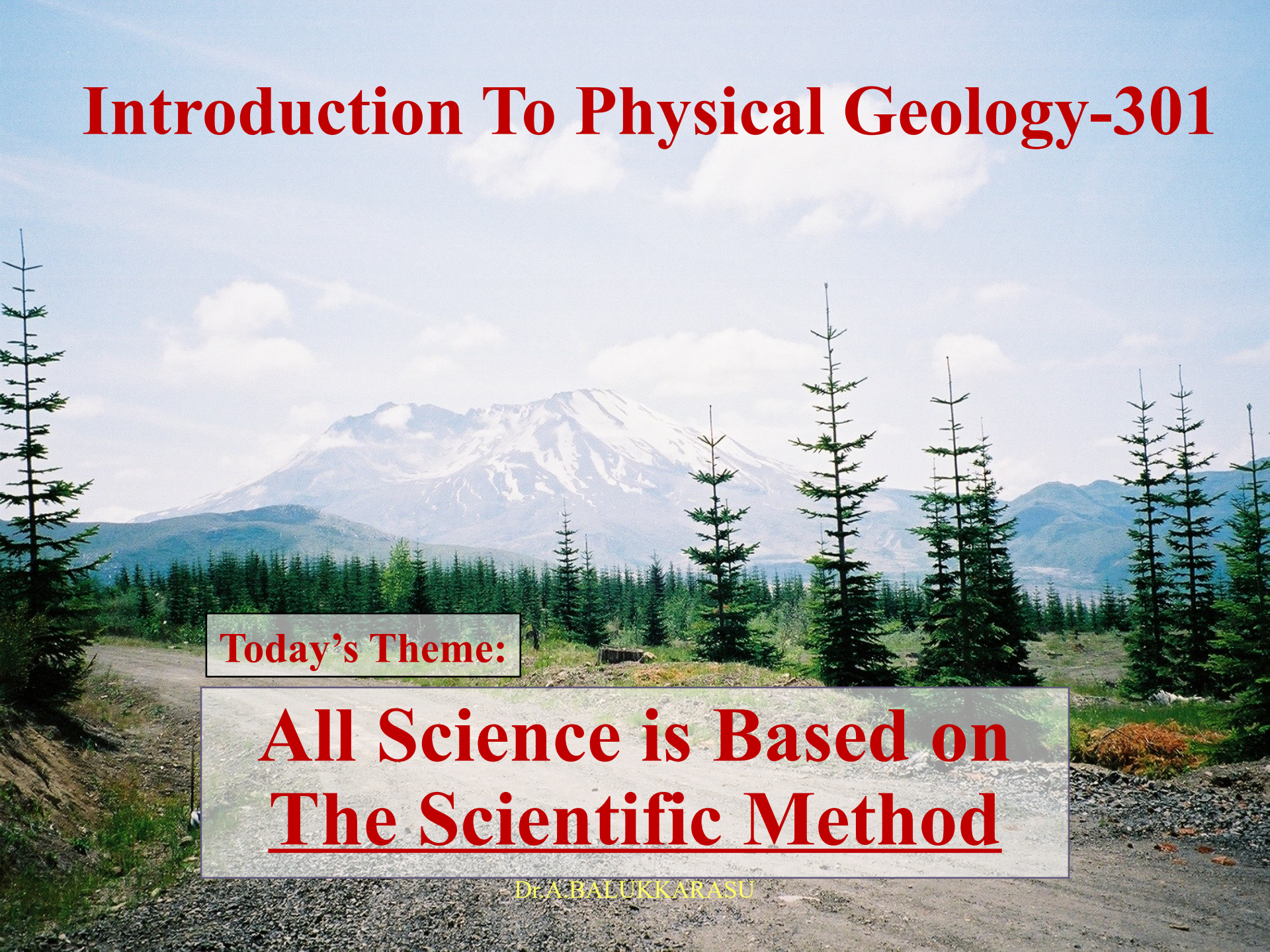
Introduction To Physical Geology-301



Today's Theme:

All Science is Based on The Scientific Method

Dr.A.BALUKKARASU

What is Geology?

- The study of the Earth
  - Composition
  - Behavior
  - History
- Geology is often called geoscience or Earth science
  - Relies heavily on…
    - Biology
    - Chemistry
    - Physics
    - Mathematics

Subdisciplines of Geology

- **Engineering Geology/Geological Engineering**
  - Stability of materials for building things
- **Paleontology**
  - Ancient life (fossils)
- **Stratigraphy/Sedimentology**
  - Layers of rocks and their sequences/sediments and their deposition
- **Petrology**
  - Rocks!
- **Structural Geology**
  - Deformed/Damaged Rocks, often related to tectonic plates
- **Hydrogeology**
  - Groundwater & surface water
- **Volcanology**
  - Volcanoes, active and ancient
- **Climatology**
  - Past, present, and future climate interactions
- **Geophysics**
  - The physics of the Earth system
- ***…and the list goes on and on…***

Themes of Course:

1. The Earth is a ***unique, evolving system***
2. The theory of *Plate Tectonics*
   - a unifying theory that is essential to explain Earth processes, Plates move slow…< 10 cm/yr!
3. The Earth is very old (~4.6 billion yrs.)
   - Geologic time…

