# **DEEP TIME**

The vastness of Earth History compared to Human History

# **DEEP TIME**

# TWO LECTURES BY ALLAN DONALDSON

QUEEN'S BSc. Engineering Geology

1956

JOHN'S HOPKINS PhD. Sedimentology

1960

Geological Survey of Canada

1959 -

1968

Carleton University

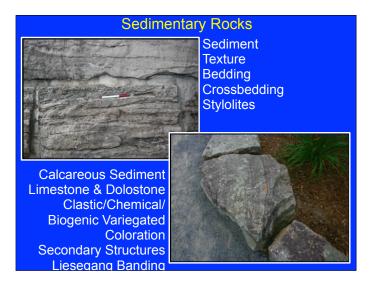
1968

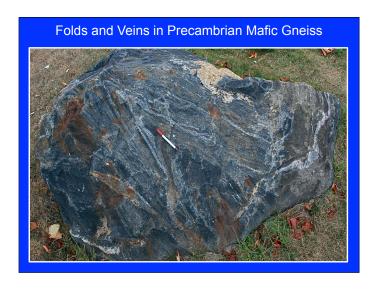


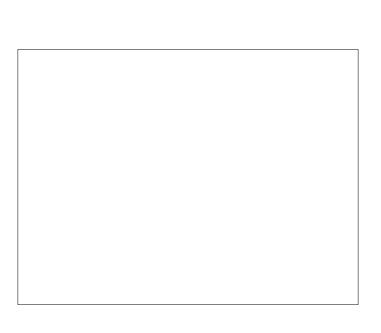


















Heritage
Stone Building:
Eganville
Town Hall (now a
Museum) built in
1900, of locally
quarried blocks
of
Limestone (white)
&
Sandstone (pink)





# **Explore Geoheritage Day**

Sunday, October 20, 2013, from 10:00 am to 3:00 pm

On this day in some of our parks, school yards and green spaces you will be able to learn how geological processes have shaped the regional landscape and provided resources for our use

Sites are hosted by volunteers from Carleton University's Department of Earth Sciences and the Ottawa-Gatineau Geoheritage Project

The Pinhey Dune Biodiversity Site will be added in 2013

Susan Kingdon explaining stromatolites. The visitor with an iPhone camera is relaying some poster information to friends in England via Skype. The poster had to be removed from our table due to sporadic gusts of wind. A nearby lamp post offered a perfect



# **DEEP TIME**

Sufficient time

to allow events to occur that seem improbable ... even impossible

# **DEEP TIME**

Sufficient time for mind-boggling events to transpire such as:

Mountain Building

Development of Unconformities

Continental Drift

Biological Evolution

**DEEP TIME:** A Scientific Concept

ETERNITY: A philosophical concept

# **DEEP TIME**

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# **GEOLOGICAL TIME**

Age of the Universe The Big Bang 13.7 BY

Our Sun is estimated to contain sufficient internal fuel to continue for another 9 BY

Age of our Solar System 4.6 BY

Age of oldest rock on Earth 4.1 BY

Age of oldest mineral grain on Earth 4.35 BY

# **GEOLOGICAL TIME**

by: Distinctive Lithologies
Index Fossils
Widespread Unconformities
Chemical Signatures
Radiometric ages

SIMPLIFIED GEOLOGICAL COLUMN FOR THE NATIONAL CAPITAL REGION					
TIME B.P.	ERA CENOZOIC -				
65 MY	MEGOZOLO	LEDA CLAY, OUTWASH, GLACIAL TILL			
250 MY	PALEOZOIC	NO GEOLOGICAL RECORD			
540 MY	PRECAMBRIAN	SEDIMENTARY ROCKS: BLACK SHALE DOLOSTONE LIMESTONE SANDSTONE			
		IGNEOUS and METAMORPHIC ROCKS			

GEOLOGICAL TIME - Scaled to one year				
Our lives Oldest written records 1 minute Last ice age started First humans 3 hours End of dinosaurs 1 week a First dinosaurs 3 weeks First metazoans 1.5 mon	ago			
First stromatolites 9.5 months Oldest rock 10 month	is			

### **GEOLOGY**

Reconstructing Earth history on the basis of simple observations:

- Geological Time Actualism
- Rock composition, Texture Primary & Secondary Structures Rock Cycle

- Lithification: Sediment vs Sedimentary rock
  Superposition of Strata
  Original Horizontality & Lateral continuity of Strata
  Cross-cutting inclusive relationships

- Truncations, Inclusions
   Fossils, Index Fossils, Trace Fossils, Evolution
   Stratigraphic Correlation
- Plate Tectonics

In his 1981 book, Basin and Range, John McPhee appears to have been the first author to reflect on "Deep Time"

> in a general-interest publication

#### Naturalists during the Age of Enlightenment (17th and 18th centuries)

Thinkers who consciously sought human advancement through logic, reason and criticism: Newton, Hume, Kant, Gibbon, Voltaire, Smith, Paine, Jefferson, to name a few. Many were all-round natural philosophers who studied the natural world as a single subject. Some were clergy who devoted time to investigating nature.

