Thinking Geologic Thoughts: Interpreting Traces Of Past Events

"Kip"-- Charles R. Ault, Jr., Professor Emeritus
Lewis & Clark Graduate School
of Education and Counseling, USA
Email: ault@lclark.edu
Website: www.darwinianwhimsy.com

Concept Mapping Geologic Reasoning in order to answer “What to Teach?”

“Kip”-- Charles R. Ault, Jr., Professor Emeritus
Lewis & Clark Graduate School
of Education and Counseling, USA
Email: ault@lclark.edu
Website: www.darwinianwhimsy.com

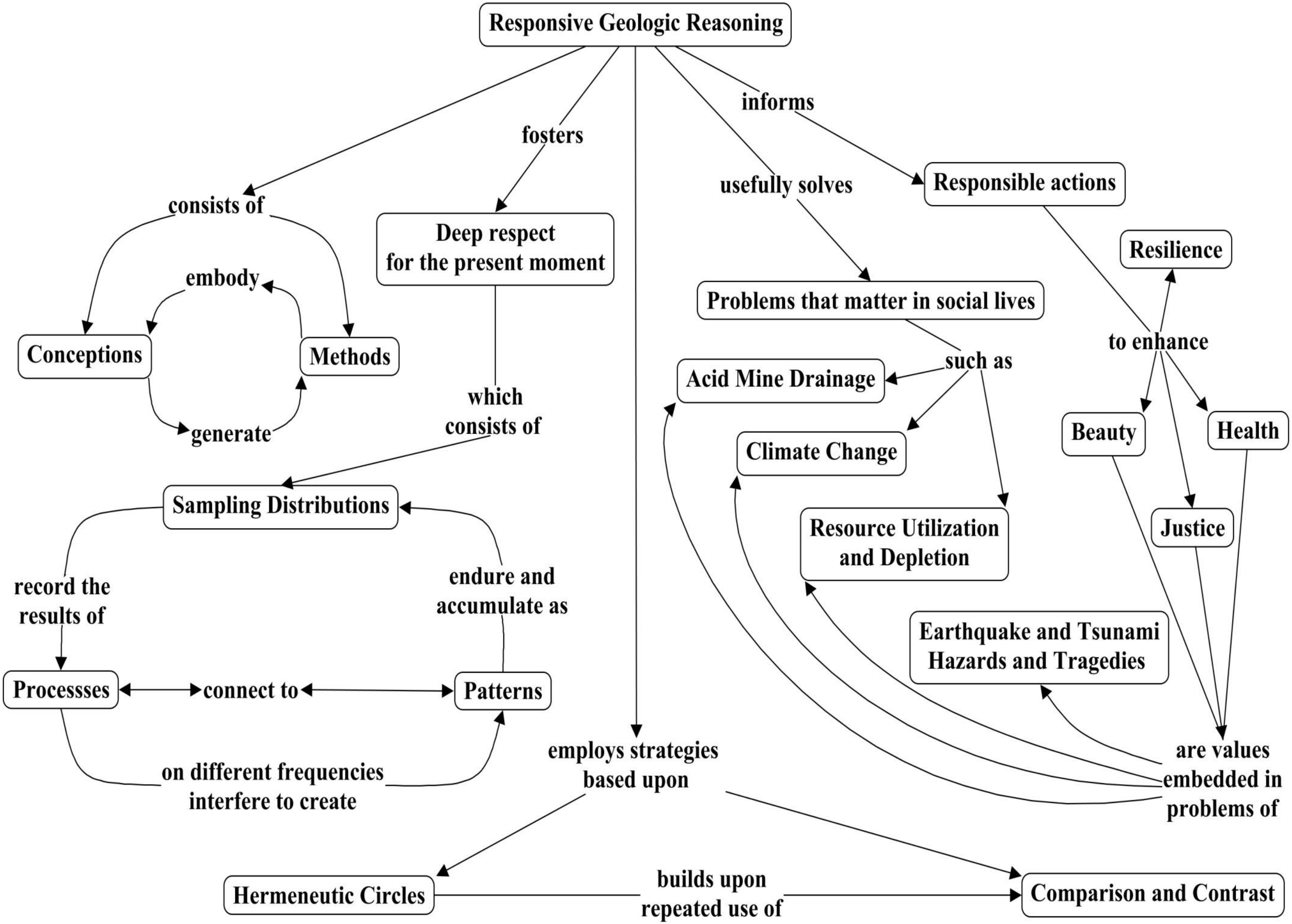
Conclusion

Geoscientist doing field work

In order to reform science education, let a search for contexts of value displace the quest to unify the sciences.

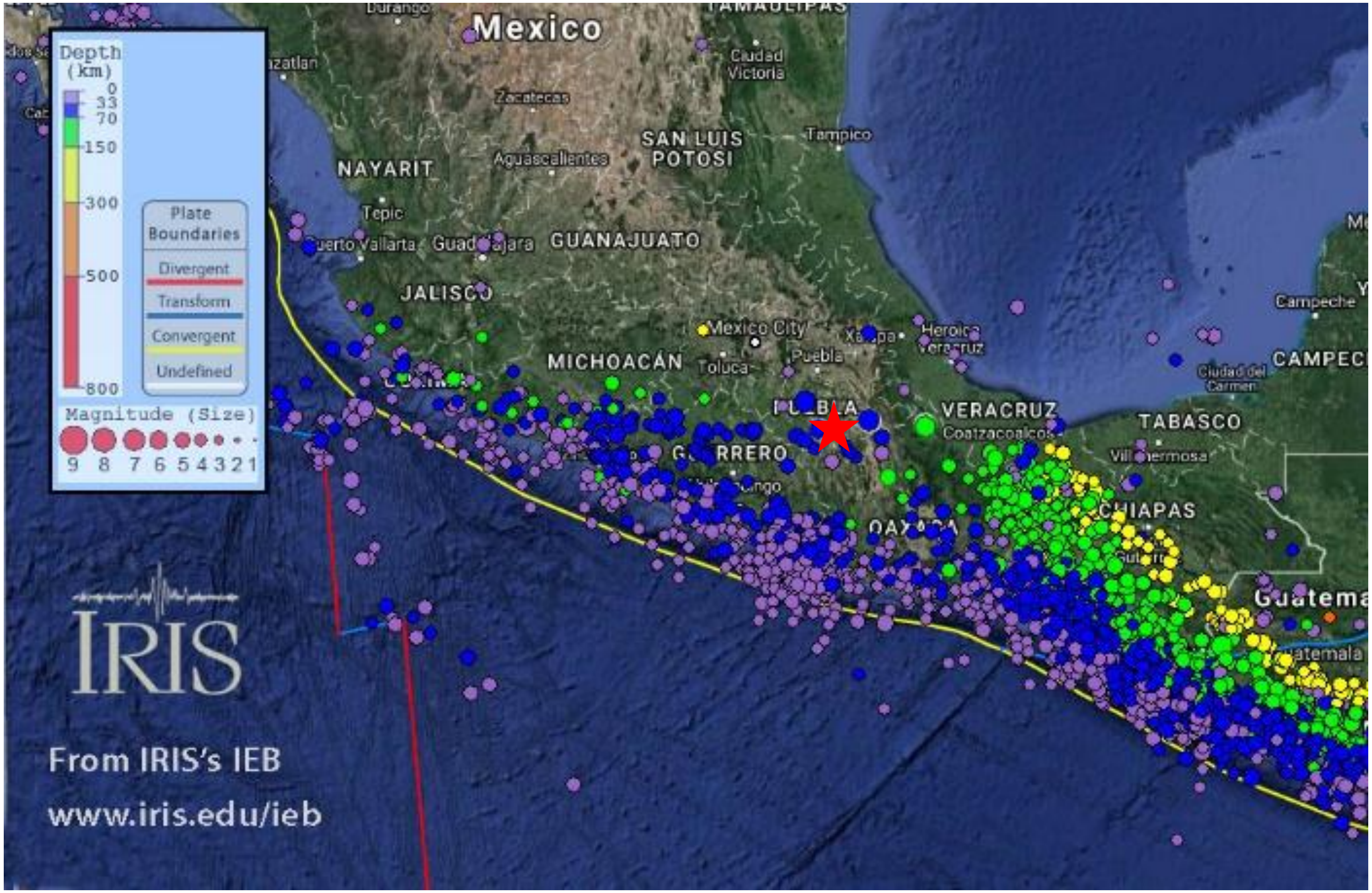
In order to reform science education, let a search for contexts of value displace the quest to unify the sciences.

Teach disciplinary contributions to understanding in contexts of value.


Responsive Geologic Reasoning
consists of
fosters
informs
usefully solves
Responsible actions
Deep respect
for the present moment
embody
Conceptions
Methods
generate
which
consists of
Resilience
Problems that matter in social lives
such as
to enhance
Acid Mine Drainage
Climate Change
Beauty
Health
Resource Utilization
and Depletion
Justice
Sampling Distributions
record the
results of
endure and
accumulate as
Earthquake and Tsunami
Hazards and Tragedies
Processses
connect to
Patterns
employs strategies
based upon
on different frequencies
interfere to create
are values
embedded in
problems of
Hermeneutic Circles
builds upon
repeated use of
Comparison and Contrast

Magnitude 7.1 PUEBLA, MEXICO
Tuesday, September 19, 2017 at 18:14:39 UTC

This map of historic seismicity shows shallow earthquakes near the trench and deeper away from the trench. This earthquake is shown by the red star.