Geologic Time - Eons

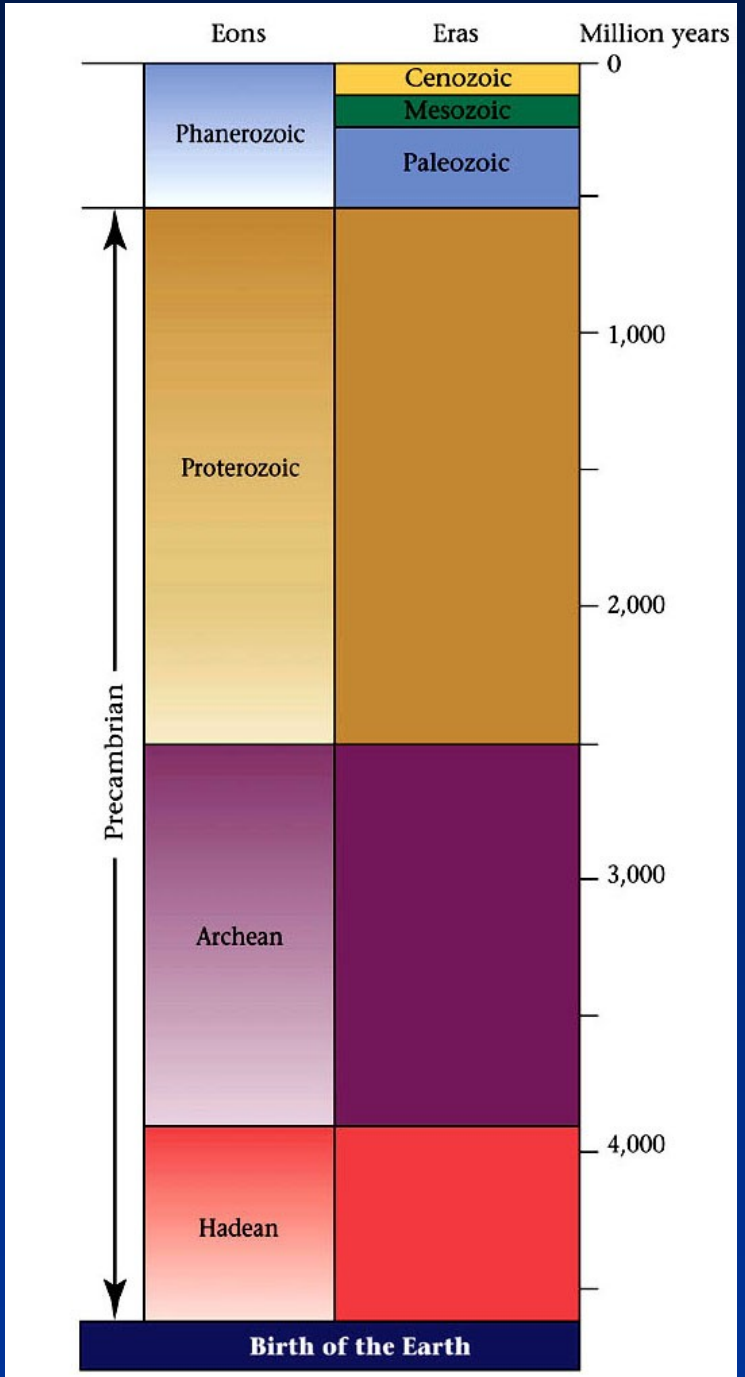
Phanerozoic – "Visible Life"

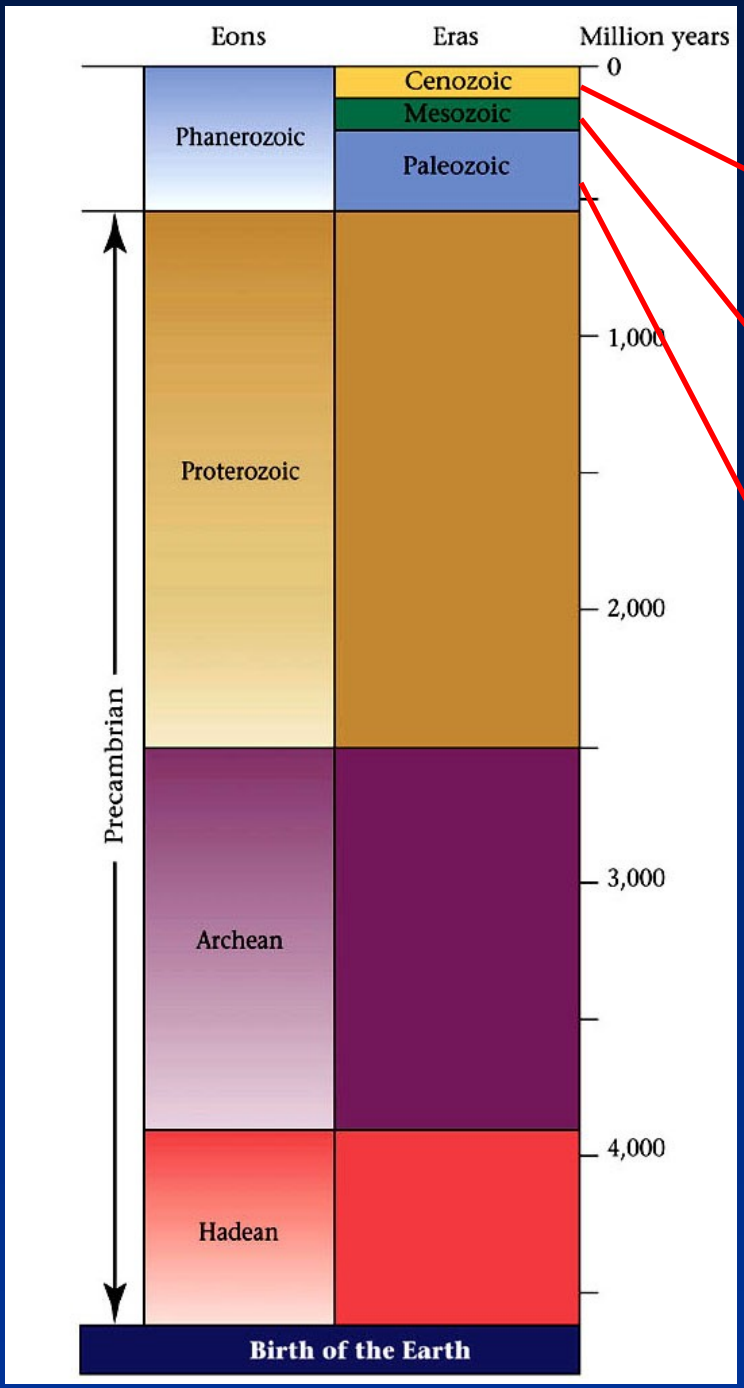
Precambrian

Proterozoic – "Former Life"
Simple Organisms

Archean – "Ancient"
Oldest Rocks

Hadean – "Beneath the Earth"
All Rocks Still Molten
Think "Hot As Hades"





Phanerozoic Era

Cenozoic – "New Life"
Now!