# Catastrophism

Earth history inferred to be the result of an accumulation of catastrophic events over a relatively short time period. Predicated on Biblical Flood and/or other Flood Stories handed down by numerous cultures

#### Uniformitarianism / Gradualism / Actualism

Slow processes such as we can observe today ... Present is the Key to the Past

#### Georges Cuvier (1769 - 1862)

Although he established the sciences of comparative anatomy and vertebrate paleontology, he was a firm supporter of catastrophism

#### Georges-Louis Buffon (1707 – 1788)

Buffon migrated from his legal education to science, and contributed significantly to the Enlightenment with works on natural history, in which he rejected the biblical chronology of the past in favour of the Earth being older, and flirted with the idea that species could change. His Histoire Naturelle aimed to classify the whole natural world, including humans.



James Hutton (1726 - 1797)

Studied medicine and chemistry at Edinburgh University, Paris and Leiden. Completed his degree in 1749.

Returning to his farming roots, in 1753 he became interested in studying the surface of our planet,

named subject of 'Grand his powers of observation Hutton went on a geological tour of the north of Scotland with George Maxwell-Clerk in 1764. To devote more time to geology, he rented his farms to tenants in 1768 and returned to Edinburgh. Between 1767 and 1774 he was closely involved with the construction of several canals.

#### ONE OF MANY QUOTES BY HUTTON:

"The past history of our globe must be explained by what can be seen to be happening now. No powers are to be employed that are not natural to the globe, no action to be admitted except those of which we know the principle"

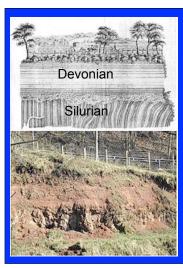
In 1802, Scottish mathematician/natural philosopher John Playfair published 'Illustrations of the Huttonian Theory of the Earth'. This volume concisely summarized Hutton's "Theory of the Earth", accompanied by numerous additional illustrations and arguments



# Unconformities

Unconformities are boundaries between different units of rock that represent significant gaps in time.

One such boundary exposed in several places within the Ottawa-Gatineau area separates
Precambrian rocks more than one billion years old from Paleozoic strata that are less than half that age. At such outcrops, you can put your finger on a surface that marks a gap in the rock record of more than half a billion years



# Sketch in Hutton's paper

1787 Hutton noted what is now known as the "Hutton Unconformity" at Siccar Point, Inchbonny, near Jedburgh, southeastern Scotland

Recent Photograph: Same vertical section

Stone Sculpture by Max Nowell replicating Hutton's nearby Devonian/Silurian Unconformity at Jedburgh.



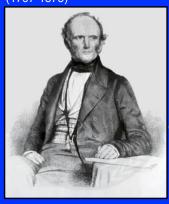


#### William Smith

(1769 –1839) Geological Map of England and Wales (1815)

This was the first nation-wide geological map ever published. Includes a Stratigraphic Column

# Charles Lyell (1797-1875)



# Principles of Geology

In this significant treatise,
Lyell argued, as had Hutton,
that the forces of
geological change
responsible for shaping
Earth through time
are observable today.
Lyell added a chronology of the
rock layers called the geologic
column and added age dates and
names to the layers. So Hutton
laid the conceptual foundation for
uniformitarianism geology and
Lyell built the structure of geology
upon that foundation

# Timest. Secretary of part of the Earth's crust explaining the theory of the contemporarious origin of the four great define of rocks. An Oney J. Meanure plan. All the rocks roles than ABCD, or introvoluted.

#### **Charles Darwin: 1809 - 1882**

He initially trained in Edinburgh to be a medical doctor, but preferred the natural sciences

He studied geology beyond the classroom with geologist Adam Sedgwick

Joined a voyage aboard HMS Beagle (1831-1836) , captained by Robert Fitzroy, who gave him a copy of Charles Lyell's book, Principles of Geology

In Chile he recognized from a sequence of beach terraces that the South American continent was rising

Developed theory for origin of atolls from visits to reef-fringed volcanic islands in the Pacific Ocean

Fossil discoveries prompted him to realize that many extinctions have occurred. Study of Galapagos Islands finches revealed speciation via natural selection, prompting later development of his theory of evolution, outlined in his On the Origin of Species (4850)

