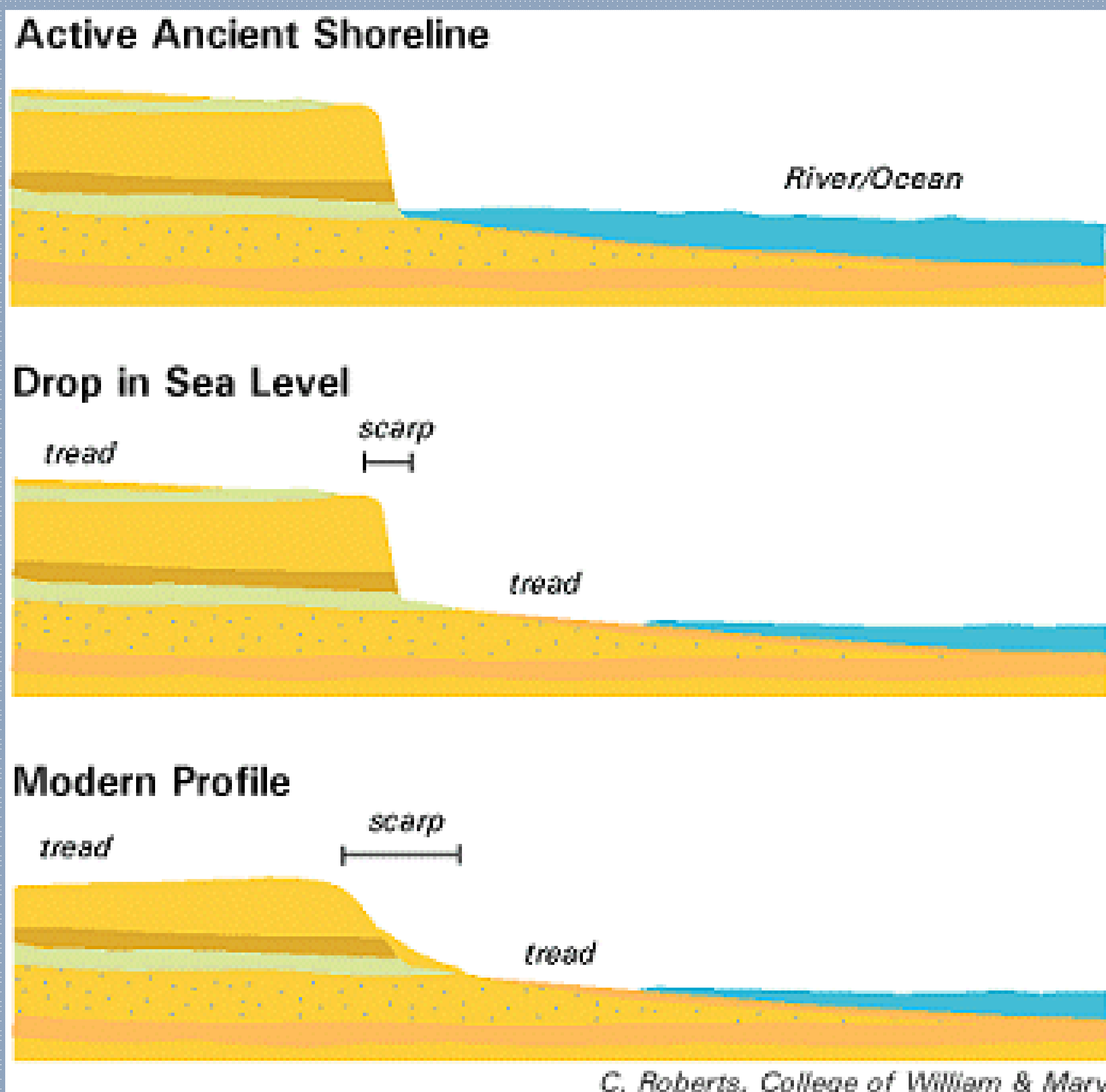
Yorktown Formation