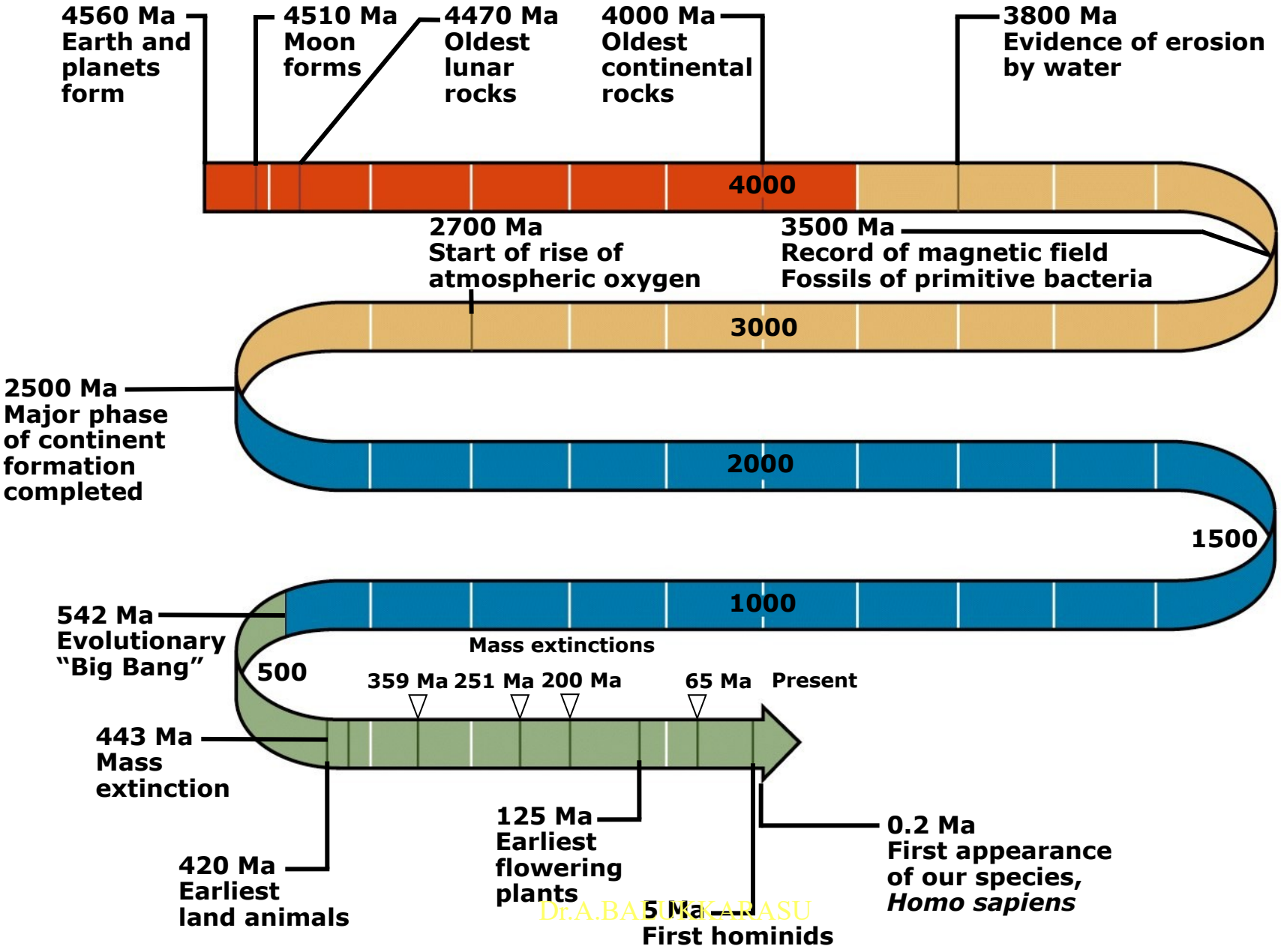
Mesozoic – "Middle Life"
Dinosaurs!

Paleozoic – "Ancient Life"

Ka = Thousand years ago
Ma = Million years ago
Ga = Billion years ago
1,000 Ka = 1 Ma
1,000 Ma = 1 Ga
1,000,000 Ka = 1 Ga

3.75 Ga = ? Ka

A Brief Journey Through Geologic Time…



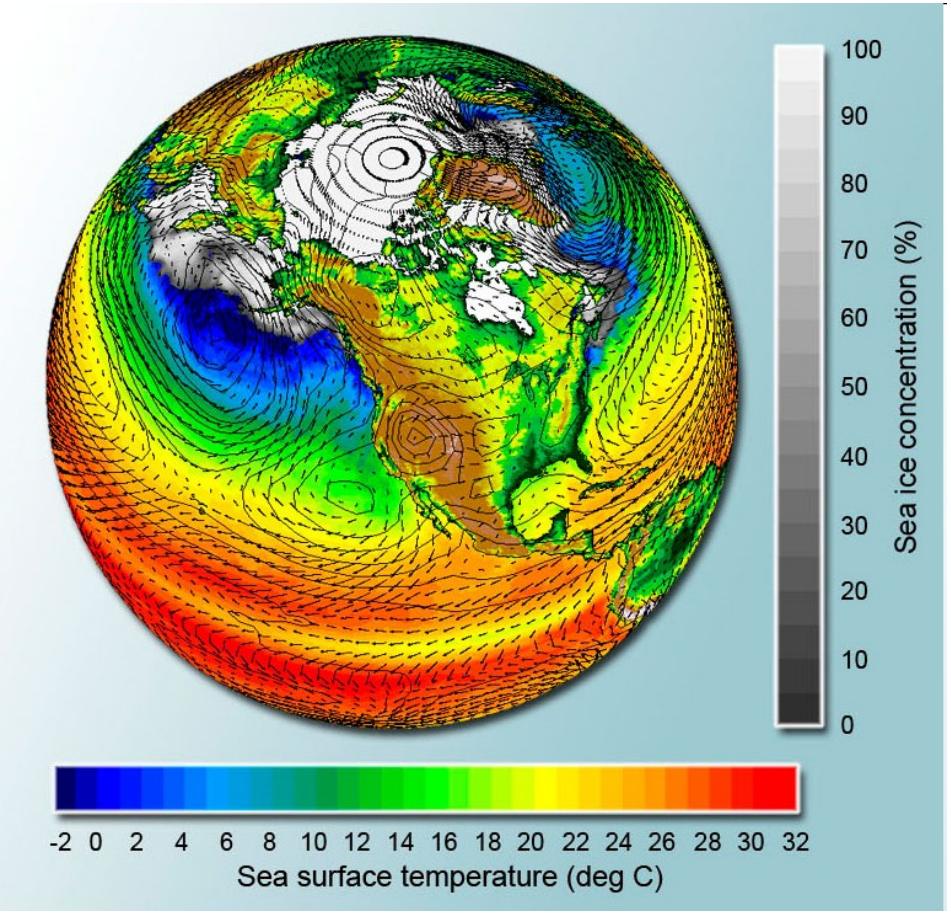
Geology Covers an *Enormous* Range of Scales

The most recent layer is about 250 million years old.