The earthquake was an intraplate event within the top of the Cocos Plate. As oceanic plates descend into subduction zones from the seafloor, they must increase their curvature. This results in extensional forces and earthquakes within the upper plate. The 2001 Nisqually earthquake was similar. That earthquake occurred at 51 km depth beneath the southern Puget Sound in Washington State due to extension within the subducting Juan de Fuca Plate.

Example of a context of value:
Societal preparation, resilience, and recovery in response to geologic hazards, risks, and tragedies

CEETEP – *Cascadia Earthscope Earthquake and Tsunami Education Project*
http://ceetep.oregonstate.edu/

Example of a context of value:
Societal preparation, resilience, and recovery in response to geologic hazards, risks, and tragedies

CEETEP – *Cascadia Earthscope Earthquake and Tsunami Education Project*
http://ceetep.oregonstate.edu/

How do counseling psychologists help survivors of natural disasters? Will concept mapping play a role some day?

The Problem?

Each epoch of reform in science education recycles the steps and language of “the” scientific method.

The Problem?

Each epoch of reform in science education recycles the steps and language of “the” scientific method.

Even calls to teach the nature and culture of science dwell upon the imagery of science as a small set of generic processes.

My Response

Ask not, *"What do all sciences have in common?"* but rather *"How do disciplines respond to the distinct challenges of their respective problems?"*

My Response

Ask not, *“What do all sciences have in common?”* but rather *“How do disciplines respond to the distinct challenges of their respective problems?”*

Geology, for example, faces challenges of “scale” and utilizes “historical methods.”

My Response

Ask not, *“What do all sciences have in common?”* but rather *“How do disciplines respond to the distinct challenges of their respective problems?”*

Geology, for example, faces challenges of “scale” and utilizes “historical methods.”

Concept maps depict principles adapted to the challenges of geologic inquiry.

Science methods match the demands characteristic of problems

--S. Toulmin, 1990, *Cosmopolis*

Science methods match the demands characteristic of problems

--S. Toulmin, 1990, *Cosmopolis*

Darwin's work established the basis for the “historical style” of science, different from the “experimental style.”

--Stephen Jay Gould, 1986
"Evolution and the Triumph of Homology"

Source of the Problem

1910

Scientific method . . . represents the only method of thinking that has proved fruitful in any subject.

--John Dewey, 1910

Science as Subject-Matter and Method

Steps of “The” Scientific Method

1. Form a question from observation.
2. Hypothesize an answer.
3. Design an experiment to test the hypothesis.
4. Accept or reject the hypothesis based on the analysis of the data.
5. Propose and test a new hypothesis.

Decadal Jargon in the Quest for Unity

1950s “The” scientific method
1960s The processes of science
1970s Scientific inquiry skills
1980s Common themes & habits of mind
1990s The nature of science
2000s The culture of science
2010s Scientific & Engineering practices
2010s Crosscutting concepts

The Next Generation Science Standards in the USA call *“for a new approach to teaching science that ties all lessons into the few ‘big ideas’ of science . . . and emphasizes the common practices that scientists use.”*

--Stephen Pruitt, 2013

Vice President, Achieve, Inc.

NGSS 3-Dimensional* Learning (3-D):

8 Scientific Practices

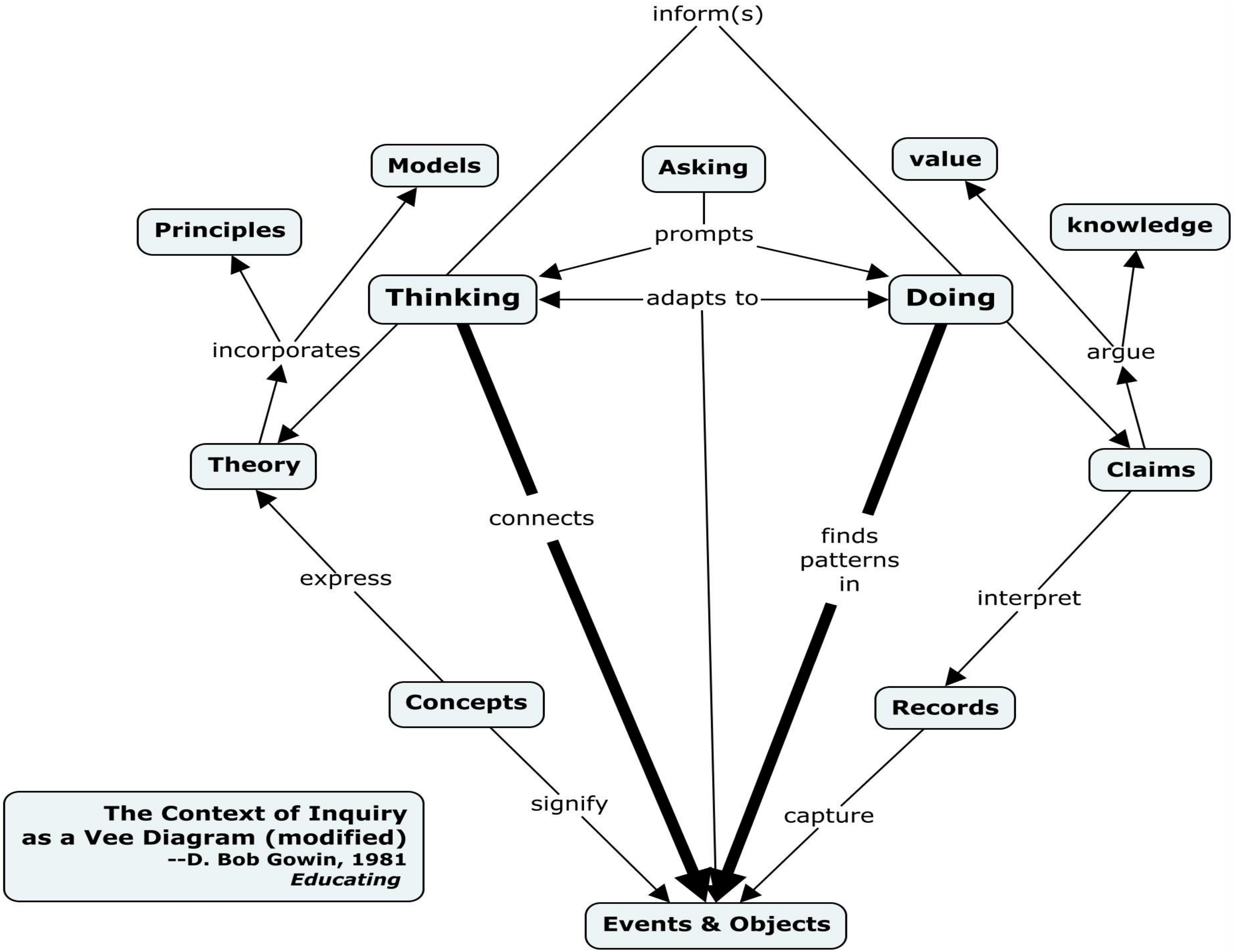
13 Disciplinary Core Ideas

7 Crosscutting Concepts

*plus a 4th dimension, the 8 essential understandings of the Nature of Science


The NGSS:
Another fine mess?

3-D alignment obscures how disciplinary ideas integrate thinking and doing in particular contexts.