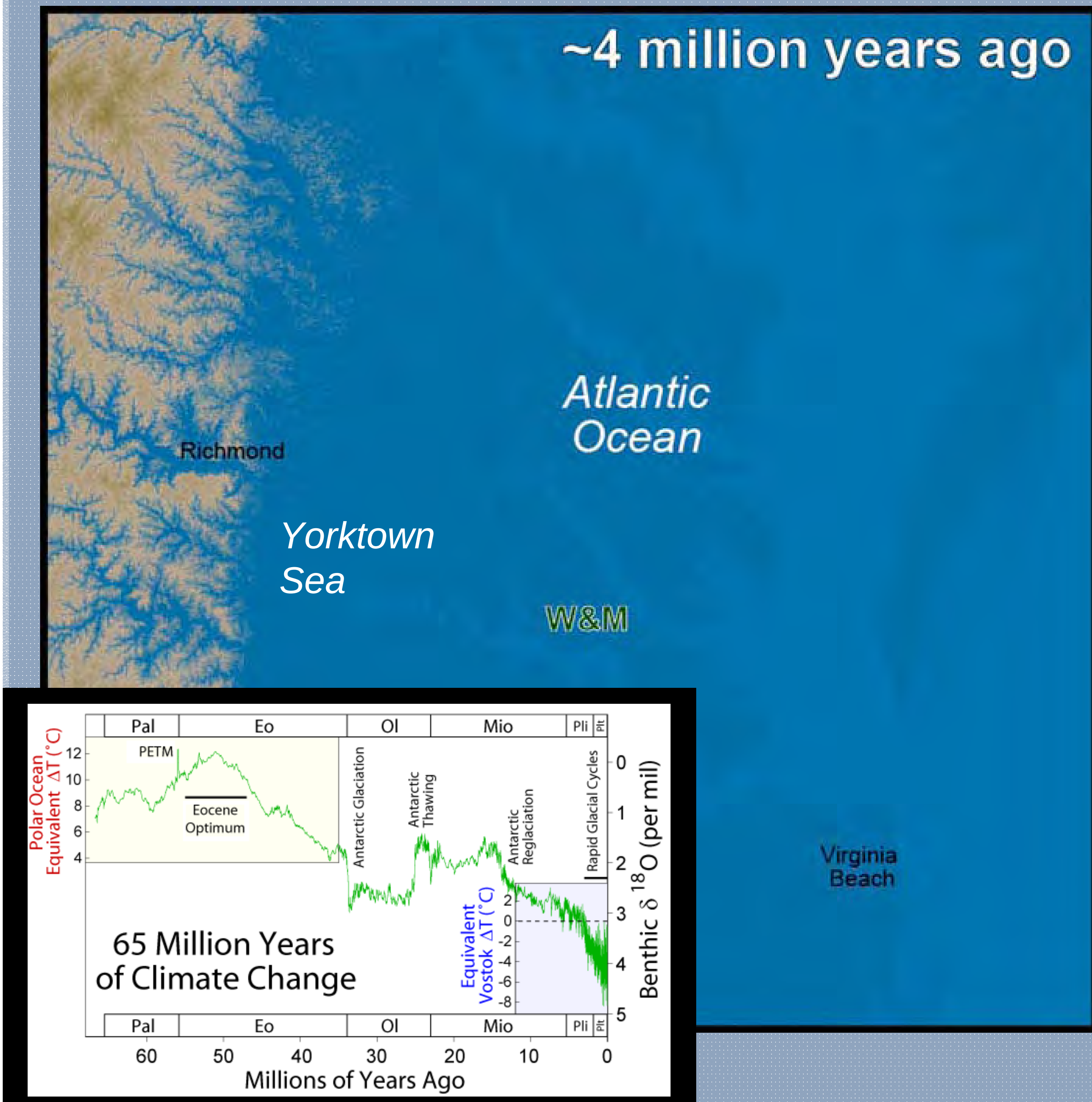
End of the last ice age 12,000 years ago

