



# Rates, Dates and Geologic Time: a Journal Club report on teaching about temporal aspects of geoscience

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# Temporal Learning Journal Club

- ❖ Purpose: to explore the cognitive underpinnings of understanding geologic time - one of the most significant yet elusive concepts for students in geoscience courses
- ❖ Participants discussed readings from the geoscience & cognitive science literature
- ❖ Five monthly, one-hour long virtual meetings, January-May 2011, plus online discussion board



# Significance

- ❖ Temporal thinking is essential in many geoscience sub-disciplines
- ❖ Understanding geologic time is an essential prerequisite for contextualizing today's rates of global change

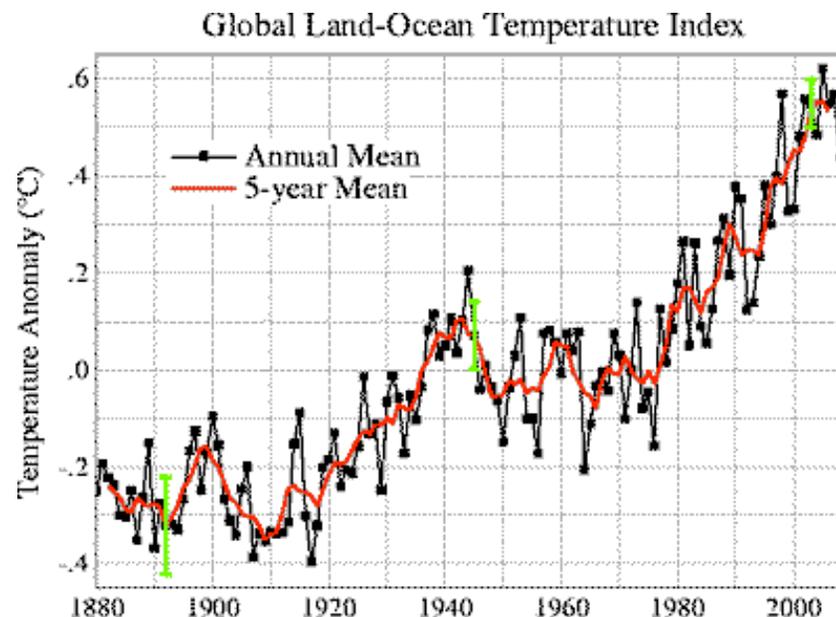


Image from NASA, Goddard Inst. for Space Studies



## Key Topics

- ❖ Temporal concepts
- ❖ How experts and novices differ in their approach to and understanding of these concepts
- ❖ How we can help our students to progress toward expert modes of temporal thinking



Image from the SERC website



# Common Challenges

- ❖ Dealing with large numbers
- ❖ Durations of events and rates of geologic processes
- ❖ Uncertainty of dates and ages
- ❖ Unfamiliarity of geologic processes and the geologic time scale

A screenshot of a web browser displaying a page titled "Barriers to Learning". The page content includes a navigation menu on the left with categories like "Affective Domain", "Public Policy", "Rates and Time", "Journal Club", "Teaching Activities", "Activity Posters", "Courses", "Visualizations", "Barriers to Learning", "Journal Club Findings", "Sedimentary Geology", "Service Learning", "Structural Geology", "Student Learning: Observing and Assessing", "Teaching Methods", "Urban Geology", "Visualization", "Web-Based Resources", and "Leadership". The main content area is titled "Barriers to Teaching or Learning About Rates and Time" and includes a sub-header "Rates, Dates and Geologic Time: Teaching about the Temporal Aspects of Geoscience". The text discusses the difficulty of authentic assessment and the depths of deep time. A "Related Links" box on the right contains links such as "Teaching Quantitative Skills in the Geosciences", "The Math You Need, When You Need It", "Measurement and Uncertainty", and "Teaching the Process of Science". A photograph of a coastline is visible at the bottom right of the page.



# Lessons from cognitive science

- ❖ Time may be processed cognitively using the same brain functions as space, i.e. we literally may think about time as a type of space.
- ❖ Thus, analogy with space is a powerful tool for teaching about geologic time and research on analogic thinking provides important insights into the design of curriculum.