# Darwin's Progression in Publication

- 1838-43 Zoology of the Voyage of H.M.S. Beagle (5 parts)
- 1839 Journal of Researches (Voyage of the Beagle)
- 1842 The Structure and Distribution of Coral Reefs
- 1844 Geological Observations of Volcanic Islands
- 1846 Geological Observations of South America
- 1851-54 Monograph on Cirripedia (Barnacles) 4 vols.
- 1859 Origin of Species

all the while being more and more convinced of a

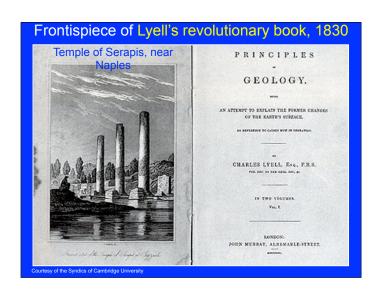
While aboard HMS *Beagle* Darwin read, and was much influenced by, Lyell's *Principles of Geology* 

Darwin essentially extended the principle of Uniformitarianism to biology:

Species, like geologic features, either evolved gradually or died out

Darwin held that the forces seen today in the biologic world:

reproduction, inheritance, and competition gradually produced the total diversity of life on Earth ...
Just like the forces Lyell discussed, causing the rising and falling of land (as illustrated by the Temple of Serapis)





# Alfred Russel Wallace

(1823-1913)

"On the tendency of varieties to depart indefinitely from the original type" (1858)

# **Evolution**

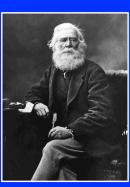




Restoration

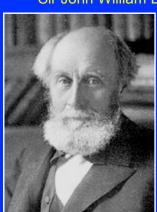
Neil Shubin with the head of Tiktaalik, the "missing link" he discovered in 2004 on Ellesmere Island. It is a tetrapod, transitional between fish and amphibians, fossilized in Devonian fluvial strata. It has a flat head like an amphibian, and its front fins contain bones akin to a crocodile that match shoulder, arm, and wrist bones.

# Sir William Logan (1798-1875)



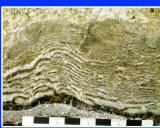
- 1st Director, Geological Survey of Canada (1842 -1869)
- Theory of coal formation (1840)
- Geological Mapping in Maritimes, Ontario, Quebec

# Sir John William Dawson (1820-1899)



- Mentored by Lyell and Darwin
- Described with Lyell:
- Ancient fossil trees at Joggins (*Origins* 1st
- Earliest fossil land snail (*Origins* 2<sup>nd</sup> ed. 1860)
- Early vertebrate fossils, Dendrerpeton Acadianum, Hylonomus Lyelli

### Eozoon Canadense 'The dawn animal of Canada discovered (1858) in Precambrian







#### **GEOLOGY**

# Reconstructing Earth history on the basis of simple observations:

- Geological Time Actualism
- Rock composition, Texture Primary & Secondary Structures

- Lithification: Sediment vs Sedimentary rock
  Superposition of Strata
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  Truncations, Inclusions
  Fossils, Index Fossils, Trace Fossils, Evolution

- Stratigraphic Correlation Plate Tectonics

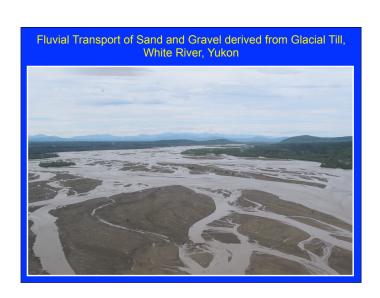
#### What is Sand? Clastic sedimentary grains are classified by size alone Boulder > 256 mm 64 -256 mm Cobble **Pebble** 4 - 64 mm **Granule** 2 - 4 mm .0625 - 2.0 Sand mm Silt .004 - .06 mm < .004 mm Clay

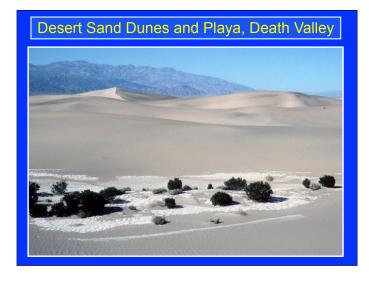
# LIFE CYCLE OF A SAND GRAIN: From Solid Rock to Sand: - Weathering - Erosion - Transportation - Deposition and Back to Solid Rock: ( Lithification )