Glaciation Creates
the modern landscape - Scarps

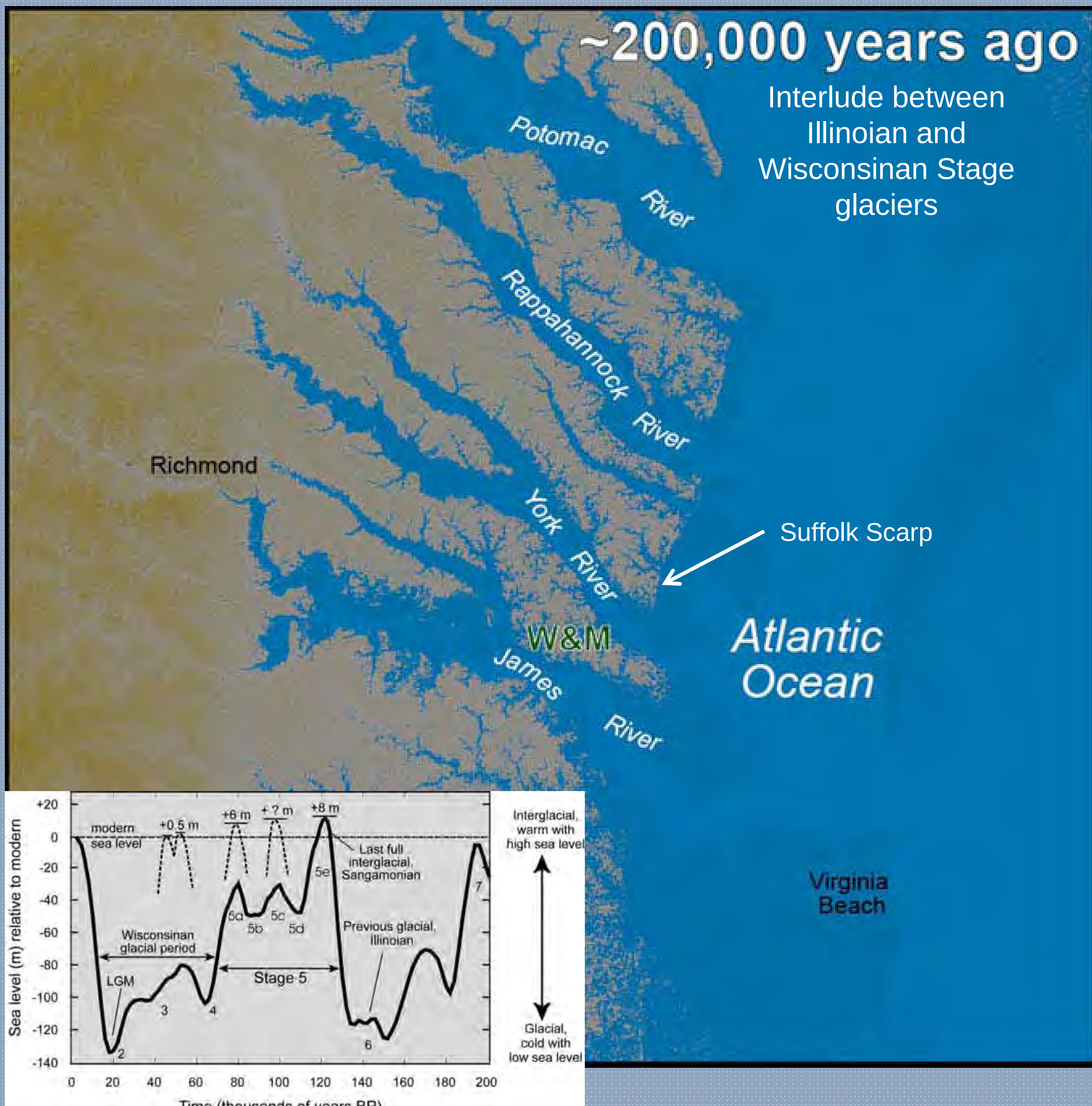
Advances and retreats of the ocean shoreline over the past 200,000 years have left us the geologically modern landscape we recognize today From Richmond east, the landscape is a series of beach terraces and bay floors