# Suggested strategies: analogies

- ❖ Use analogies, but use them carefully:
  - ❖ Start with the familiar (to students!)
  - ❖ Be explicit about what maps on to what
  - ❖ Be explicit about where an analogy breaks down

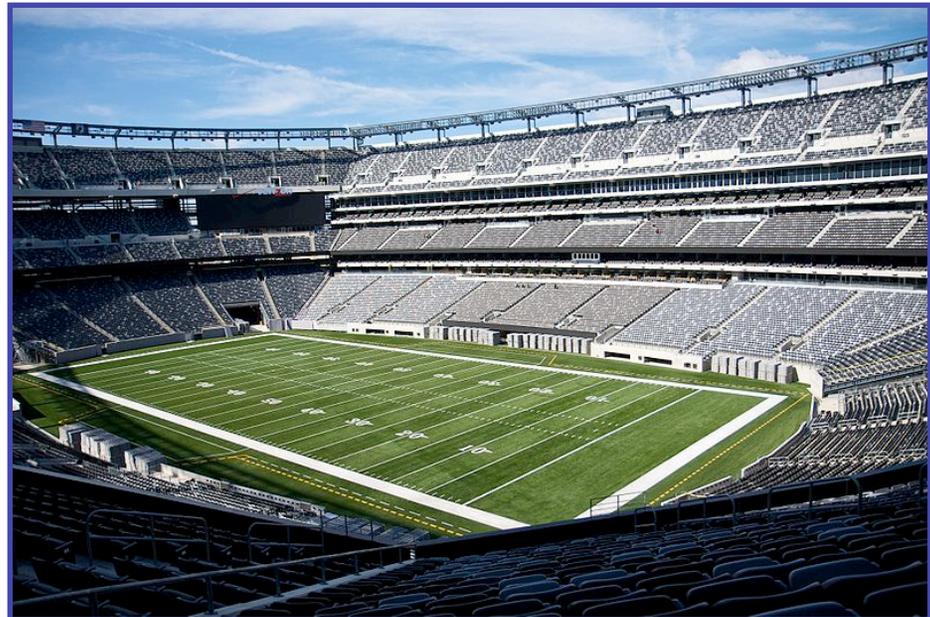


Image from Wikimedia Commons



# Suggested strategies: analogies

- ❖ Don't limit yourself to visual analogies; aural and kinesthetic analogies can also be powerful
- ❖ Ex: if clapping your hands once represents 1 million years, how long would it take to “clap out” the history of the Earth?



Image from Wikimedia Commons



# Suggested strategies: timelines

- ❖ Use nested, scaled time lines
  - ❖ Include important "landmark" events on each timeline as cognitive anchors - these are essential!
  - ❖ Use anchors that are as meaningful as possible for students - i.e., choose interesting events and take the time to explain their significance
  - ❖ Give students structured opportunities to compare the timelines and find landmark events on each one



# Suggested strategies: address misconceptions

- ❖ Be cognizant of, and address, misconceptions about the durations of events in geologic time

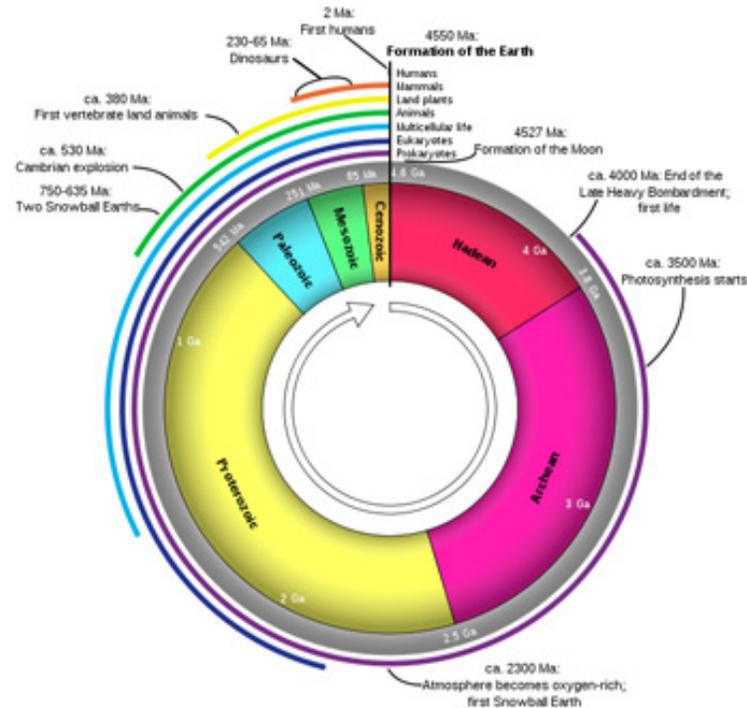


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# Suggested strategies: observations