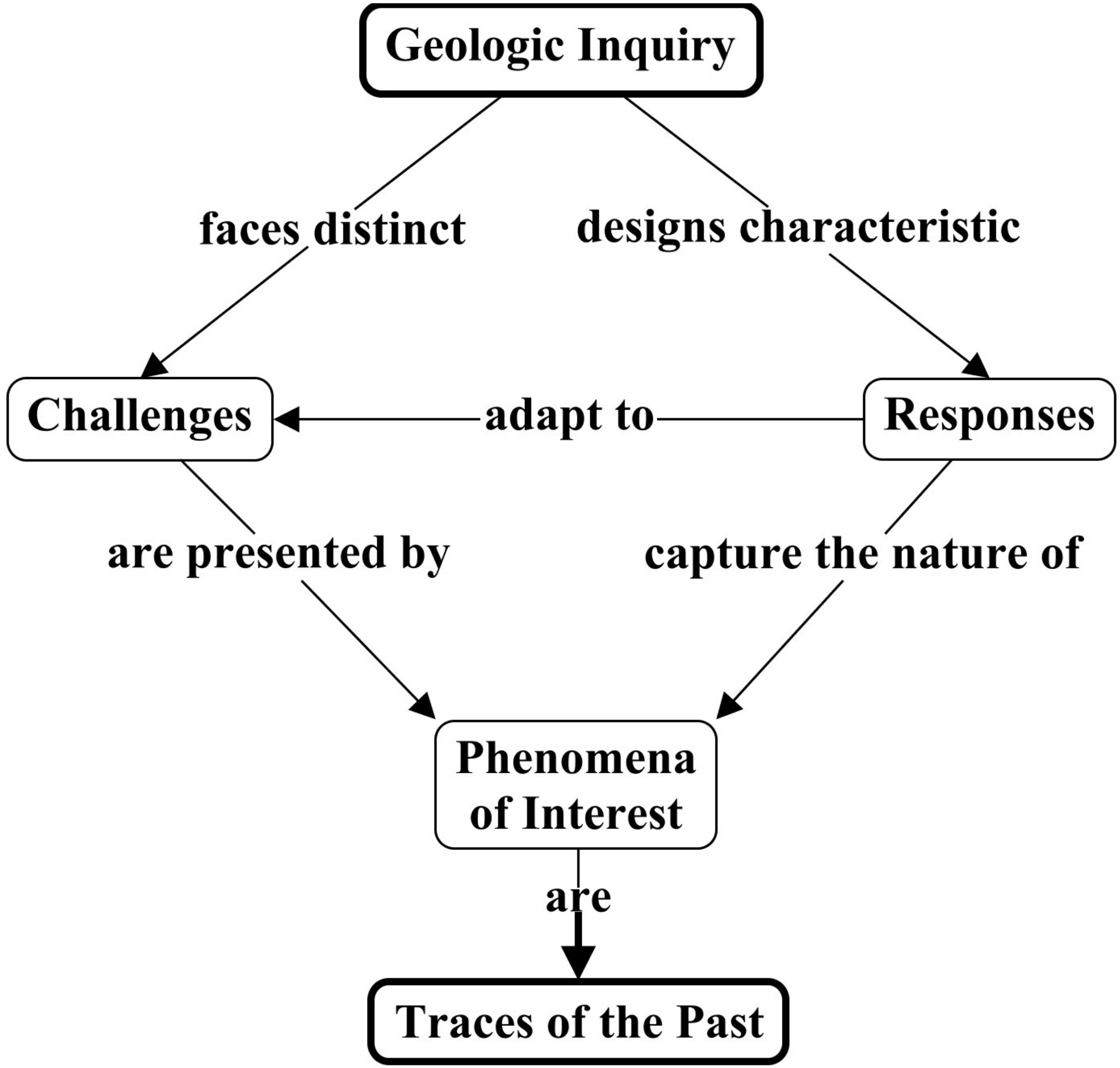

inform(s)
Models
Asking
value
Principles
prompts
knowledge
Thinking
adapts to
Doing
incorporates
argue
Theory
Claims
connects
finds
patterns
in
express
interpret
Concepts
Records
signify
capture
Events & Objects
The Context of Inquiry
as a Vee Diagram (modified)
--D. Bob Gowin, 1981
Educating

Each discipline responds to its respective challenges: scale in geology, human diversity in medicine, modeling in climate science.

Each discipline responds to its respective challenges: scale in geology, human diversity in medicine, modeling in climate science.

Interest and expertise reside in the match between challenge and response.

The Case of Geologic Inquiry


Geologic Inquiry
faces distinct
designs characteristic
Challenges
adapt to
Responses
are presented by
capture the nature of
Phenomena of Interest
are
Traces of the Past

Place often substitutes for time in order to overcome the challenge of vast durations.


coral
Pacific Ocean
Atafu village
N

Reconstructing earth stories from traces of the past often invokes modern analogues.

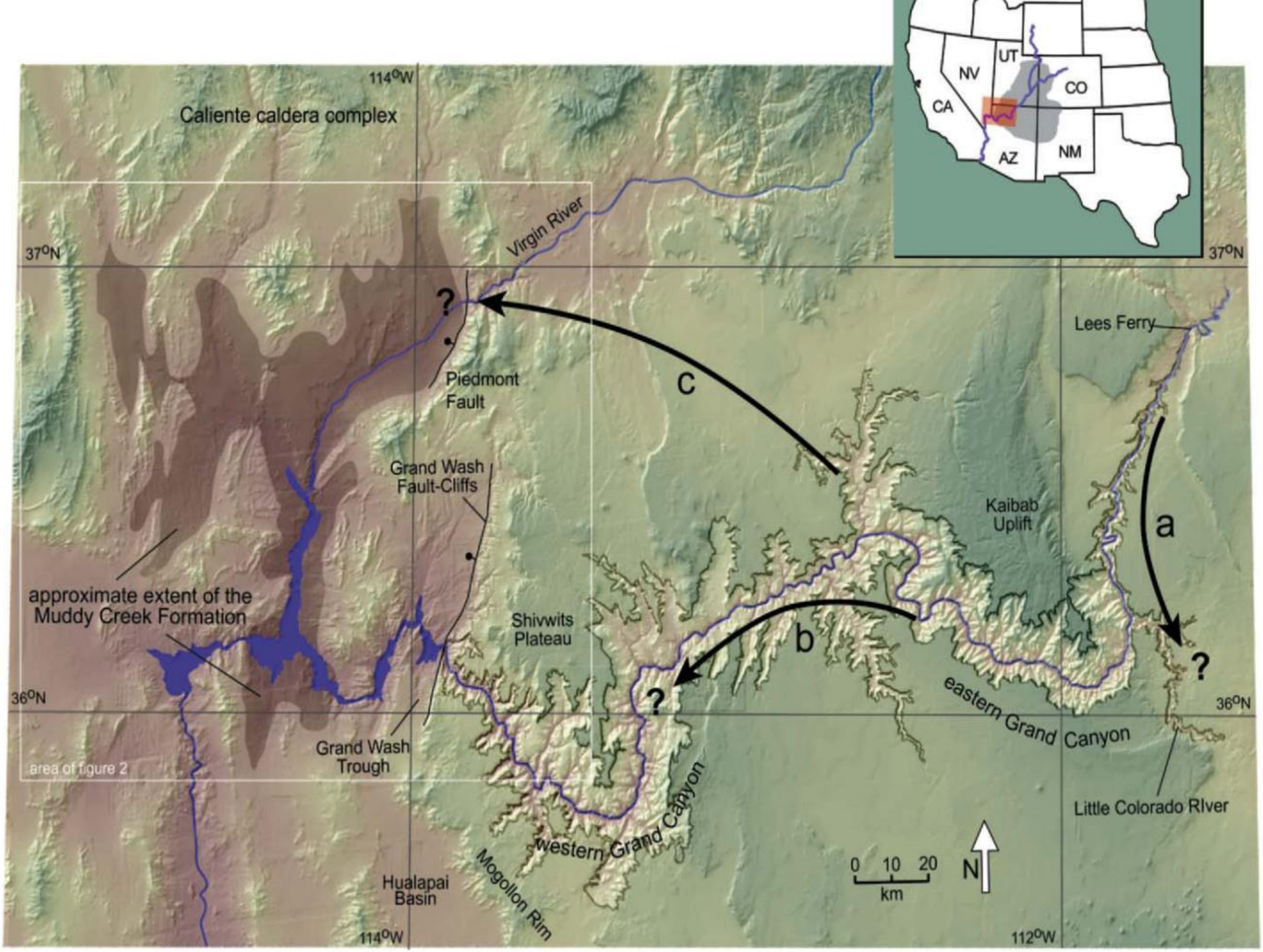
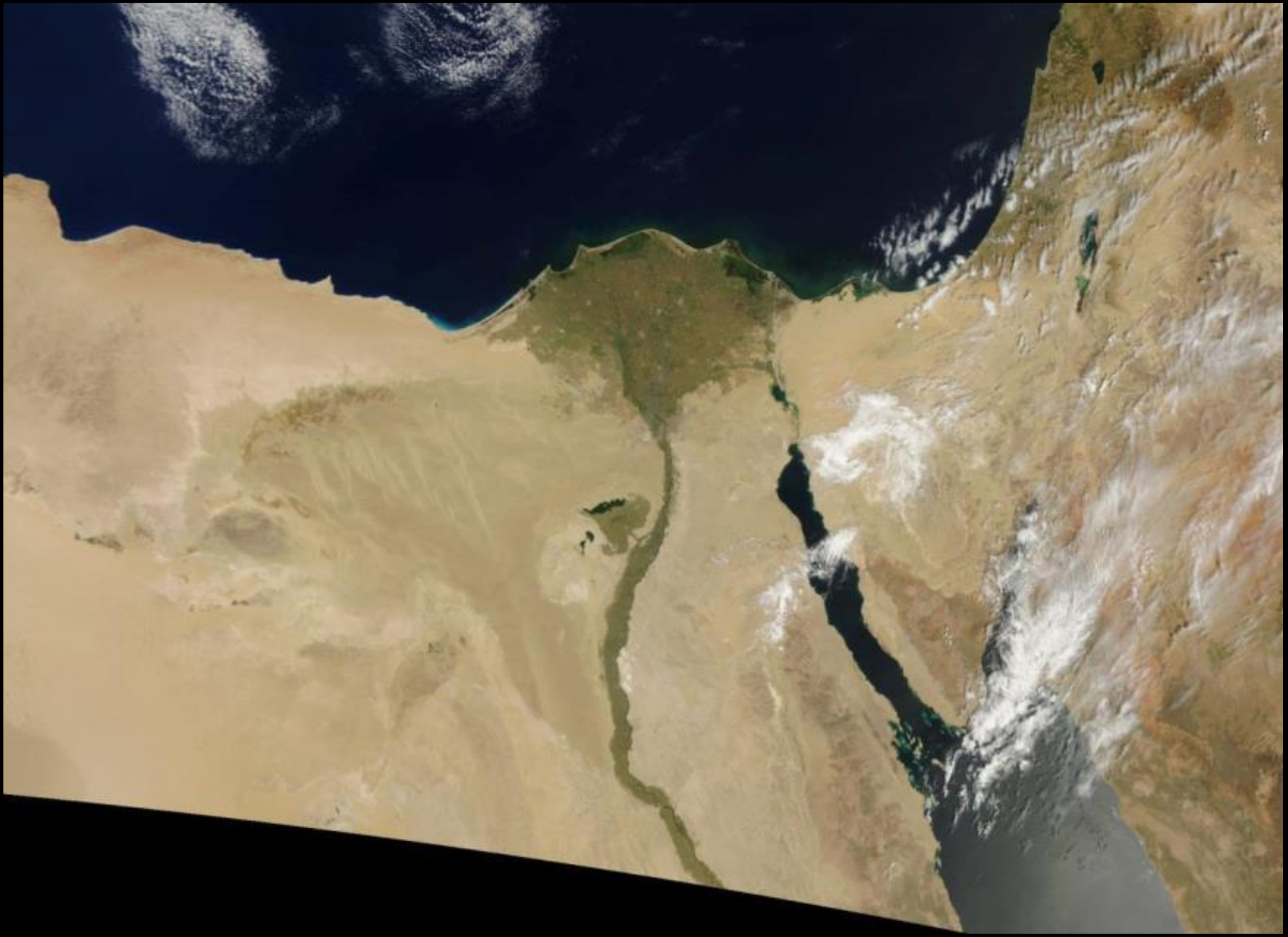