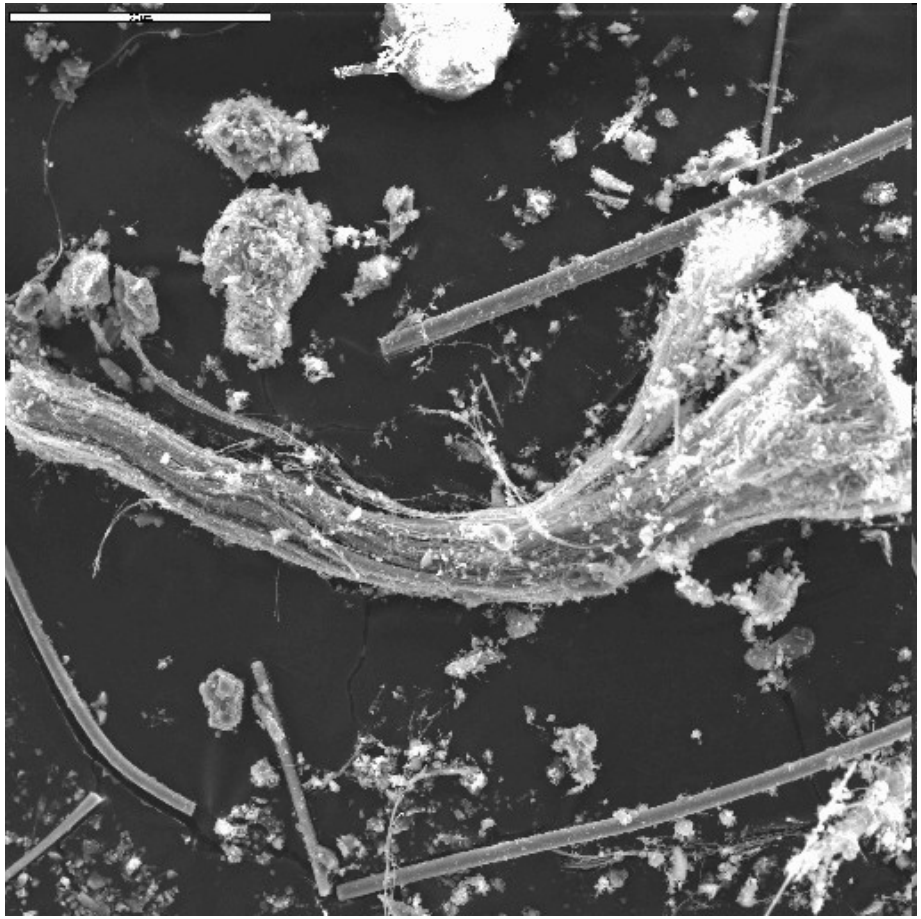
The explosive impact of a meteorite created this 1.2-km-wide crater in just a few seconds.

The rocks at the bottom of the Grand Canyon are 1.7–2.0 billion years old.

Geology Covers an *Enormous* Range of Scales



Global-scale model of ocean temperatures



Scanning electron microscope image of a minerals (chrysotile) within dust.

Themes of Course:

- The Earth is a ***unique, evolving system***
- ***Plate Tectonics*** is a unifying theory that is essential to explain Earth processes
- The Earth is very old (~4.6 billion yrs.)
  - Geologic time…
- Internal and external forces interact at the Earth's surface

  Internal – volcanoes, earthquakes

  External – wind, glaciers
- Geologic phenomena affect our daily environment

  Groundwater, Landslides, Oil Reserves, Hurricanes, Weather Patterns etc. *(see Watauga landslide map)*

More Themes:

- Physical aspects of the Earth are linked to life processes

  Soils, temperature, water flow, etc…
- The study of geology can increase science literacy

  Make better decisions about your environment
- Science comes from observation

  People make science happen

  Science is based on ***The Scientific Method*…**
  - Science IS NOT in the business of proving things
  - Science is all about gathering data and testing ideas

The Scientific Method

- Science is not subjective
- Results are ***statements*** based on ***observations***
- Results must be ***reproducible*** and ***thoroughly tested***
- Scientific discovery is the results of human efforts… people just like you!
- Science proves nothing,

The Basic Steps of the Scientific Method

- 1- Identifying the problem or question

  What are we trying to figure out?
- 2- Collecting data

  Collect data that addresses the problem
- 3- Propose hypothesis

  An idea that is consistent with your collected data
- 4- Test hypothesis

  If your idea is correct, then other things should be true too. Test 'em! Get 'er done!

Over time, others will test your hypothesis

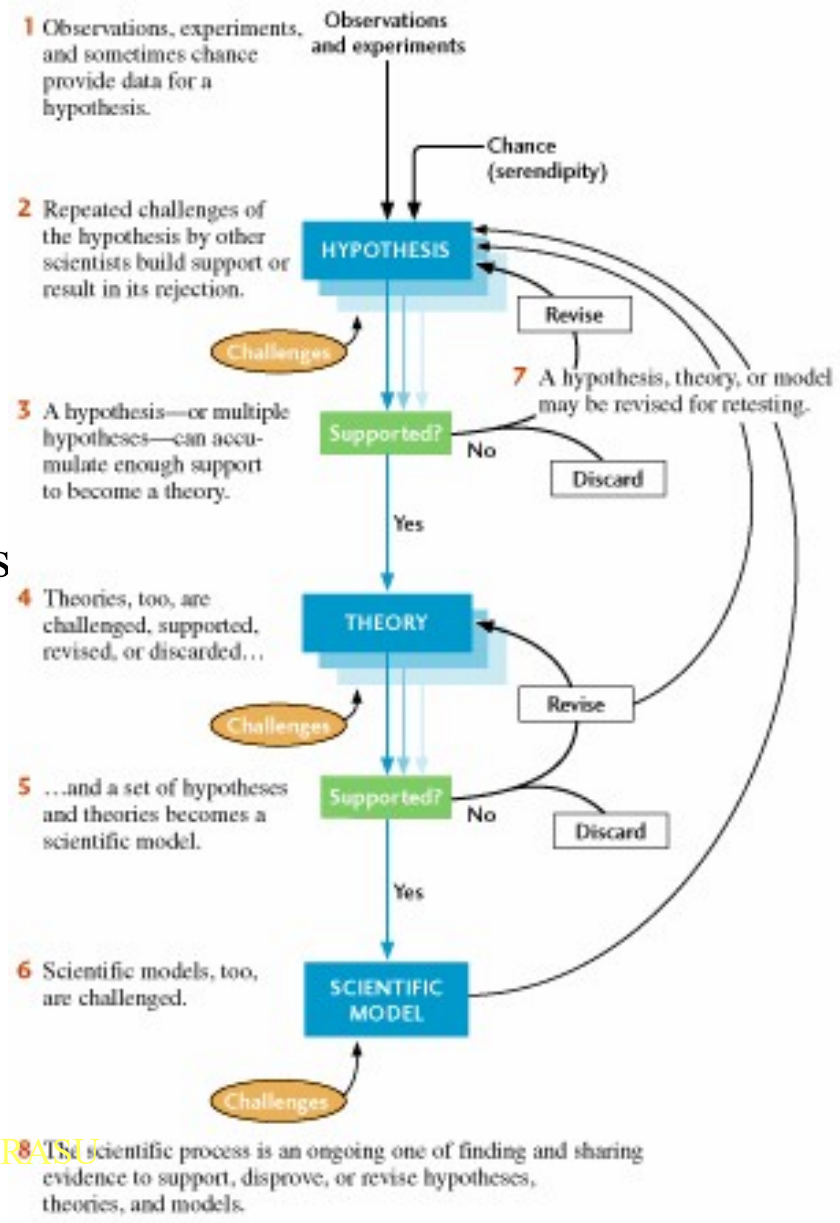
- Does the hypothesis agree with other data?
- Does the hypothesis predict behaviors?
  - If yes, then the hypothesis may become a ***theory***
  - If no, then the hypothesis must be modified or rejected

Hypotheses, Theories, and Laws, Oh My!