- ❖ Have students spend some time observing geologic processes in action

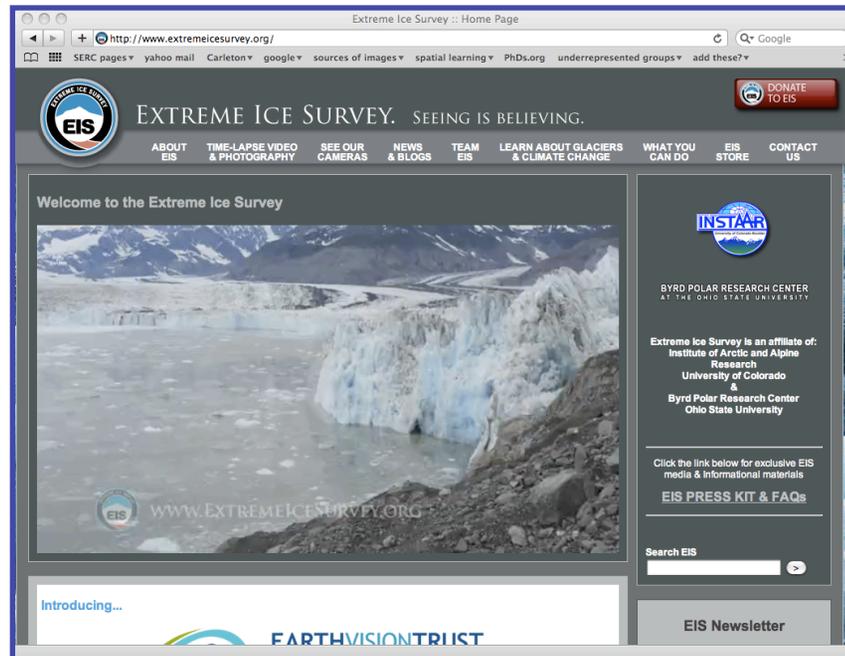


Image from the SERC website



# Suggested strategies: observations

- ❖ Have students observe time-lapse photographic sequences (e.g. Extreme Ice Survey)
- ❖ Caveat: cognitive science experiments show that people have a hard time deciphering sequences of events from animations





# Suggested strategies: employ the affective domain

- ❖ Use a narrative voice to "tell the story" of the history of the Earth
  - ❖ Humans are wired to look for causal relationships; providing a causal narration may aid students in remembering

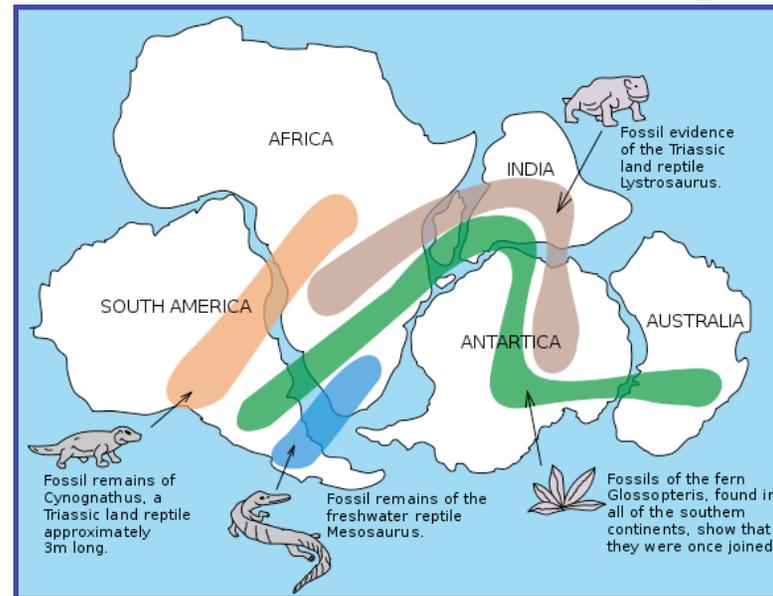
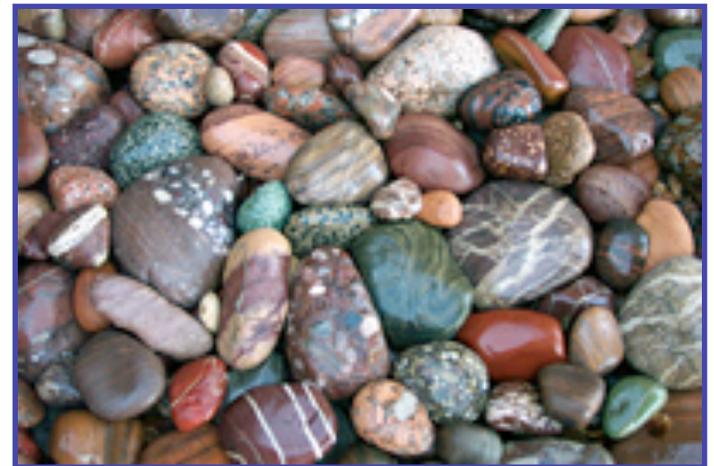