Figure 1. Regional geography and topography of Grand Canyon and Lake Mead region along the Colorado River at the edge of the Colorado Plateau (gray area of inset), southwestern United States. Large arrows indicate hypothetical paths of late Miocene upper Colorado River before major incision of Grand Canyon, with letters matching the hypotheses as reviewed in the text.

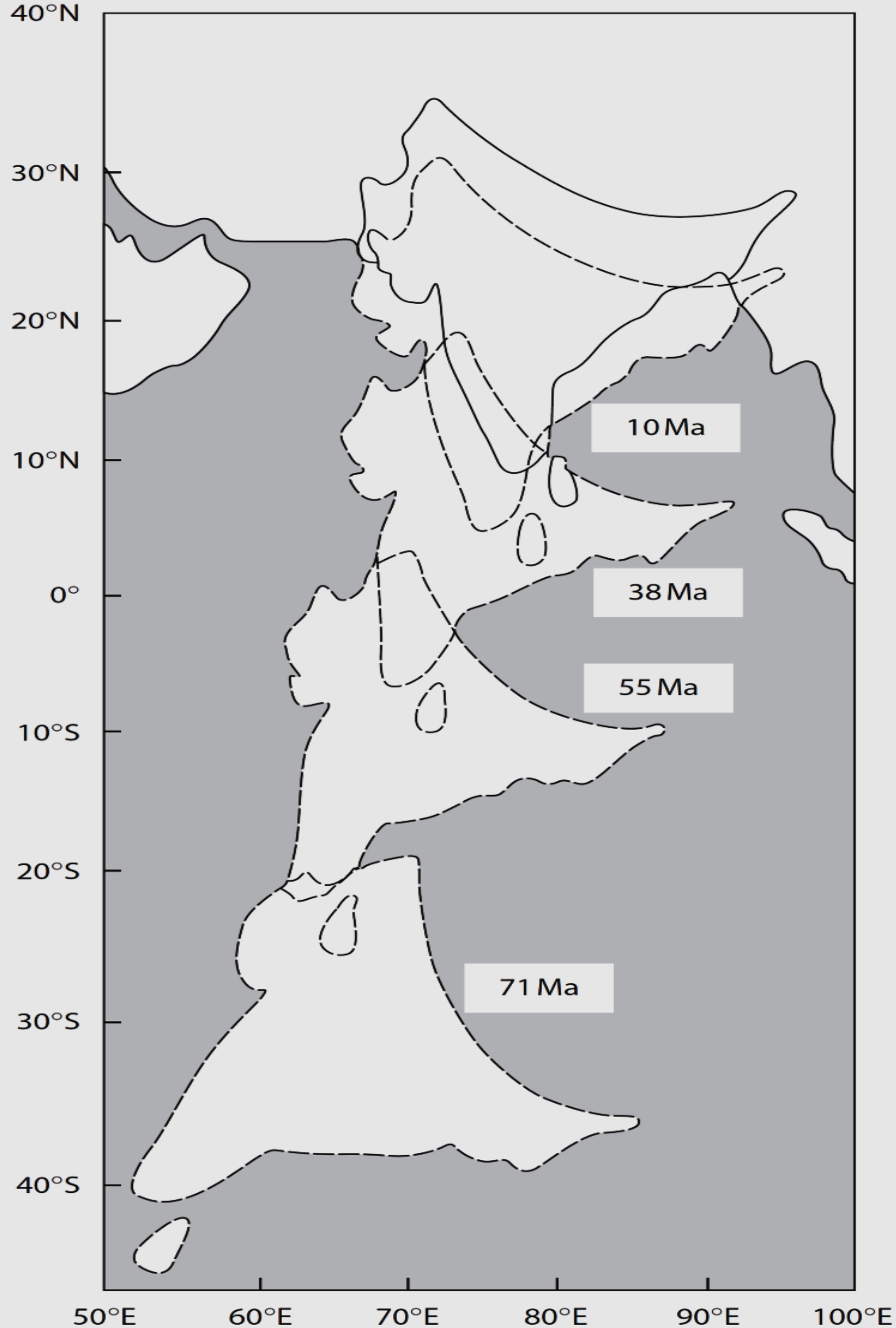
Phenomena of interest have features contingent upon their histories. Category boundaries are “necessarily ambiguous.”



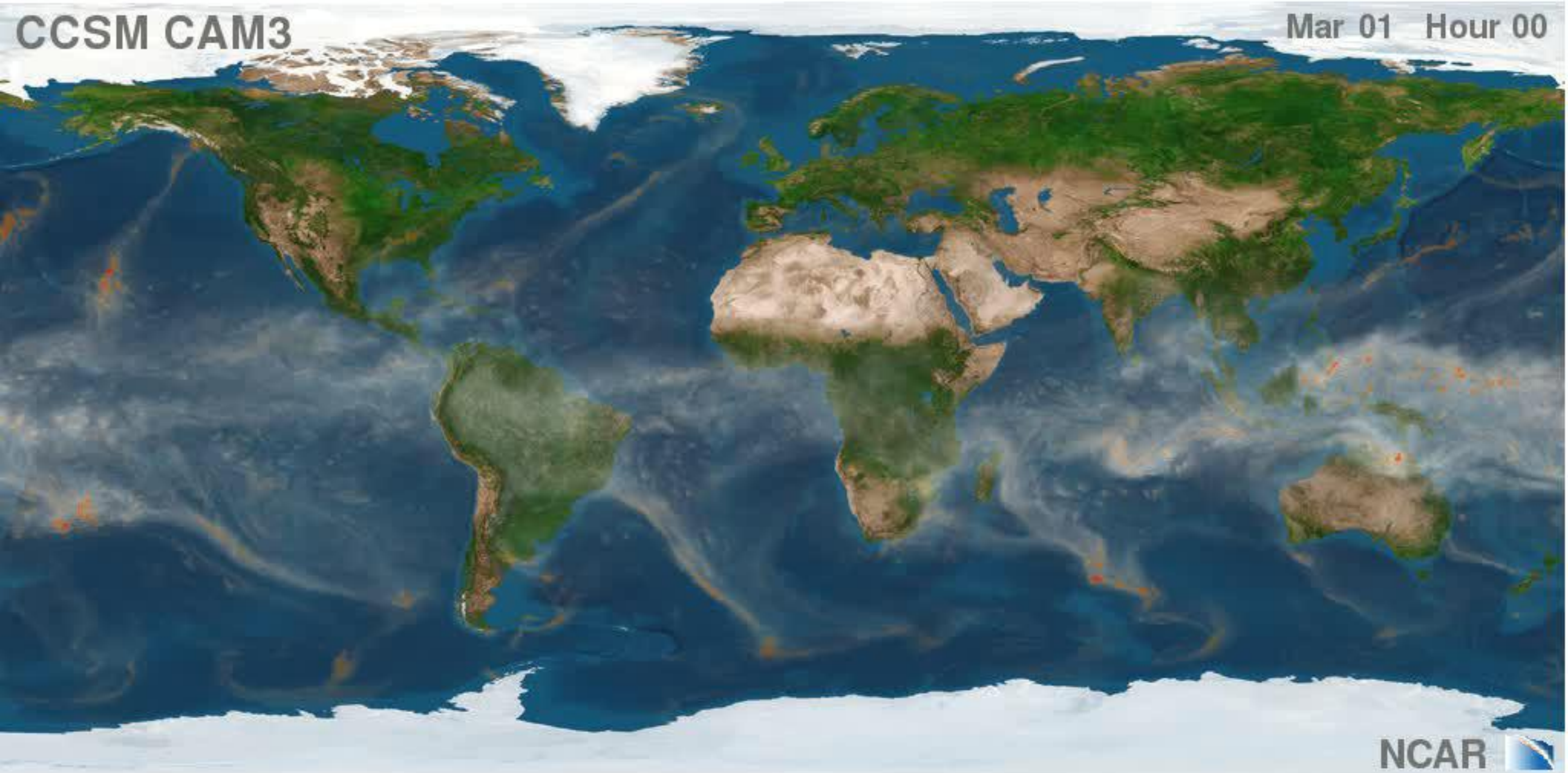

Chesapeake Bay
50 km
N

Determining order and synchrony in time is essential to geologic reasoning. Time is the “referee.”