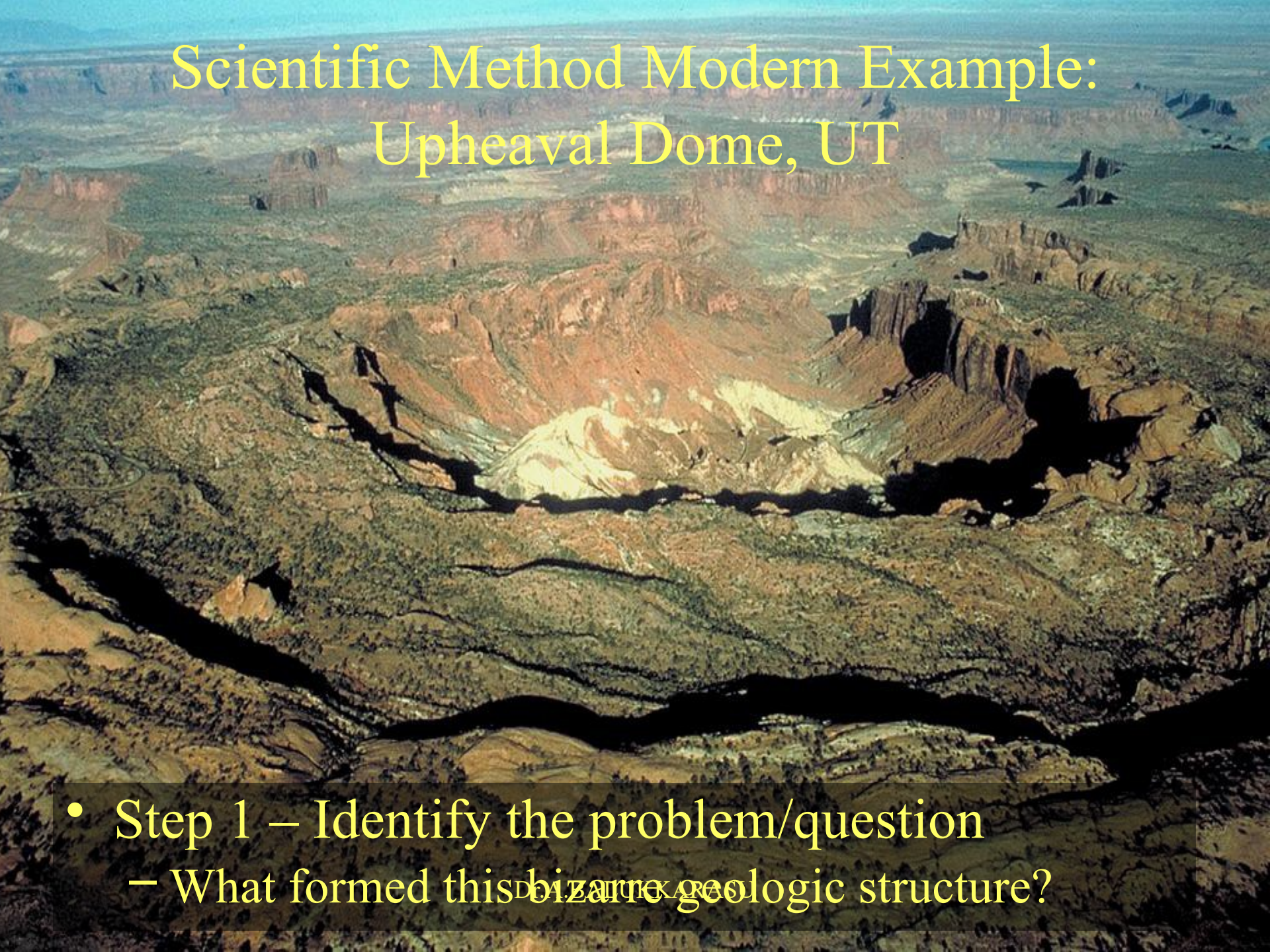
- Hypothesis
  consistent with your data
  other researchers test it
- Theory
  consistent with ***all*** verified data
  may be modified if new data is presented
- Scientific Model
  Combines many theories and hypotheses to explain a complex system
- Law
  considered absolutely correct throughout the natural universe (e.g. gravity)

The Moral…

Its not easy to become a theory.



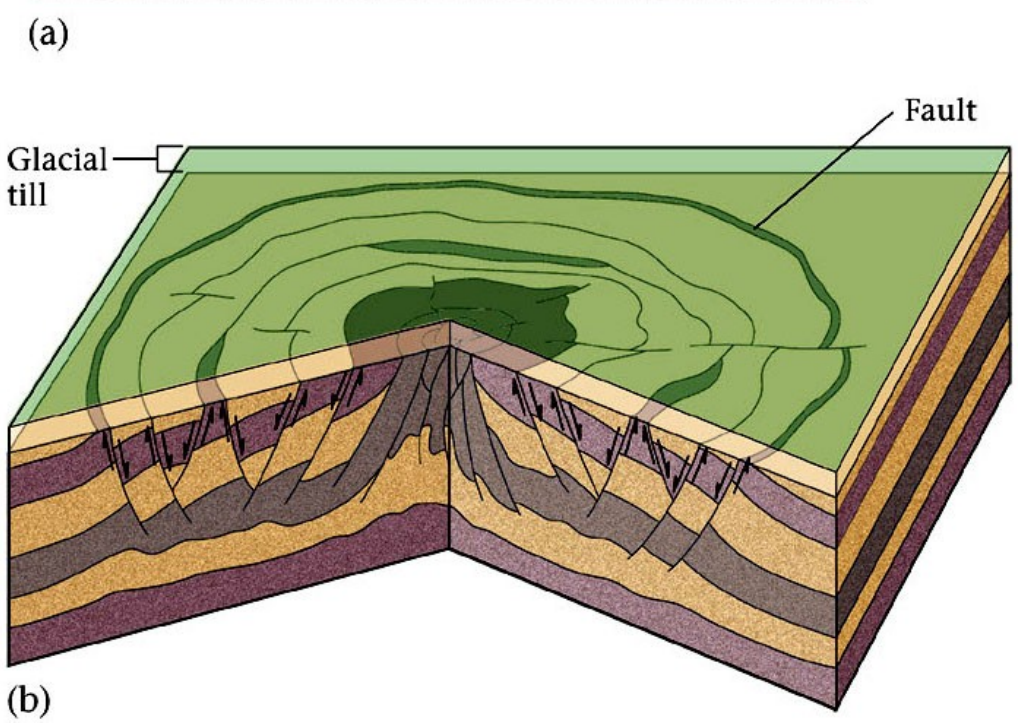
Scientific Method Modern Example: Upheaval Dome, UT