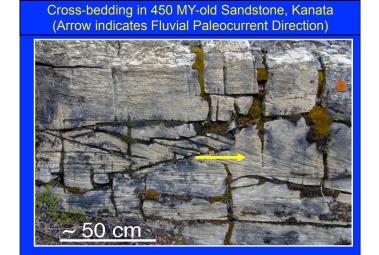








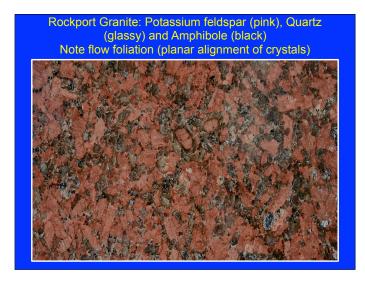




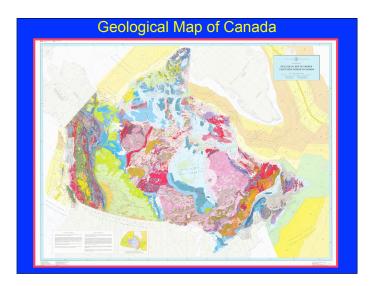


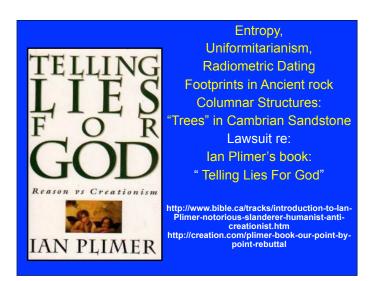
# COMMON ROCK-FORMING MINERALS

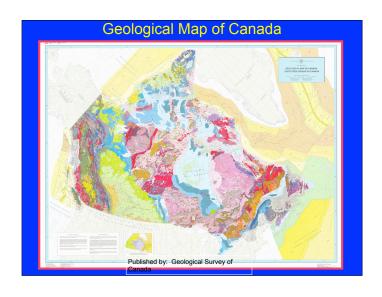
Feldspar, Quartz, Mica, Amphibole, Pyroxene, Olivine, Garnet, Epidote, Chlorite, Clay Minerals, Serpentine Calcite & Dolomite Gypsum, Halite Apatite