Consider the timing of the Tibetan Plateau uplift. Did raising the plateau cool the earth? Are climate changes synchronized to plateau uplift?



40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°E
60°E
70°E
80°E
90°E
100°E
10 Ma
38 Ma
55 Ma
71 Ma


CCSM CAM3
Mar 01 Hour 00
NCAR

A common cause that resolves puzzling associations among traces of the past often indicates a causal relationship—and changes the context for interpreting interesting phenomena.

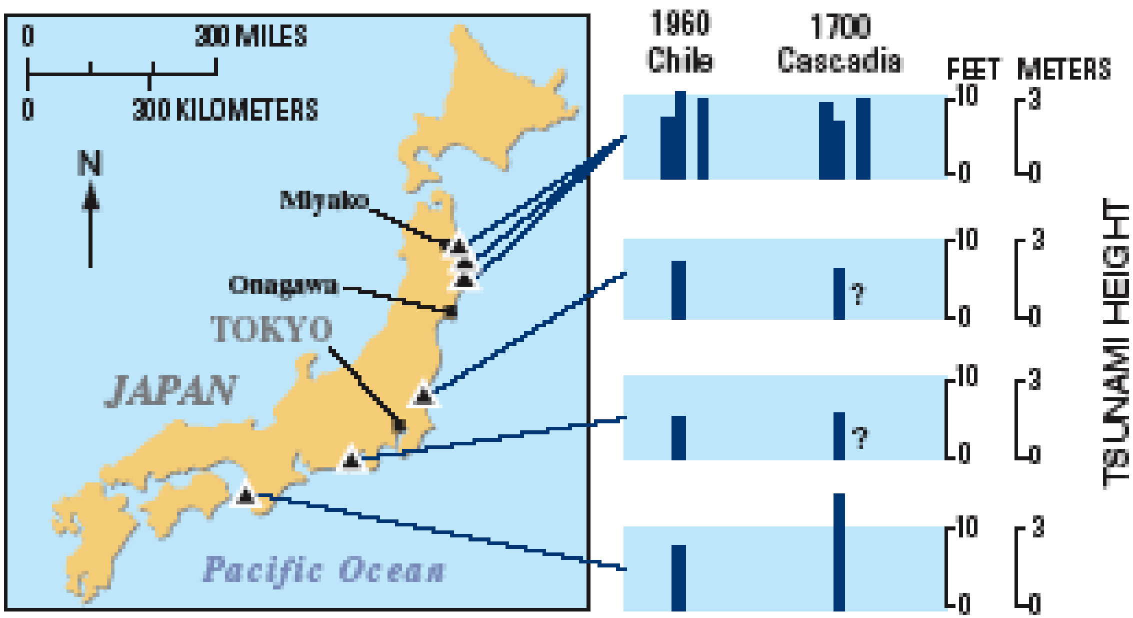
Cretaceous extinction and the iridium anomaly

Naselle River, Willapa Bay

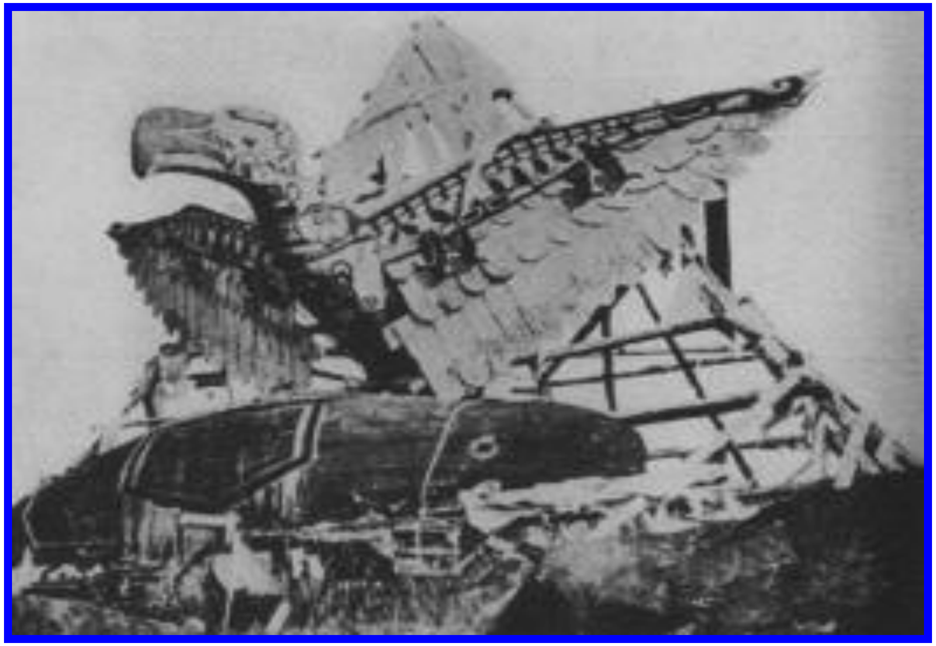
“Ghost Forests” of Coastal Oregon and Washington

Trees in near shore died when the ground dropped and seawater killed the trees. Compare rings from **victim** trees with rings from **witness** trees on higher ground. Result: Trees killed between fall 1699 and spring 1700.

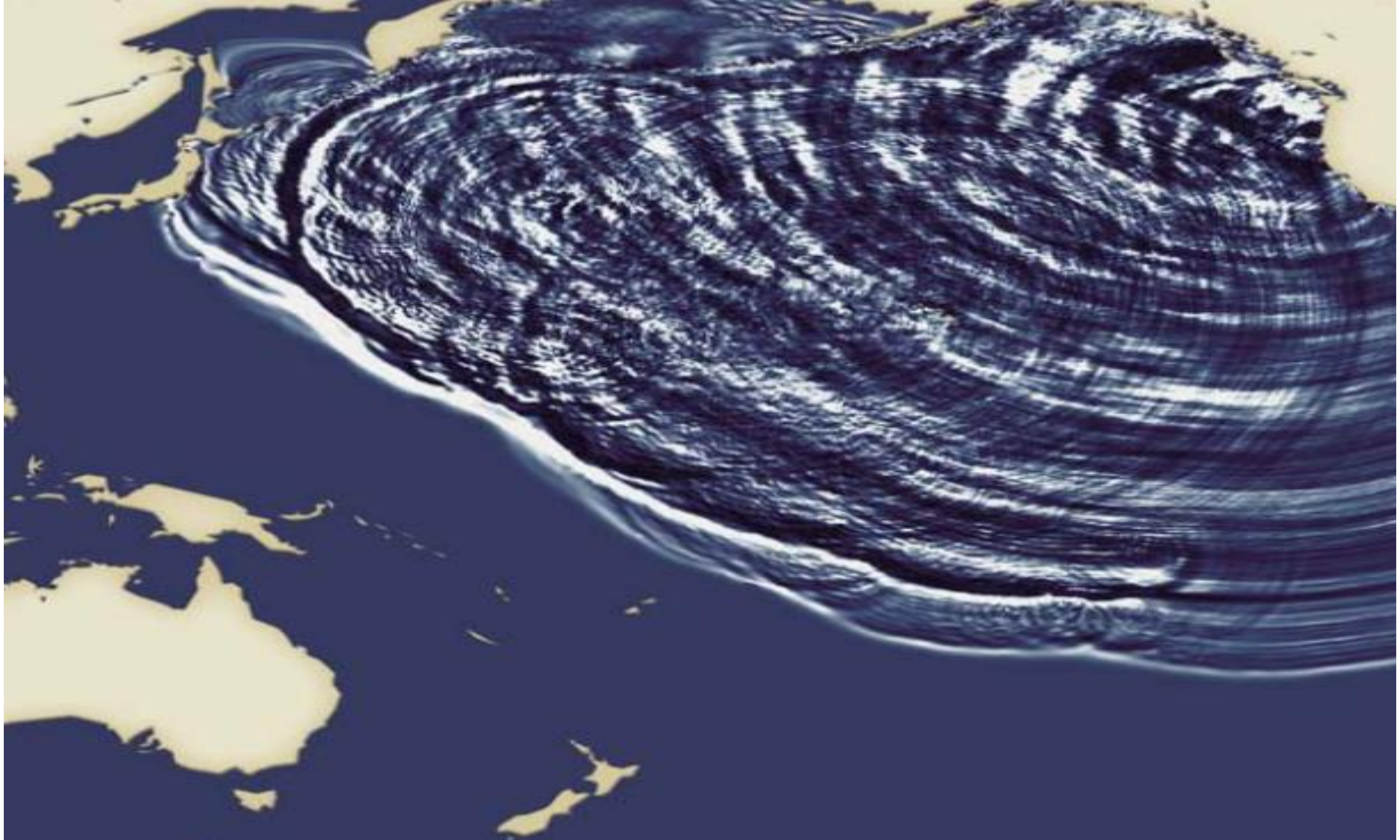
Japanese Tsunami Records



Native American Oral Histories



Oral histories tell of
“a great wave that arrived in the night
and put the canoes in the trees …”