- Step 1 – Identify the problem/question
  - What formed this bizarre geologic structure?

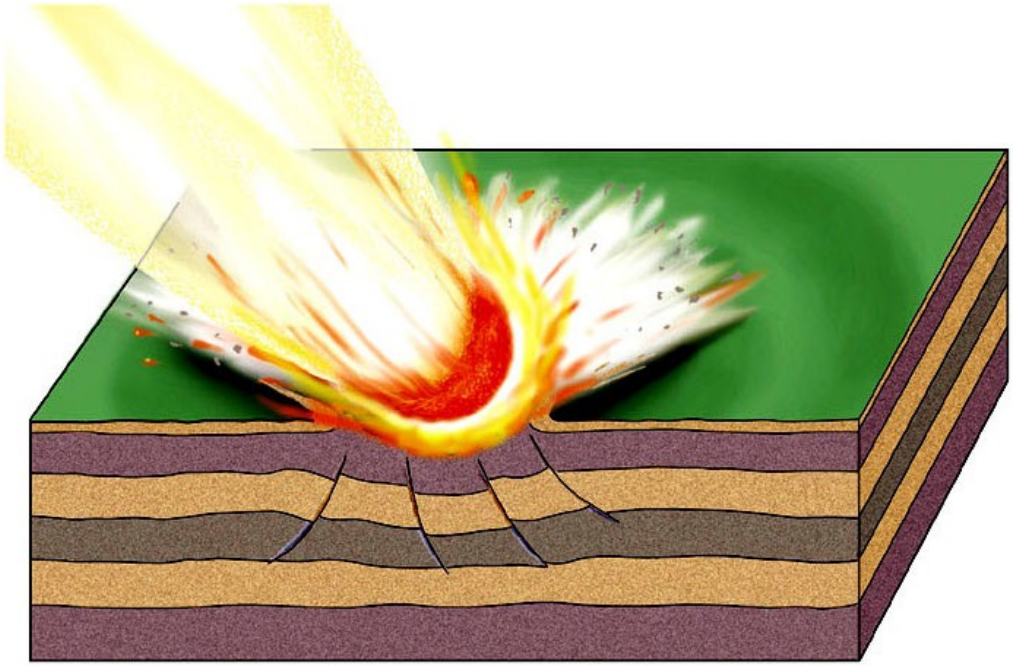
Collect Data

- Circular shape
- Dome structure
- Lots of Faults



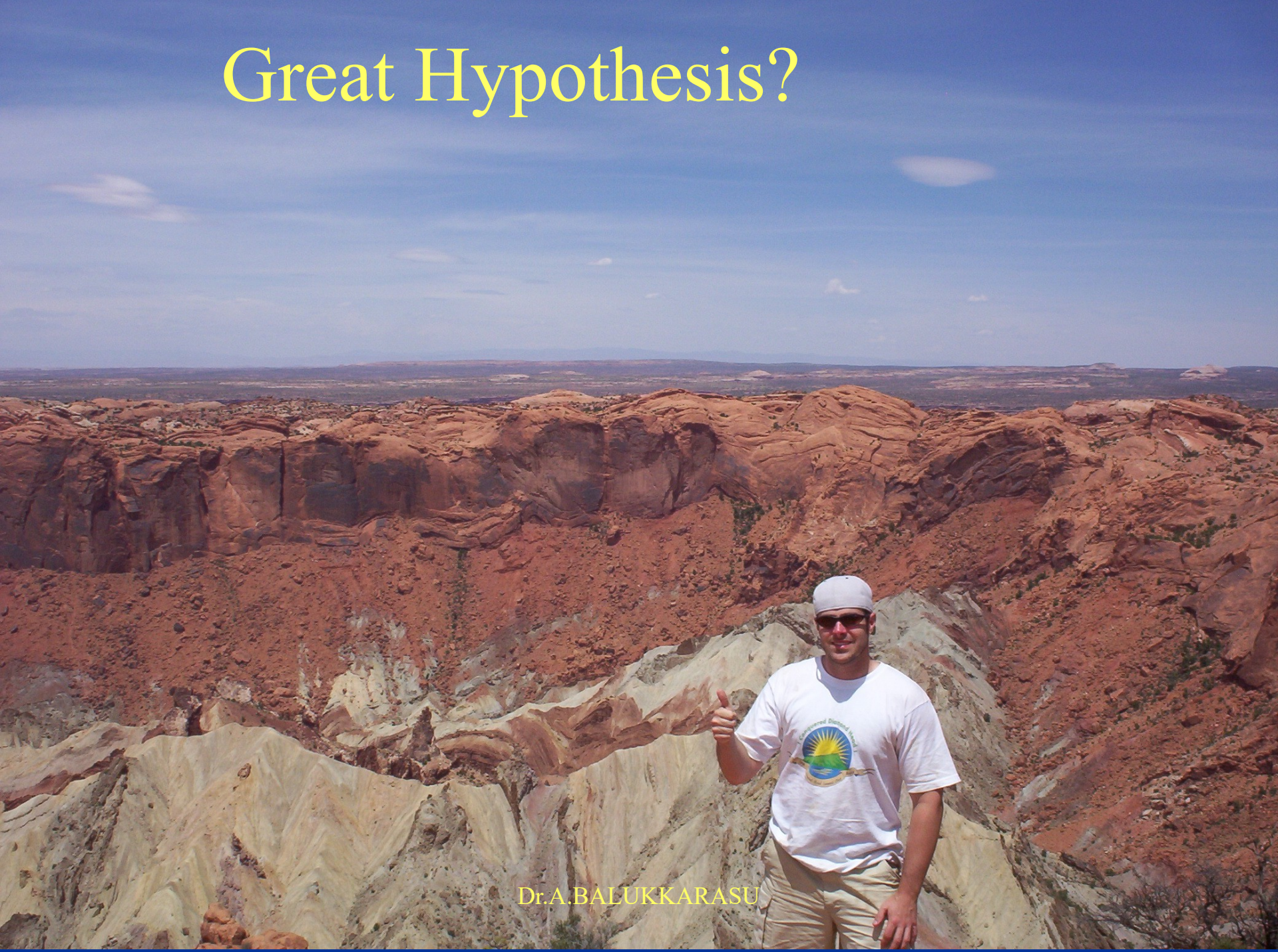
Make A Hypothesis

- Meteor Impact!
  - Consistent with dome structure and lots of faults

