EXPLORING PLATE TECTONICS WITH MODELS AND AN ONLINE CURRICULUM

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GEODE

Time to Explore: Actively Engaging with Rigorous Three-Dimensional Learning Materials

EXPLORING PLATE TECTONICS WITH MODELS AND AN ONLINE CURRICULUM

In this presentation, the following questions will be addressed:

1. Why create online curriculum materials and models for students?
2. What supports are in place for online curriculum to support student learning of science?
3. What supports are in place to aide teachers in use of the online curriculum?

Plate tectonics demands an understanding of complex, invisible, dynamic processes.

Experiments, as traditionally perceived of in K-12 classrooms, are impossible.

The processes that shape the Earth take place out of sight, over unimaginably long times. This temporal scale challenges K-12 students understanding of the processes.

The processes of plate tectonics take places a part of an integral system, which challenges the spatial skills of students.

To truly understand plate tectonics, you need to consider system level processes occurring over a vast spatial scale and extensive periods of time.

(Resnick, Atit, & Shipley, 2012)

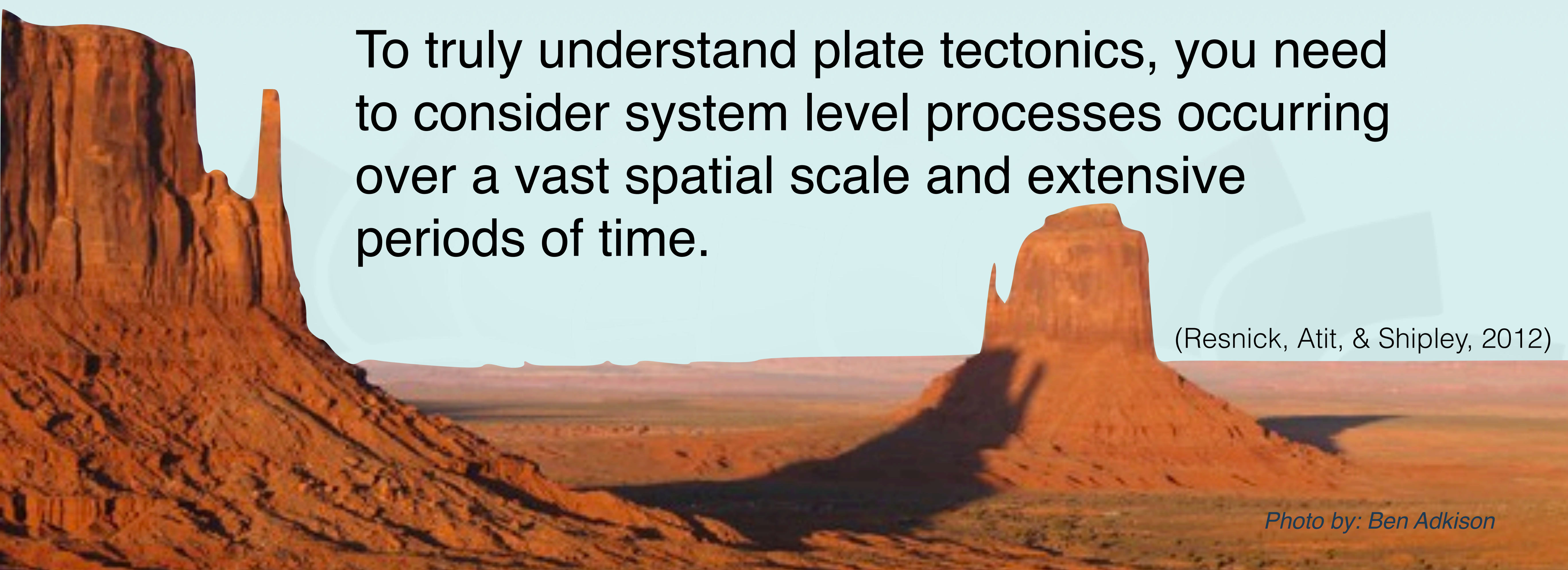

Photo by: Ben Adkison


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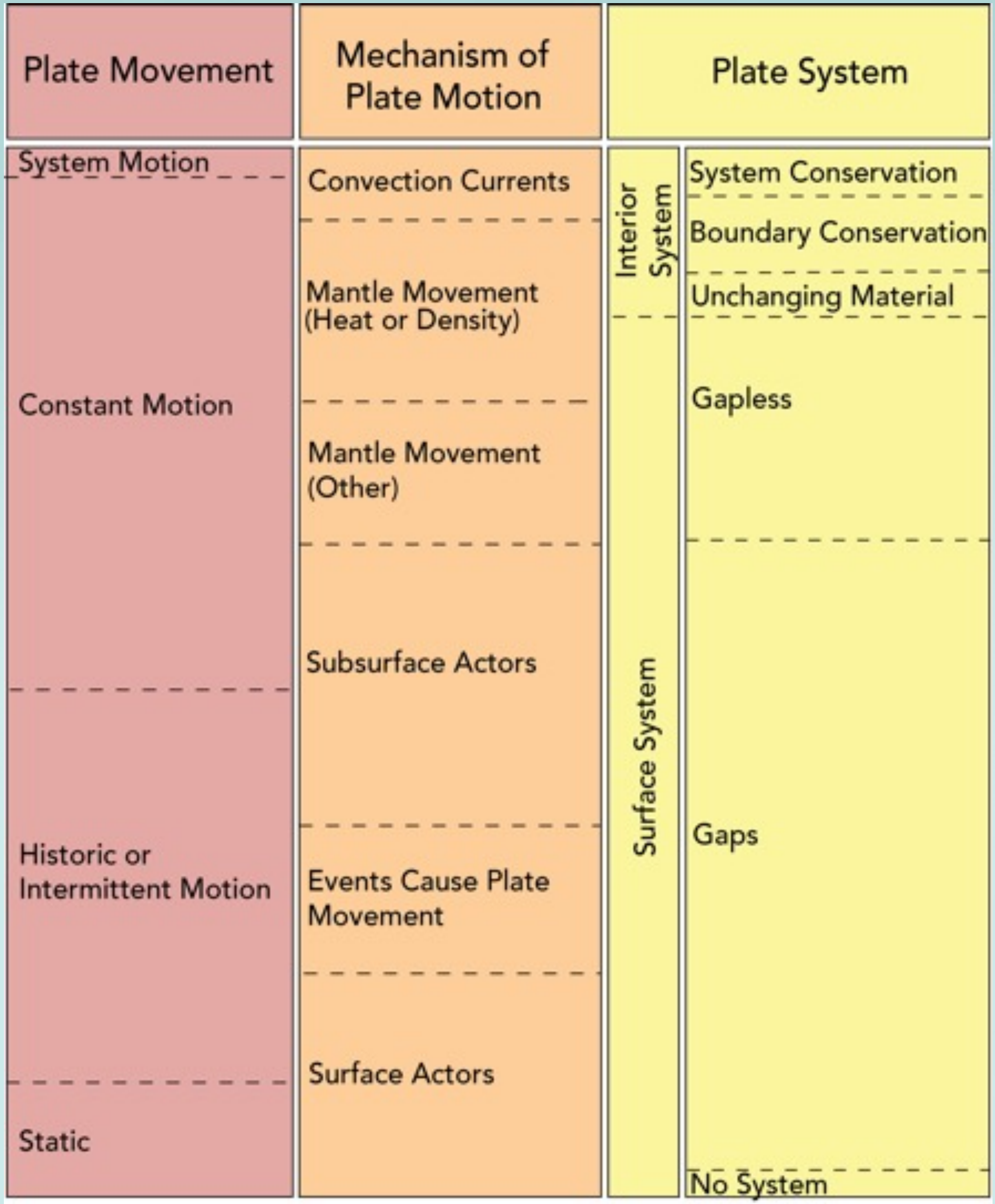


Learning Progressions around the big idea of Plate Tectonics show what ideas K-12 students express, at varying levels of normative explanations.

The ideas expressed in this diagram at the left showcase three progress variables (Plate Motion, Mechanism of Plate Motion, and Plate System) and the empirically generated and tested levels at which students explanations may be expressed.

This learning progression served as a jumping off point for the GEODE curriculum and its focus on system understanding.The way plate tectonics is currently taught in secondary schools, students don’t develop a system-level understanding.

Students need to understand plate tectonics as a dynamic system process of mantle convection causing plate to move with respect to each other beyond limited boundary-level understandings.

Teaching Plate Tectonics

The way plate tectonics is currently taught in secondary schools, students don't develop a system-level understanding.

Students need to understand plate tectonics as a dynamic system process of mantle convection causing plate to move with respect to each other beyond limited boundary-level understandings.