The ORPHAN TSUNAMI of 1700

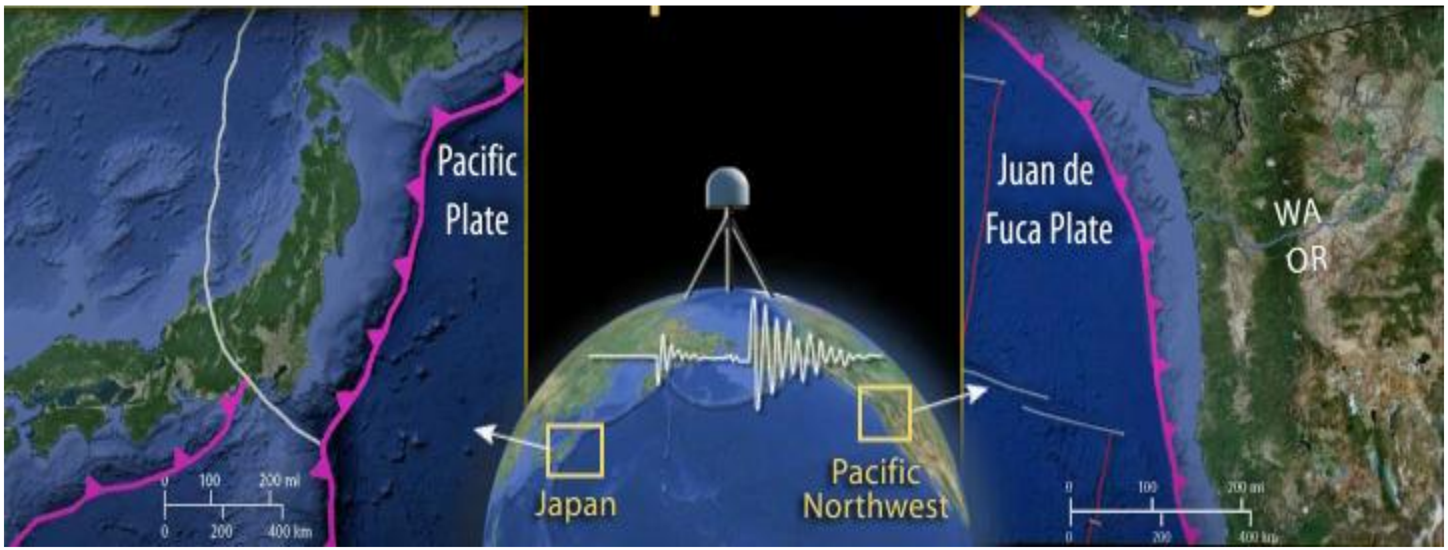
みなしご元禄津波

親地震は北米西海岸にいた

Japanese Clues to a Parent Earthquake in North America

Tōhoku 2011

Cascadia 20??



Interpretation of Ghost Forests and tsunami risk based on thinking thoughts about common cause, time as a referee, and modern analogues.

Earthquake Hazard Inventory & Mitigation Planning Activity

Objectives

In this two-part activity, students/participants first:

- Complete a Hazard Inventory for their city or area of interest in the event of a magnitude 9 Cascadia subduction zone earthquake and tsunami
- Identify what critical structures and infrastructure will be affected

Then:

- Write a summary statement assessing strengths and vulnerabilities of essential services or infrastructure.
- Propose actions for mitigating vulnerabilities.
- Create an Action Plan to address identified needs.

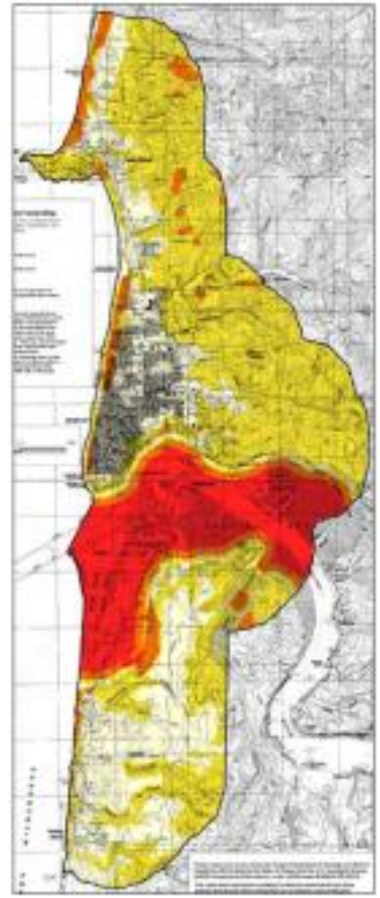
Part 1: Hazard Inventory

Students/Participants investigate the vulnerability of essential public services (police, fire, hospitals, schools, etc.) and essential infrastructure (major roads, bridges, utilities, etc.) from the effects of a great earthquake that can cause liquefaction, ground amplification, and landslides. Tsunami inundation is assessed as well as mobilization of dangerous debris (logs, boats, building materials, etc.). Students/Participants evaluate how the age and construction style of buildings and infrastructure affect their vulnerability. A comprehensive document called Rapid Visual Screening provides additional assessment of critical structures. The investigation also considers access to high ground and to basic survival supplies.

Part 2: increase Community Resilience by Mitigating Hazard Vulnerability

After completing the Hazard Inventory in Part 1, students/participants analyze their findings and consider the implications to their community for selected essential services and infrastructure in the event of a magnitude 9 Cascadia Subduction Zone Earthquake and Tsunami. Students/participants should address both strengths and weaknesses (areas that need improving) to better survive this significant natural disaster in a written summary statement. Students/Participants next determine positive, achievable steps that will mitigate vulnerabilities and improve the resilience of selected essential services and infrastructures such as relocating a school to a safer area, or seismically retrofitting a roadway, bridge, or water reservoir. Finally, an Action Plan is proposed to meet the need for improvements.

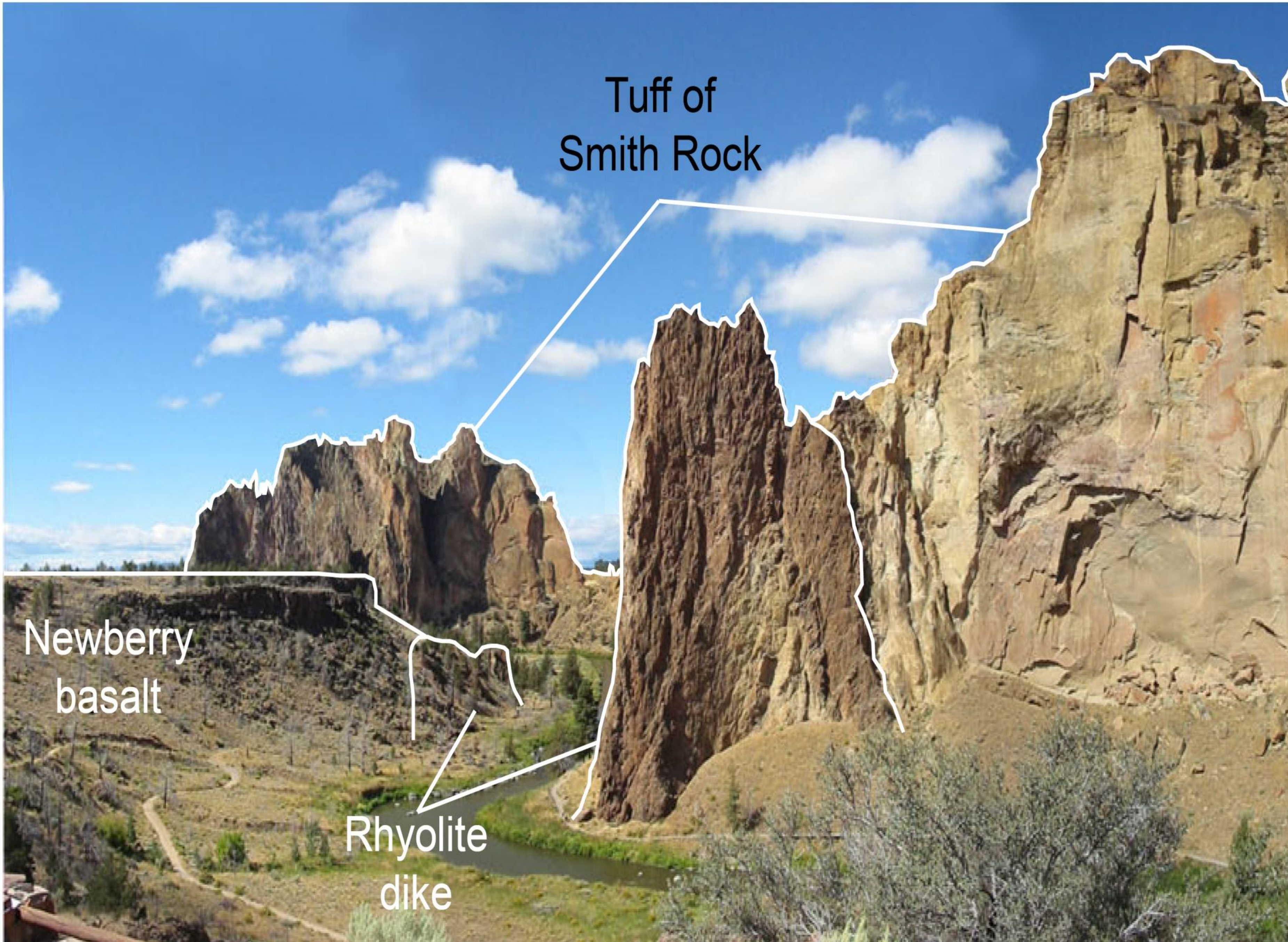
Materials and NGSS Standards on next page