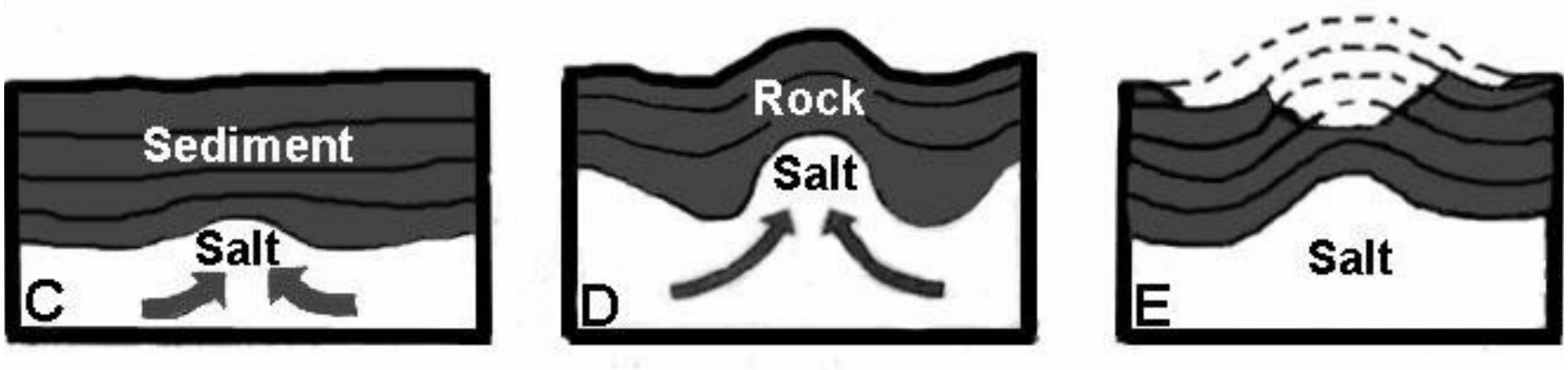


(a)

Great Hypothesis?

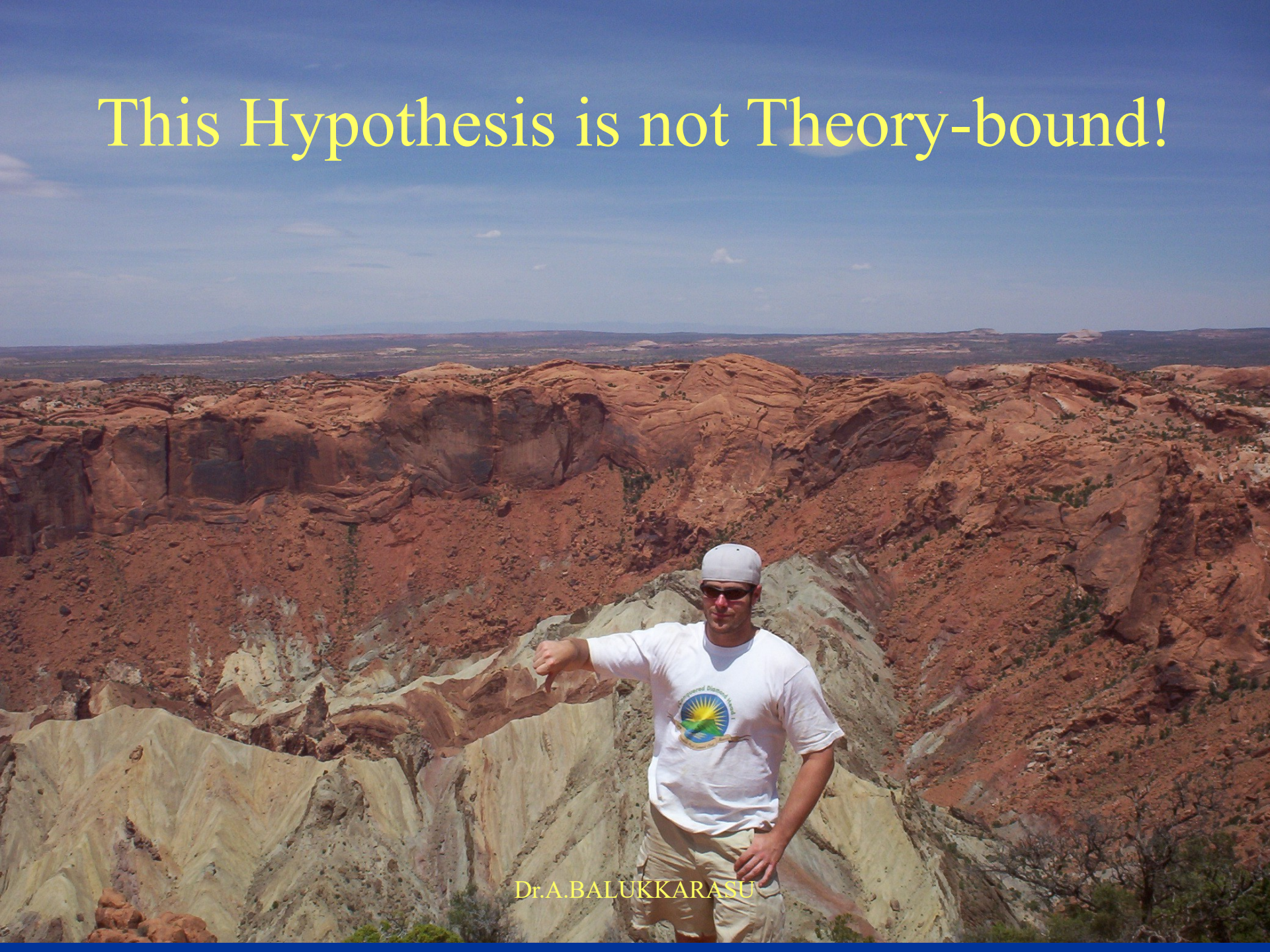


Hypothesis Testing



- After you submit your findings, someone else reviews your work and points out that
- Salt deposits can also make circular domes!!
- Uh Oh! ☹

This Hypothesis is not Theory-bound!