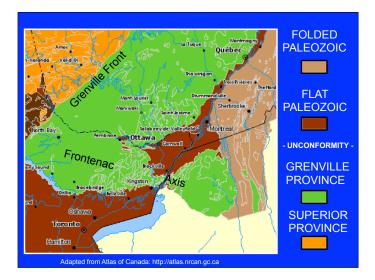


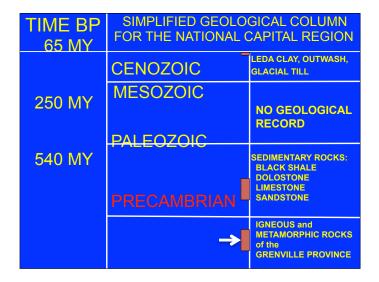


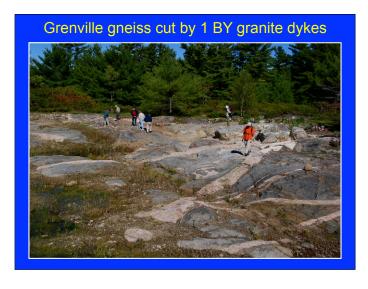




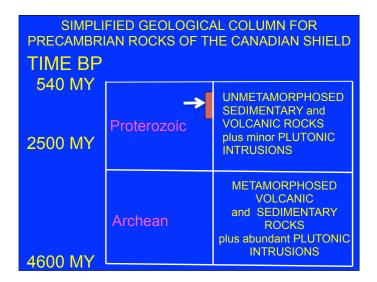






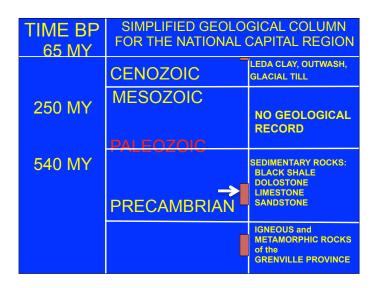








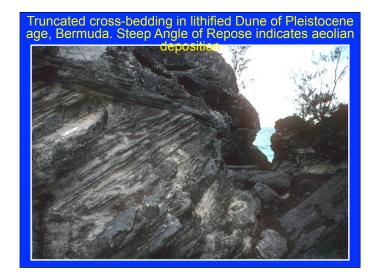


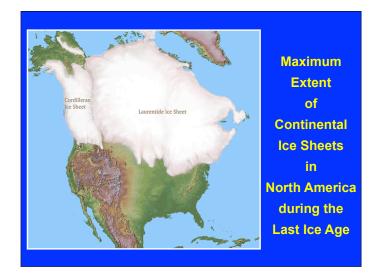




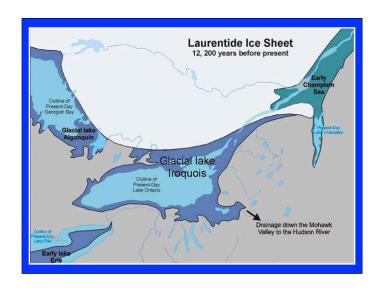


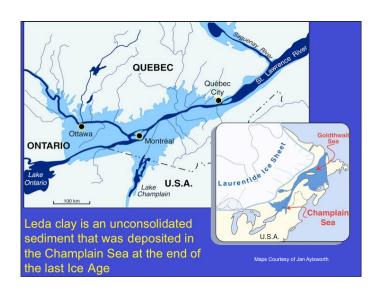
TIME BP	SIMPLIFIED GEOLOGICAL COLUMN FOR THE NATIONAL CAPITAL REGION		
	CENOZOIC	LEDA CLAY, OUTWASH, GLACIAL TILL	
250 MY	MESOZOIC	NO GEOLOGICAL RECORD	
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540 MY		SEDIMENTARY ROCKS: BLACK SHALE DOLOSTONE LIMESTONE	
	PRECAMBRIAN -	SANDSTONE	
	ı	IGNEOUS and METAMORPHIC ROCKS of the GRENVILLE PROVINCE	