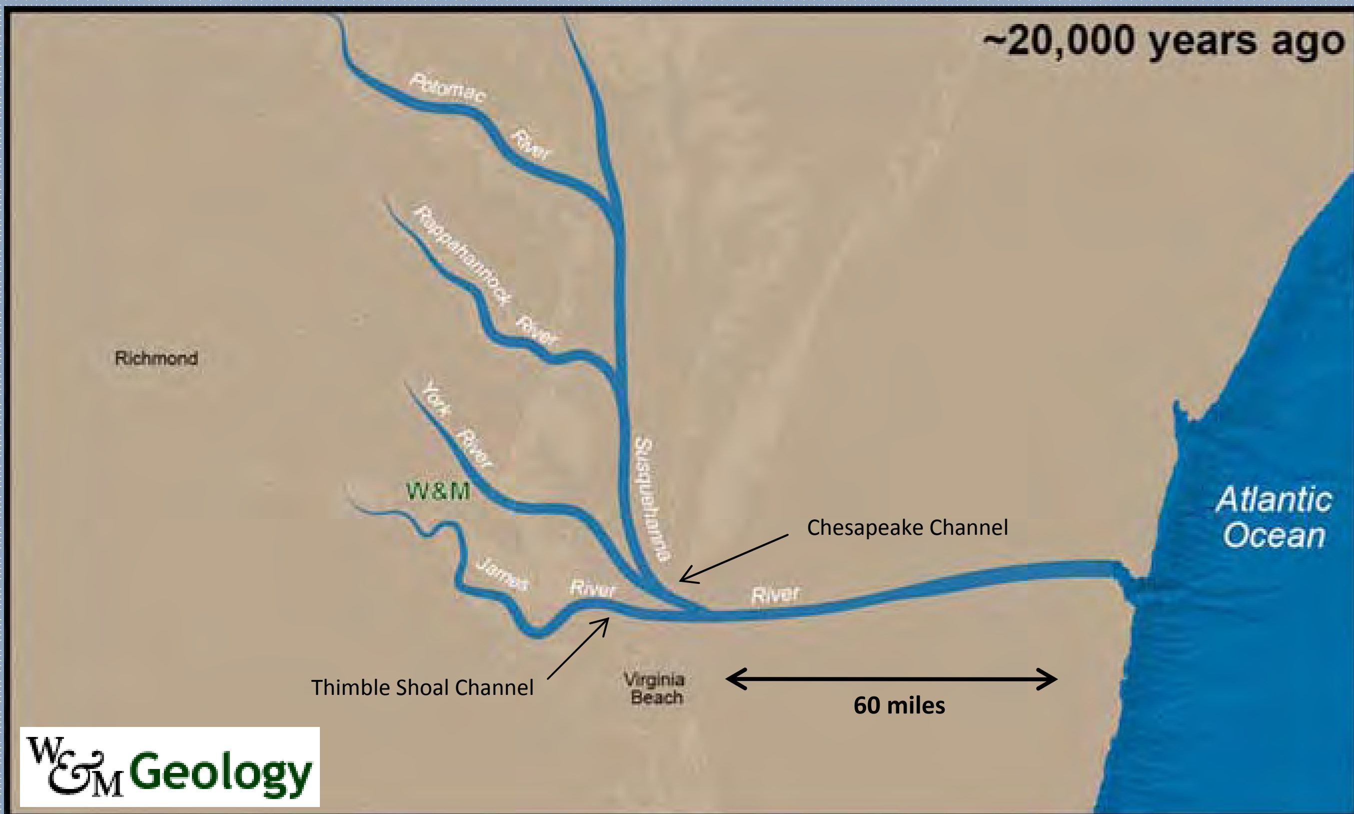
Glaciation Creates the modern landscape: Scarp formation