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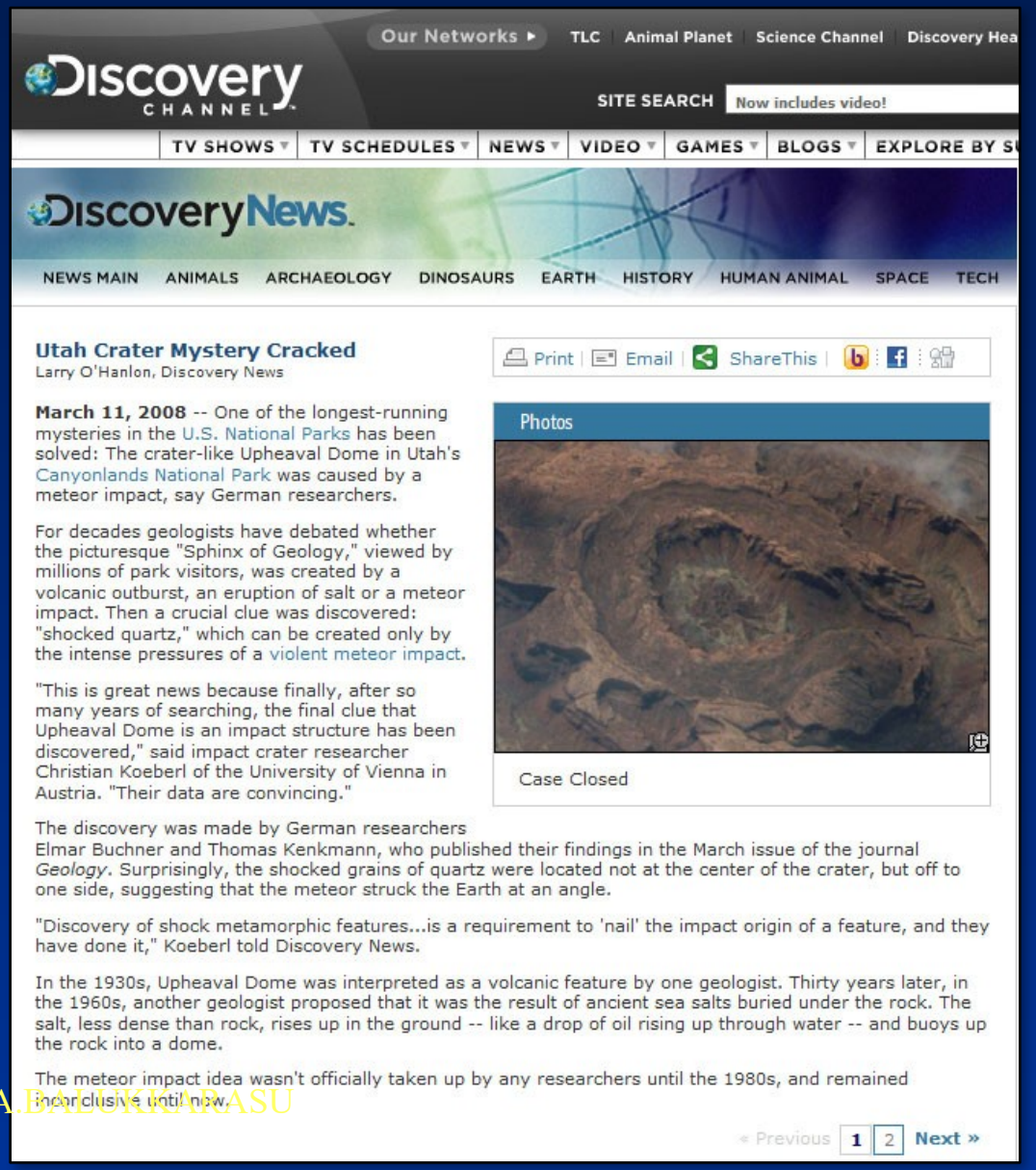
Solved!

- In 2008, Researchers from the University of Vienna:
  - Found Shocked Quartz
  - Demonstrated that the impact hypothesis was the only idea that was consistent with all of the data
  - Now if the community verifies and reproduces these results…
    - we will have a theory to explain upheaval dome!



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Utah Crater Mystery Cracked

Larry O'Hanlon, Discovery News

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March 11, 2008 -- One of the longest-running mysteries in the U.S. National Parks has been solved: The crater-like Upheaval Dome in Utah's Canyonlands National Park was caused by a meteor impact, say German researchers.

For decades geologists have debated whether the picturesque "Sphinx of Geology," viewed by millions of park visitors, was created by a volcanic outburst, an eruption of salt or a meteor impact. Then a crucial clue was discovered: "shocked quartz," which can be created only by the intense pressures of a violent meteor impact.

"This is great news because finally, after so many years of searching, the final clue that Upheaval Dome is an impact structure has been discovered," said impact crater researcher Christian Koeberl of the University of Vienna in Austria. "Their data are convincing."

Photos

Case Closed

The discovery was made by German researchers Elmar Buchner and Thomas Kenkmann, who published their findings in the March issue of the journal *Geology*. Surprisingly, the shocked grains of quartz were located not at the center of the crater, but off to one side, suggesting that the meteor struck the Earth at an angle.

"Discovery of shock metamorphic features...is a requirement to 'nail' the impact origin of a feature, and they have done it," Koeberl told Discovery News.

In the 1930s, Upheaval Dome was interpreted as a volcanic feature by one geologist. Thirty years later, in the 1960s, another geologist proposed that it was the result of ancient sea salts buried under the rock. The salt, less dense than rock, rises up in the ground -- like a drop of oil rising up through water -- and buoys up the rock into a dome.

The meteor impact idea wasn't officially taken up by any researchers until the 1980s, and remained inconclusive until now.

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Science?…or Something Else?

- A friend tells you that he read that sandstone is made of tiny diamonds.
  - So small that they are not detectable by any means.
- Is this science? Is it correct?
- String Theory…
  - Is it science or philosophy?

The Moral of the Story

- Most hypotheses don't become theories

- *It takes a LOT of data for a hypothesis to become a theory*
- *Ideas that are not testable are not science*

Geologic Time

Cenozoic: 65 Ma – Now
Mesozoic: 248 Ma – 65 Ma
Paleozoic: 542 Ma – 248 Ma

Proterozoic: 2500 Ma – 542 Ma

Archean: 3800 Ma – 2500 Ma

Hadean: 4600 Ma – 3800 Ma

Formation of Earth: 4600 Ma