Image from  
Wikimedia  
Commons



# Suggested strategies: employ the affective domain

- ❖ Make Geology personal
  - ❖ Have students collect and research their own rock samples
  - ❖ Tell stories about when and where you (or your colleagues) collected the rock samples you use in your classes



Images from the SERC website



# Suggested strategies: contextualize dates & ages

- ❖ Bring rates and time scales together to understand the impact of geologic processes
  - ❖ Be explicit about the interaction of short, infrequent high impact events with slow processes occurring over very long periods of time (the geologic timeline is a great illustration of both)

Image from  
the USGS



August 14, 2002



# Suggested strategies: bring in the human dimension

- ❖ Explicitly address the difference between natural rates and processes and anthropogenic rates and processes
  - ❖ Move from the past to the present to implications for the future

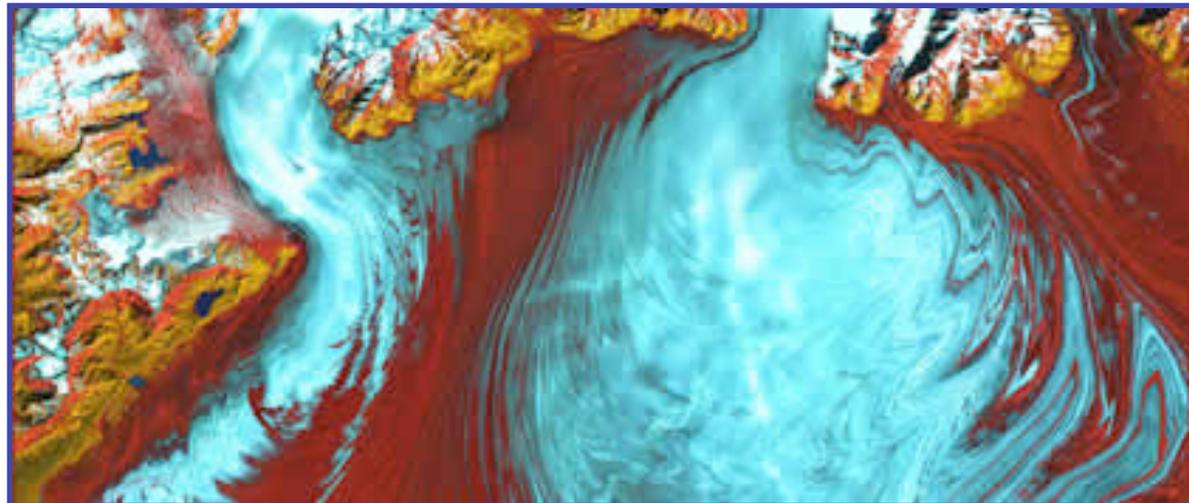


Image courtesy of NASA Landsat Project Science Office and USGS National Center for EROS