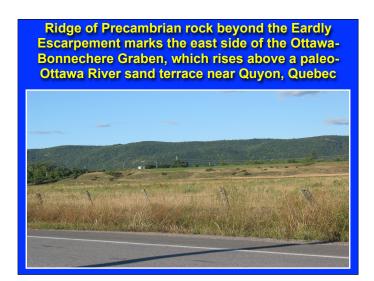


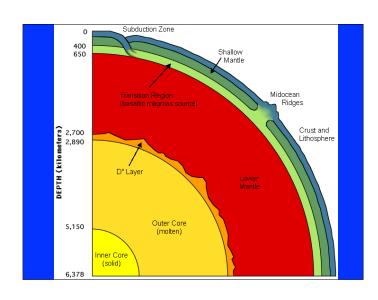


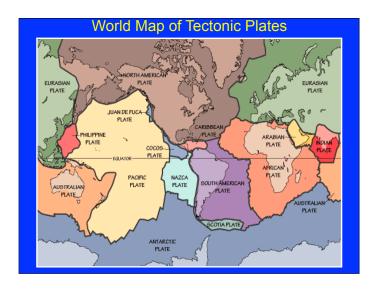


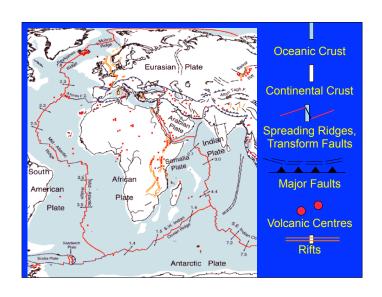


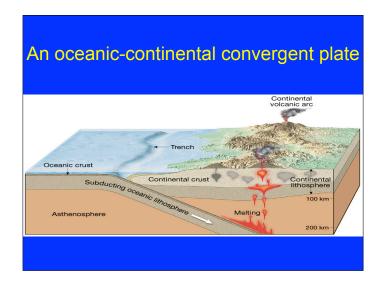


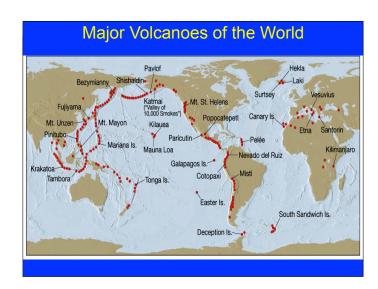




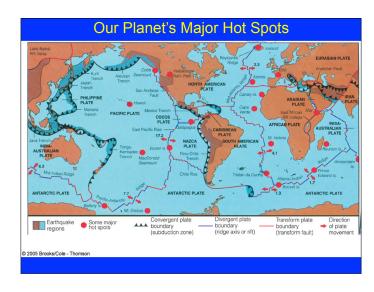


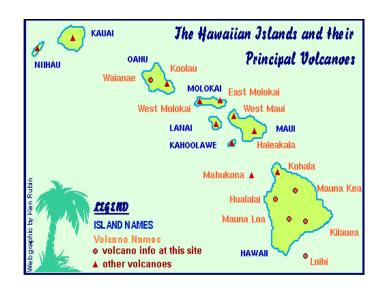




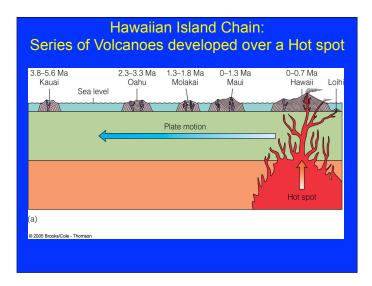


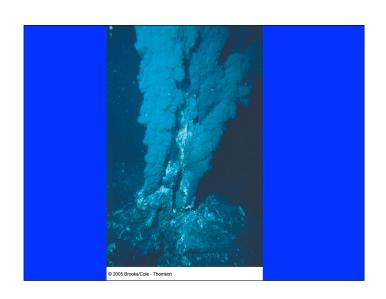




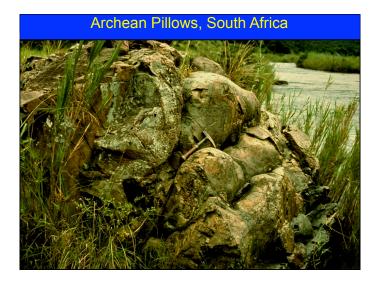














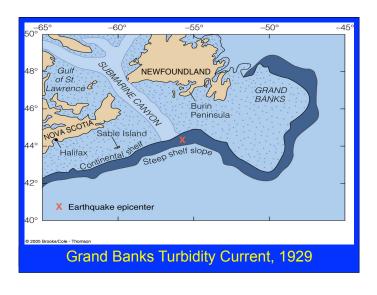






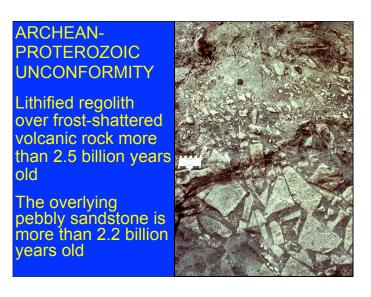


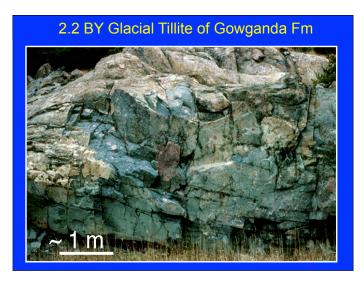






# Precambrian Banded Iron-formation, Indian Shield







# **Reconstructing Earth history on** the basis of simple observations:

- Rock composition, Texture
- Superposition
- Primary and Secondary Structures
- Horizontality, Lateral continuity
- Cross-cutting intrusive relationships Truncations, Inclusions
- Fossils, Trace fossils
- Geological Time Scale

**Multiple Working Hypotheses** 

(Thomas Chamberlain, 1890)







# RECONSTRUCTING EARTH HISTORY ON THE BASIS OF SIMPLE OBSERVATIONS:

- Rock composition, Texture - Rock composition, Texture
  - Superposition
  - Primary Structures
  - Horizontality, Lateral continuity
  - Cross-cutting relationships
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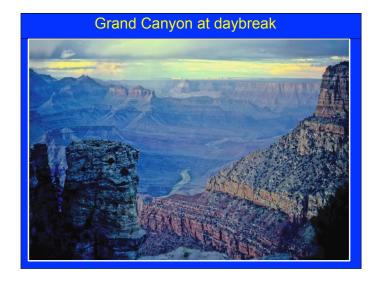
TIME BP 65 MY	GEOLOGICAL COLUMN CENOZOIC
225 MY 540 MY	MESOZOIC PALEOZOIC
2.5 BY	Proterozoic Archean
4 BY	Hadean



Proterozoic & Paleozoic sedimentary strata rest unconformably over metamorphic Archean basement rocks more than 2.5 billion years old

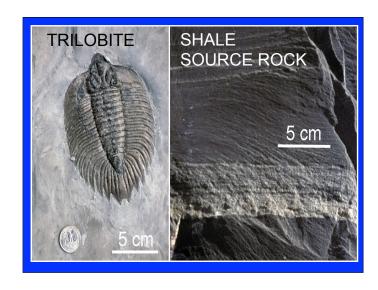
Colorado River has carved the Grand Canyon in less than 6 million years

#### **EVENTS** 1 Deposition of sediments 1.a Metamorphism and intrusion 2 Grand Canyon Supergroup 5 4 Temple Butte, Redwall, Surprise 5 Supai Group 4 6 Hermit, Coconino, Toroweap, Kaibab 7 Mesozoic deposition 8 Creation of the canyon 3 8.1 Uplift and nearby extension 8.2 Colorado River System developed 8.3 Volcanic activity, western canyon 9 Ongoing geology and human impact