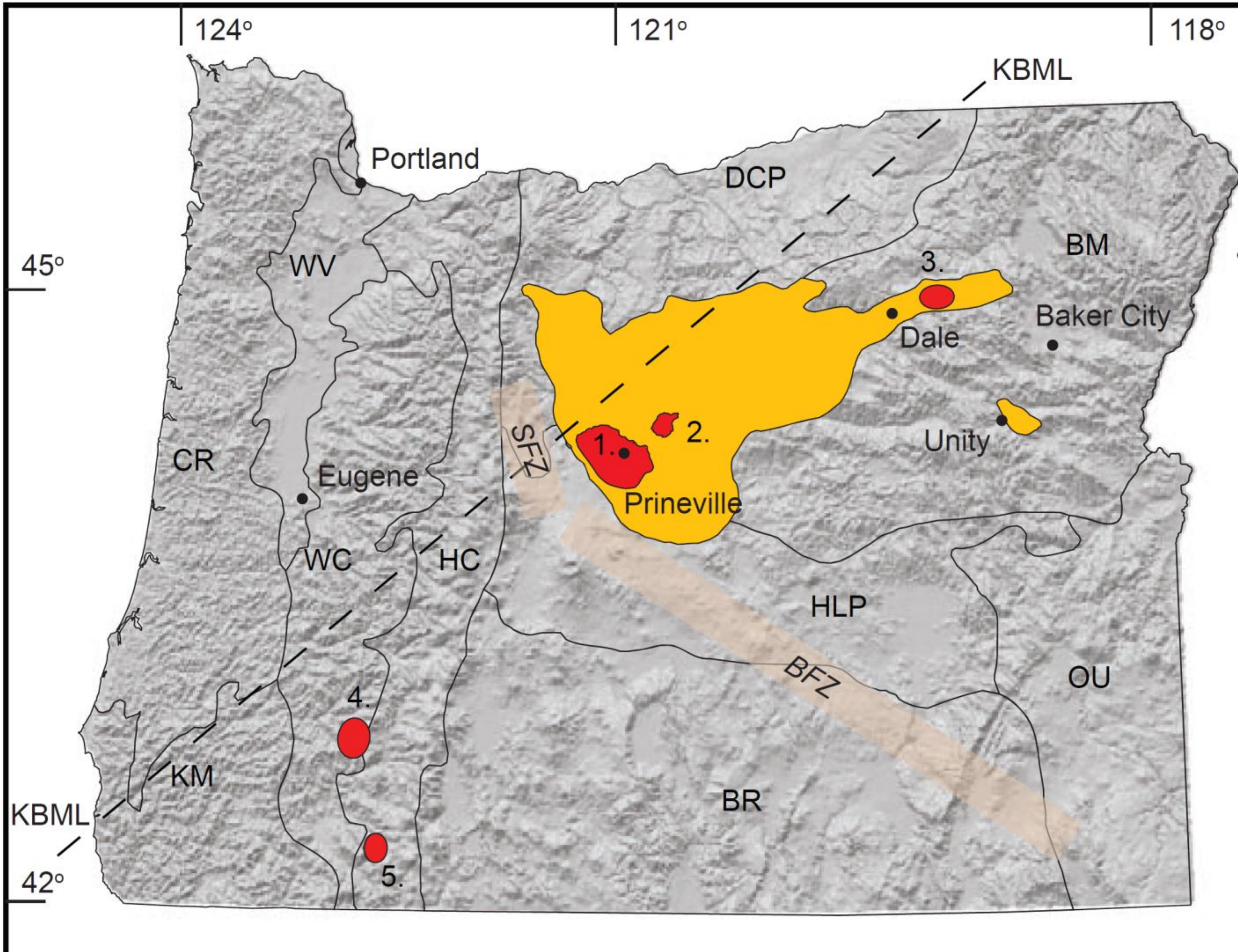


Sample of a DOGAMI Relative Earthquake Hazard map for Newport, Oregon shows the possible occurance of earthquake hazards compiled from amplification-, liquefaction-, and landslide-hazard studiess.

This activity was prepared by Bonnie Magura, retired teacher Portland Public Schools, education consultant.

The earth is a text to interpret in a Hermeneutic fashion: context controls the interpretation of the parts; the parts contribute to the understanding of the whole.


Tuff of
Smith Rock
Newberry
basalt
Rhyolite
dike


124°
121°
118°
KBML
Portland
DCP
BM
45°
WV
3.
Baker City
Dale
SFZ
2.
1.
Unity
CR
Eugene
Prineville
WC
HC
HLP
BFZ
OU
4.
KM
KBML
BR
5.
42°

Thinking geologic thoughts responds to the challenge of scale, the complexity of earth systems, and the historical nature of the phenomena of interest.

The reconstruction of earth history from traces of past events utilizes modern analogues, resolves puzzling associations, and depends on temporal logic to adjudicate among competing claims.

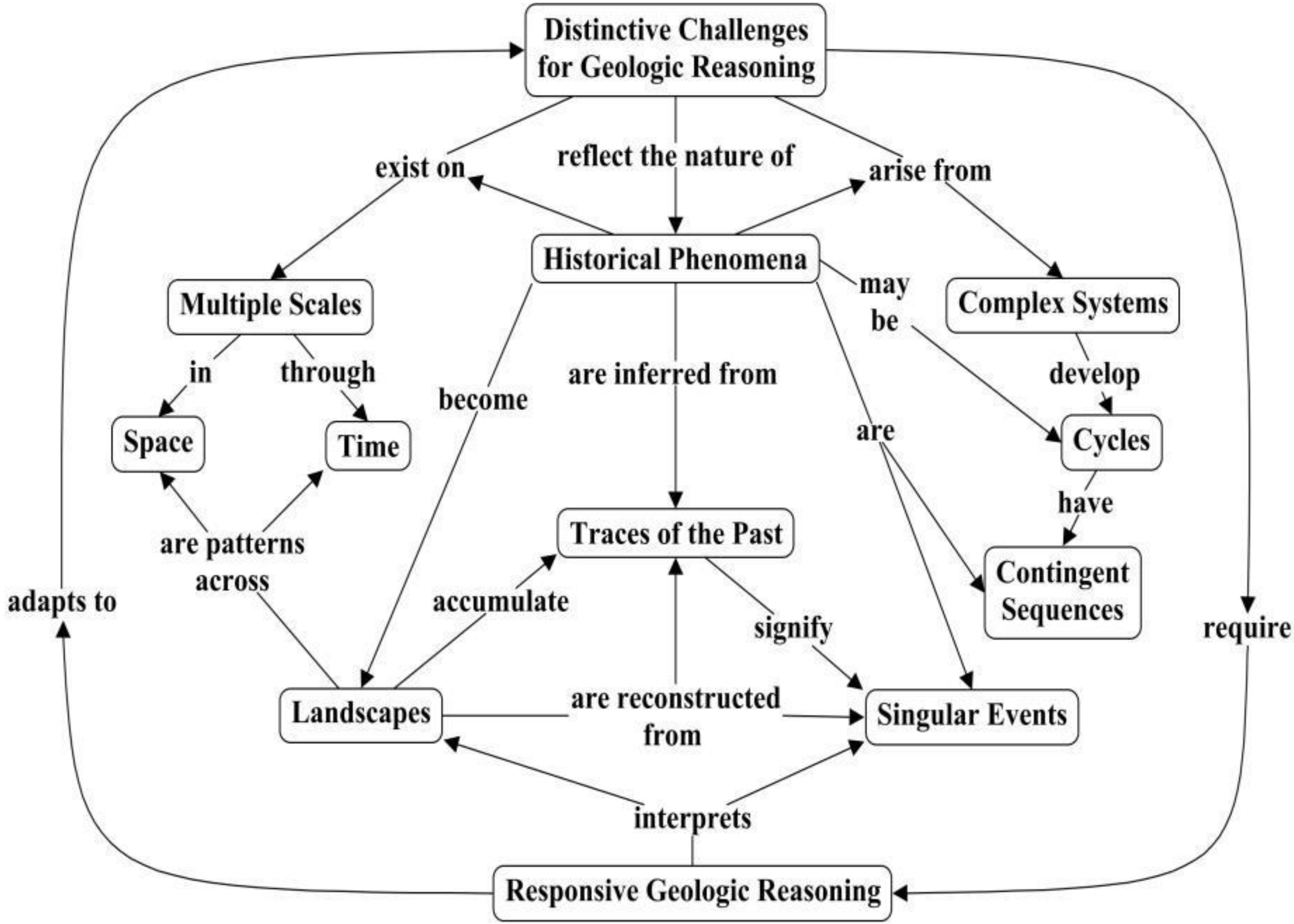
Conclusion

Thinking geologic thoughts stands as an example of what the quest for unity among the sciences obscures:

Thinking geologic thoughts stands as an example of what the quest for unity among the sciences obscures:

the dependence of inquiry upon conceptualization serving an explicit purpose within a valued context.