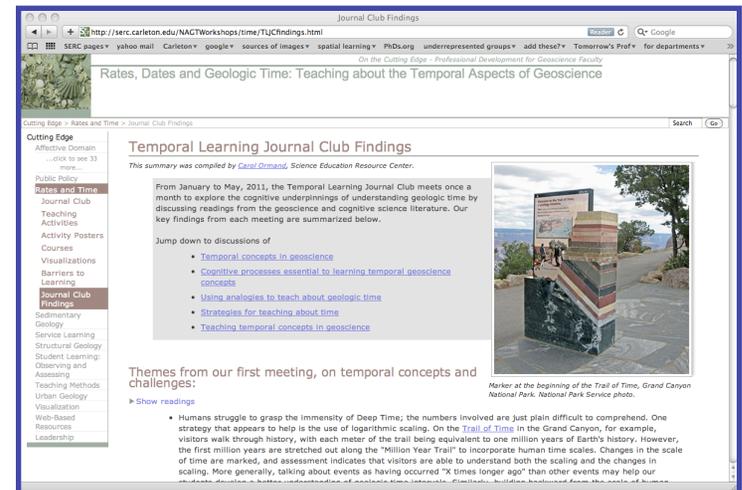
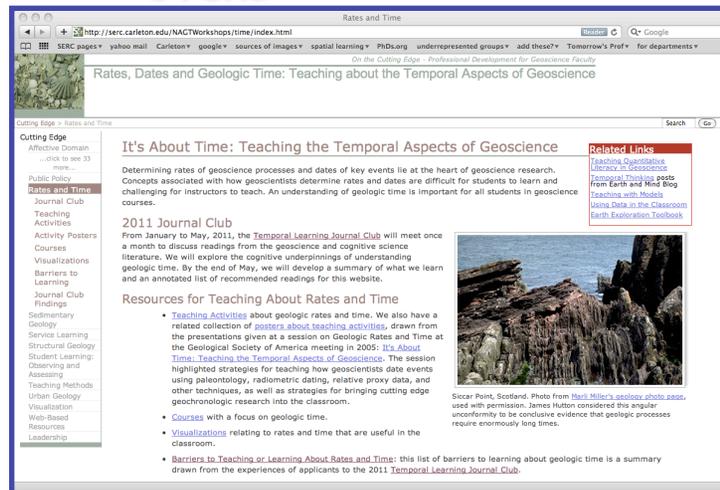
# Areas of further exploration

- ❖ Rates, fluxes, reservoir time, frequency, magnitude, duration, threshold, recurrence interval, evolutionary/faunal turnover, etc. are temporal concepts that are fundamental to understanding geologic processes and history, but present major barriers to learning



# Resources: our website

- ❖ More complete descriptions of common temporal learning challenges, their cognitive roots, and research-based strategies recommended for addressing them can be found online by Googling "geologic time journal club"





# Upcoming workshop: Teaching About Time

- ❖ February 2012 in Tempe, AZ
- ❖ Pick up a flyer of upcoming "Cutting Edge" events at the NAGT booth

Teaching About Time

http://serc.carleton.edu/NAGTWorkshops/time/workshop2012/index.html

On the Cutting Edge - Professional Development for Geoscience Faculty

## Teaching About Time

Arizona State, Tempe, AZ

Cutting Edge > Rates and Time > Teaching About Time

Search [Go]

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### Workshop: Teaching About Time

February 26-28, 2012, at Arizona State University

**Application deadline: January 2, 2012**  
Limited stipends are available to help defray workshop costs; the stipend application deadline is also January 2, 2012.

Geologic time is a critically important concept in the geosciences and in biology. From the magnitude of geologic history to the rates of geologic processes, a sophisticated understanding of geologic time is an essential foundation for unraveling the complex history of the Earth, for understanding evolution, and for contextualizing natural and anthropogenic changes occurring on our planet today. Students struggle with the enormous numbers involved in Deep Time, with rates and scales of geologic processes that are beyond their personal experiences, and with the complex interactions of slow processes over long time scales. How can we best help our students to overcome these challenges?

Join us for a workshop that will bring together faculty teaching about time in geoscience and biology, education researchers, and cognitive psychologists to

1. Understand current best practice in teaching about time,
2. Bring forward the ideas from education and cognitive psychology that can inform improved practice, and
3. Work together in ways that support improved teaching about time in the biological and geological sciences.

**Conveners**

Erica Crespi, Biology, Vassar College  
Cathy Manduca, Science Education Resource Center, Carleton College  
Carol Ormand, Science Education Resource Center, Carleton College  
Steve Semken, Geoscience Education and Geological Sciences, Arizona State University

*Stromatolites at Lake Thetis, Western Australia. Photo by Ruth Ellison; original available on [Wikimedia Commons](#).*