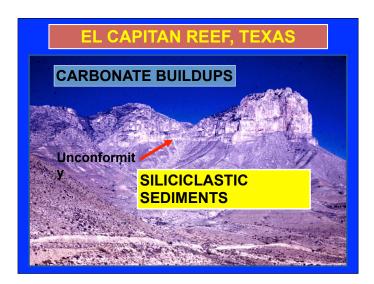


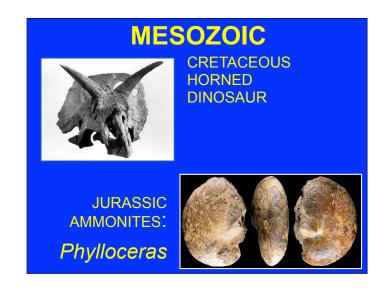


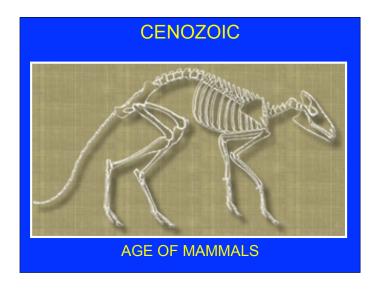


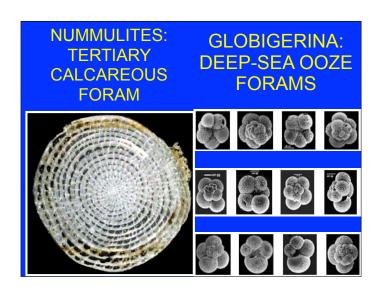




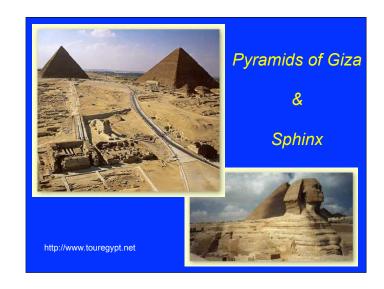


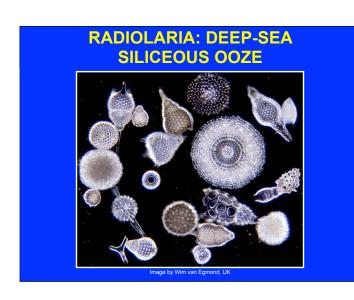


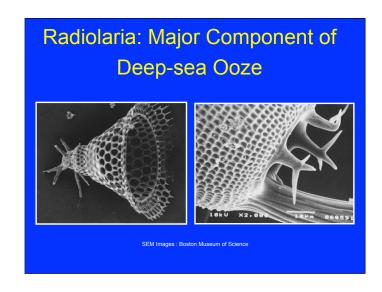






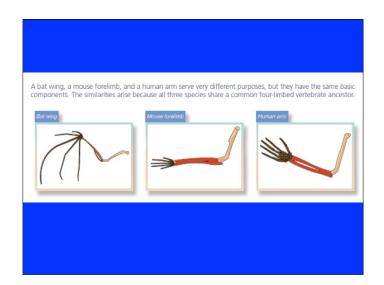








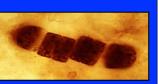




Biofilms are biogenic layers capable of trapping and/or precipitating sediment



Biofilm-forming cyanobacteria that built stromatolites caused the oxygen content of Earth's atmosphere to increase, allowing advanced life forms to evolve





STROMATOLITES ARE DOMED & BRANCHED
STRUCTURES FORMED BY CYANOBACTERIAL
MATS THAT TRAP SEDIMENT.
THEY PROVIDE THE ONLY EVIDENCE OF LIFE
THROUGH THE FIRST
80% OF GEOLOGICAL TIME
and
THEY WERE RESPONSIBLE FOR
THE DEVELOPMENT OF EARTH'S OXYGENRICH ATMOSPHERE

Shark Bay, Western Australia (800 km north of Perth)

Stromatolites growing in a hypersaline marine basin Domed to club-like structures Individual heads offshore Coalescent patches nearshore Strong elongation perpendicular to shore

# Stromatolites growing in Hamelin Pool

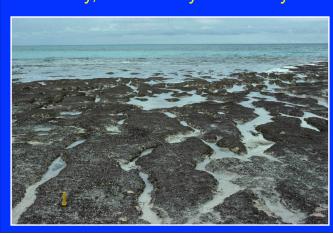




Hamelin Pool is south of barrier bar



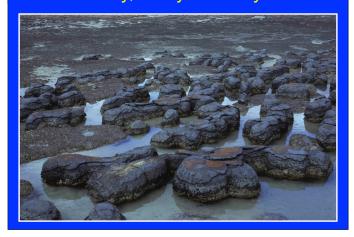
Shark Bay, one tidal cycle after cyclone



Shark Bay, 2 tidal cycles after cyclone



Shark Bay, 2 days after cyclone



Shark Bay: stromatolite elongation normal to shoreline



1.4 BY Dismal Lakes Group: stromatolite elongation normal to presumed shoreline



# Lake Clifton, Western Australia (80 km south of Perth)

In this locality, stromatolites & thrombolites are now growing in a marginal-marine, low-salinity lake