Glaciation Creates the modern landscape: Scarp formation

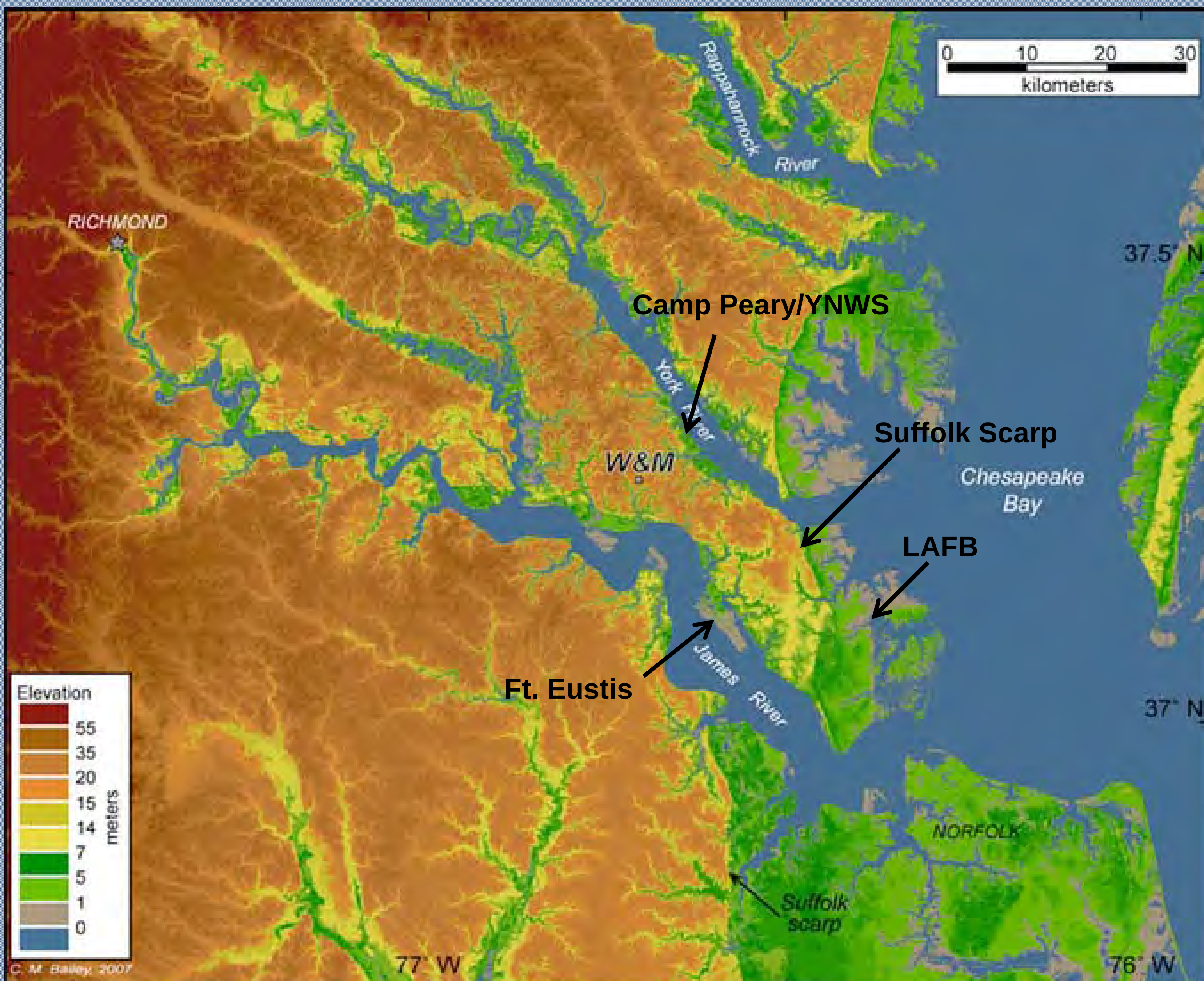


Glaciation Creates the modern landscape



In North America, the most recent glacial event is the **Wisconsin glaciation**, which began about 80,000 years ago and ended with a warming trend around 10,000 years ago, at which time the Atlantic shore line was 60 miles to the east. The rate of sea level rise slowed ab ut the time of Christ, but warming continues, with a corresponding advance of the ocean. Today, the Atlantic Ocean is roughly 300 to 350 feet higher than when glaciers reached into Pennsylvania, and sea level has been rising slowly at the rate of 6 inches/century