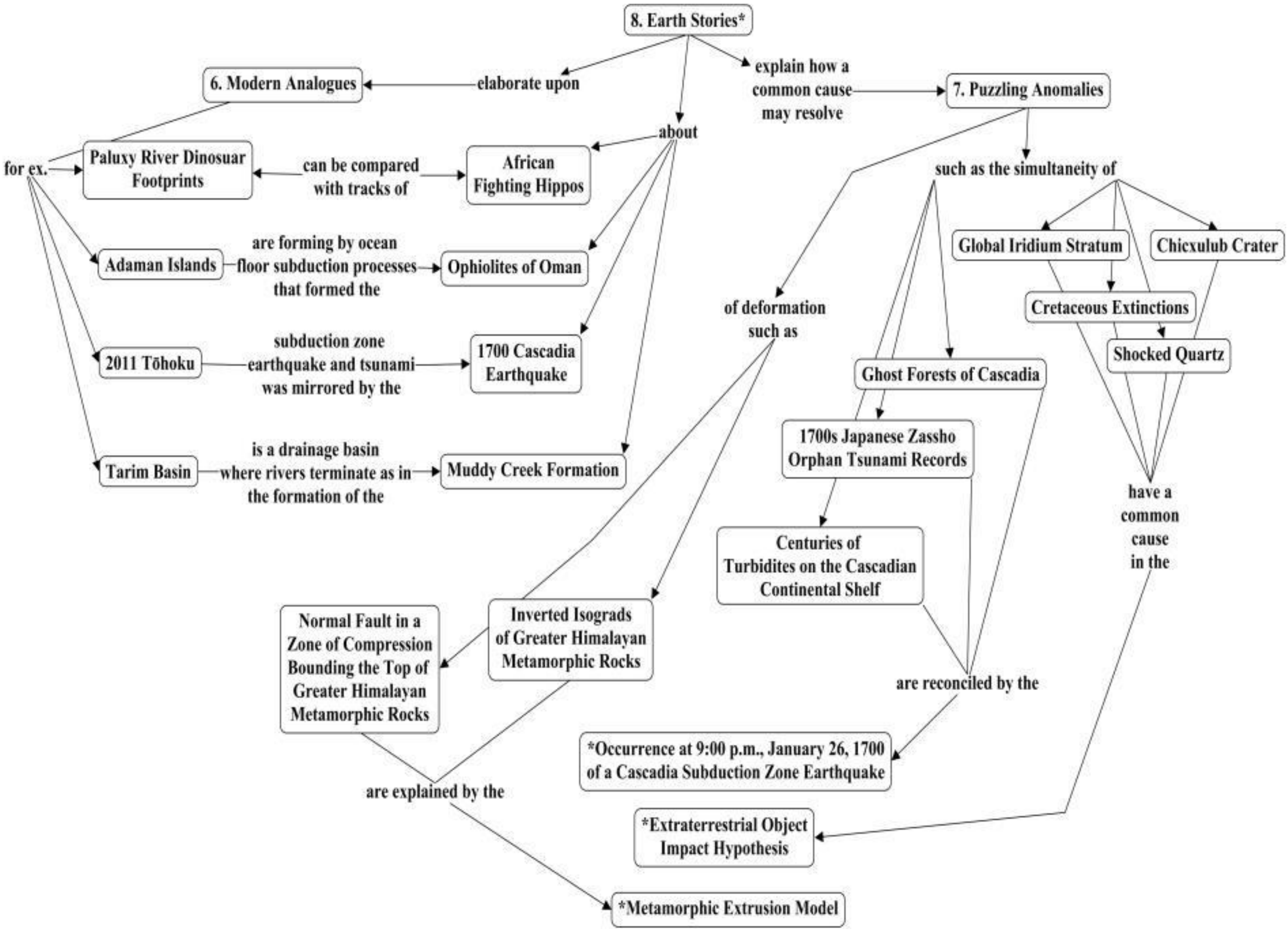
. . . as demonstrated by concept mapping several principles for thinking geologic thoughts


Distinctive Challenges for Geologic Reasoning
exist on
reflect the nature of
arise from
Historical Phenomena
Multiple Scales
Complex Systems
may be
in
through
develop
become
are inferred from
Space
Time
are
Cycles
have
are patterns across
Traces of the Past
Contingent Sequences
adapts to
accumulate
signify
require
Landscapes
are reconstructed from
Singular Events
interprets
Responsive Geologic Reasoning

In order to reform science education, let a search for contexts of value displace the quest to unify the sciences.

In order to reform science education, let a search for contexts of value displace the quest to unify the sciences.

Teach disciplinary contributions to understanding in contexts of value.


8. Earth Stories*
elaborate upon
6. Modern Analogues
explain how a common cause may resolve
7. Puzzling Anomalies
about
for ex.
Paluxy River Dinosuar Footprints
can be compared with tracks of
African Fighting Hippos
Adaman Islands
are forming by ocean floor subduction processes that formed the
Ophiolites of Oman
2011 Tōhoku
subduction zone earthquake and tsunami was mirrored by the
1700 Cascadia Earthquake
Tarim Basin
is a drainage basin where rivers terminate as in the formation of the
Muddy Creek Formation
such as the simultaneity of
Global Iridium Stratum
Chicxulub Crater
Cretaceous Extinctions
Shocked Quartz
of deformation such as
Ghost Forests of Cascadia
1700s Japanese Zassho Orphan Tsunami Records
Centuries of Turbidites on the Cascadian Continental Shelf
have a common cause in the
Normal Fault in a Zone of Compression Bounding the Top of Greater Himalayan Metamorphic Rocks
Inverted Isograds of Greater Himalayan Metamorphic Rocks
are reconciled by the
*Occurrence at 9:00 p.m., January 26, 1700 of a Cascadia Subduction Zone Earthquake
are explained by the
*Extraterrestrial Object Impact Hypothesis
*Metamorphic Extrusion Model

Thinking geologic thoughts results in deep respect for the present moment . . .

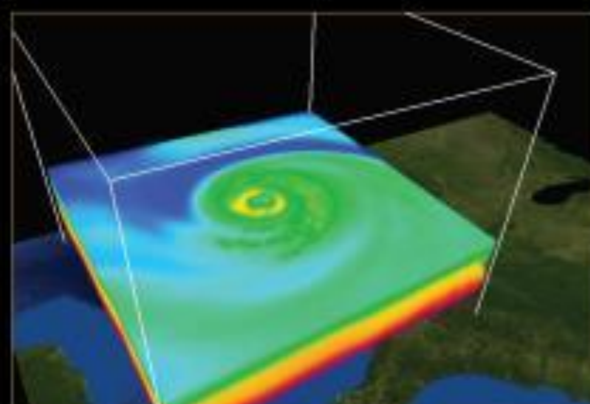
and informs the exercise of responsibility for the future of the Earth.


Thank you!


Thank you!
Questions?

CHARLES R. AULT, JR.

CHALLENGING SCIENCE STANDARDS



A SKEPTICAL CRITIQUE OF THE QUEST FOR UNITY

The 8 practices of science and engineering in the NGSS essential for all students to learn are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

3D

The 13 Core Ideas in 4 Disciplinary Areas

Physical Sciences

1: Matter and its interactions

2: Motion and stability: Forces and interactions

3: Energy

4: Waves and their applications for information transfer

Life Sciences

LS 1: From molecules to organisms: Structures and processes

LS 2: Ecosystems: Interactions, energy, and dynamics

LS 3: Heredity: Inheritance and variation of traits

LS 4: Biological Evolution: Unity and diversity

Earth and Space Sciences

ESS 1: Earth's place in the universe

ESS 2: Earth's systems

ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science

ETS 1: Engineering design

ETS 2: Links among engineering, technology, science, and society

3D

The 7 NGSS crosscutting concepts bridge disciplinary boundaries, uniting the fields of science and engineering. They help students deepen their understanding of the disciplinary core ideas and develop a coherent and scientifically based view of the world.

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

3D

The 8 basic understandings of the Nature of Science in the NGSS

1. Scientific Investigations Use a Variety of Methods
2. Scientific Knowledge is Based on Empirical Evidence
3. Scientific Knowledge is Open to Revision in Light of New Evidence
4. Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
5. Science is a Way of Knowing
6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems
7. Science is a Human Endeavor
8. Science Addresses Questions About the Natural and Material World

3D