Domed to pancake-like structures Individual heads offshore

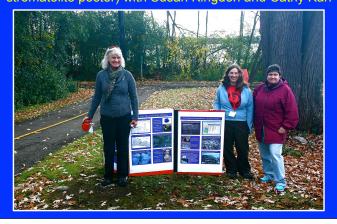
# Domal Stromatolites, Lake Clifton, Western Australia



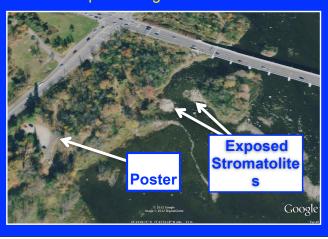
#### Domal Stromatolites, Appleton, Ontario

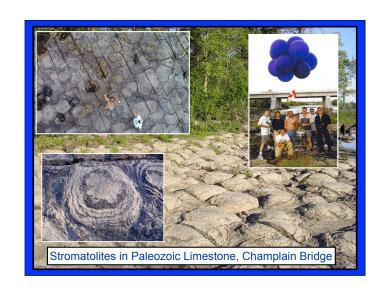


#### Geoheritage Day (Oct.20, 2013): Visitor Christy Vodden (her dog is hiding behind the stromatolite poster) with Susan Kingdon and Cathy Kari



# Champlain Bridge Stromatolite Site





String of coalesced domal stromatolites Champlain Bridge Site Blue pen points northward



# Ordovician Stromatolites, Ottawa

Evidence of hypersalinity
- No gastropods
- Evaporite pseudomorphs
- Stellate projections from concentric laminae

**Evidence of shallow-water conditions** 

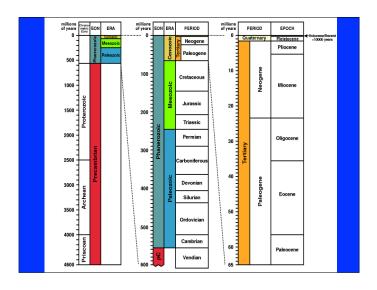
Desiccation cracks
 Symmetrical ripple marks
 Truncation of laminae

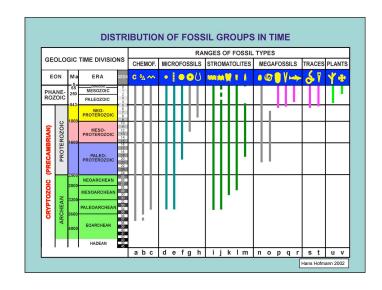


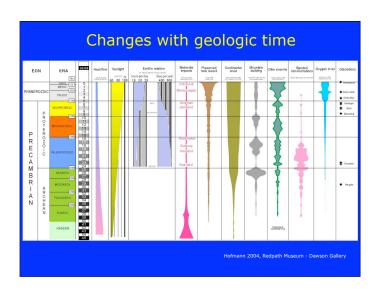


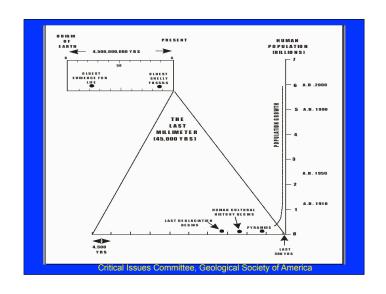


AGE (Ma)	EON	ERA	PERIOD, SUBPERIOD	
1.6 -		CENOZOIC	TERTIARY	NEOGENE PALE OGENE
100 -		MESOZOIC	CRETACEOUS	
200 -	PHANEROZOIC		JURASSIC	
	5		TRIASSIC	
300 -	ĕ		PERMIAN	
	岁	PALEOZOIC	CARBONIFEROUS	PENN SYLVANIAN
400 -	₹			MISSISSIPPIAN
	盂		DEVONIAN	
			SILURIAN	
500 -			ORDOVICIAN	
570			CAMBRIAN	
	PRECAMBRIAN		PROTEROZOIC	
			ARCHEAN	









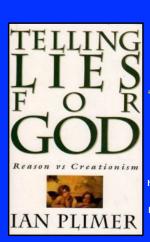
# Scientific Methodology

Clever presentations of arguments to bolster "Creation Science" and "Intelligent Design" must be confronted with convincing scientific evidence, rather than being smugly dismissed

Scopes Trial 1925

Present-day push to have teaching of Evolution watered down or removed

"Young Earth Creationist" publications and websites (Ken Ham, Answers in Genesis)



Entropy,
Uniformitarianism,
Radiometric Dating
Footprints in Ancient rock
Columnar Structures:
"Trees" in Cambrian Sandstone
Lawsuit re:
Ian Plimer's book:
"Telling Lies For God"

http://www.bible.ca/tracks/introduction-to-lan-Plimer-notorious-slanderer-humanist-anticreationist.htm http://creation.com/plimer-book-our-point-bypoint-rebuttal

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