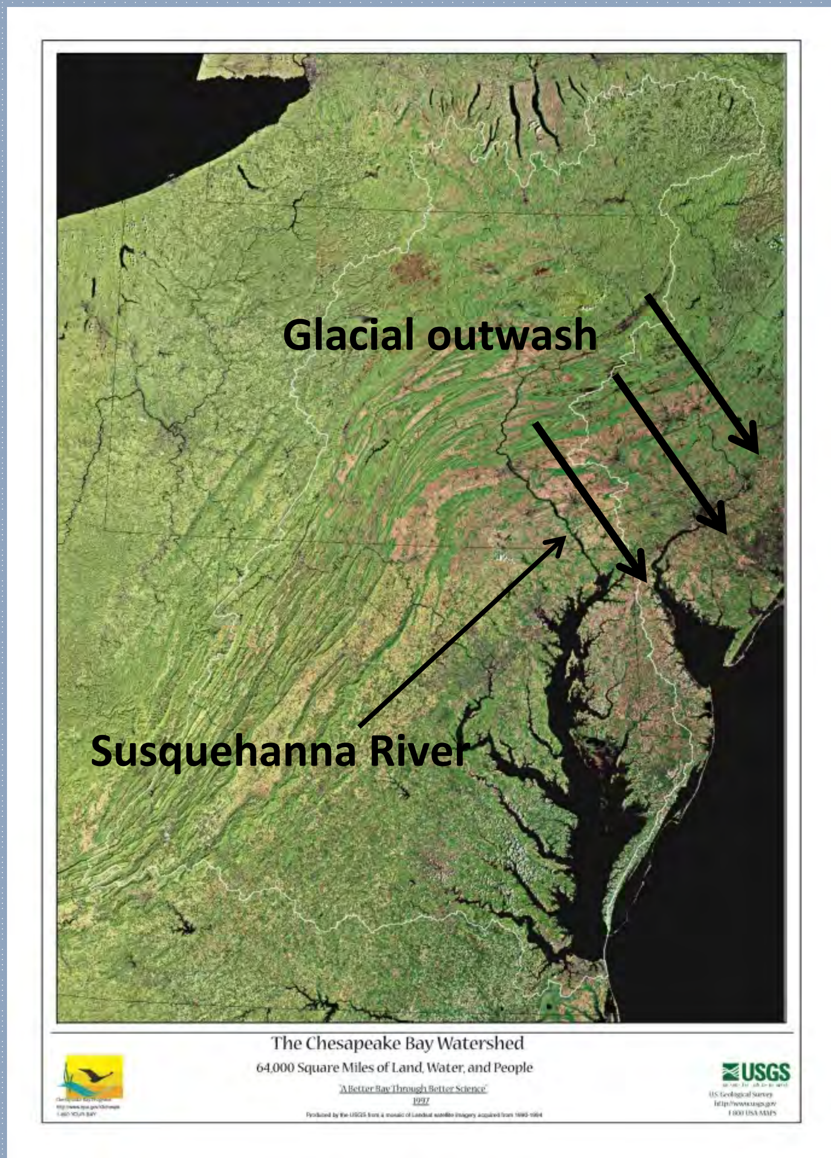
Glaciation Creates the modern landscape: Scarp formation



Scarps visible from space via thermal imaging

W&M Geology

Glaciation Creates the Eastern Shore



When the glaciers first retreated after the peak of the last Ice Age 18,000 years ago, the Susquehanna River carried glacial debris to its mouth and formed a delta at the edge of the Atlantic Ocean Other glacial debris left along the coast further north has been pushed south by longshore currents, building up beaches and barrier islands along the East Coast shoreline Several times, these barriers have blocked the flow of the Susquehanna River directly into the Atlantic Ocean, forcing the river to etch a new channel to the south and creating the Eastern Shore The mouth of the ancestral Susquehanna River flooded 3,000 years ago, creating the Chesapeake Bay.

Barrier Islands