The Challenges in Geoscience

Geosciences, and plate tectonics in particular, needs to join the other sciences as an investigatory (lab) science—it needs to be about developing an understanding of the world via exploration of data, observations, and models. However, geoscience, because of its temporal and spatial scales, does not explore scientific questions in the same way as more traditional classroom sciences.

The Next Generation Science Standards (NGSS)

The NGSS provide states, districts, schools, and teachers with a framework for teaching science. At the Middle School level, students are expected to use historical data to explain plate motion. However, what this data looks like and the sources from which it comes are undefined.

Students who demonstrate understanding can:

MS-ESS2-3. **Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.** [Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [*Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence.	**ESS1.C: The History of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(HS.ESS1.C GBE),(secondary)* **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems.

Connections to other DCIs in this grade band:
MS.LS4.B

Articulation of DCIs across grade-bands:
3.LS4.A ; 3.ESS3.B ; 4.ESS1.C ; 4.ESS2.B ; 4.ESS3.B ; HS.LS4.A ; HS.LS4.C ; HS.ESS1.C ; HS.ESS2.A ; HS.ESS2.B

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ESS2-3)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3)

Mathematics -

MP.2 Reason abstractly and quantitatively. (MS-ESS2-3)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS2-3)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS2-3)*

The GEODE Model

The GEODE curriculum is grounded in not only the NGSS but also in Ambitious Science Teaching (Windschitl, Thompson, & Braaten, 2018) where a unit of investigation is driven by a phenomenon and students collect evidence to support an explanation of the phenomenon. Student talk, not often a part of online curricula is high encouraged in the model, and supported with tips in the teacher edition.

The GEODE driving phenomenon: What will Earth look like in 500 million years?

GEODE

What will Earth look like in 500 million years?

The Concord Consortium
CELEBRATING 25 YEARS

Hi, apallant

In this module, you will consider the question: what will Earth look like in 500 million years? You will use data from Earth and models of a fictional planet to explore plate tectonics.

Estimated Time to Complete This Module: 345 minutes

1 Earth's moving surface

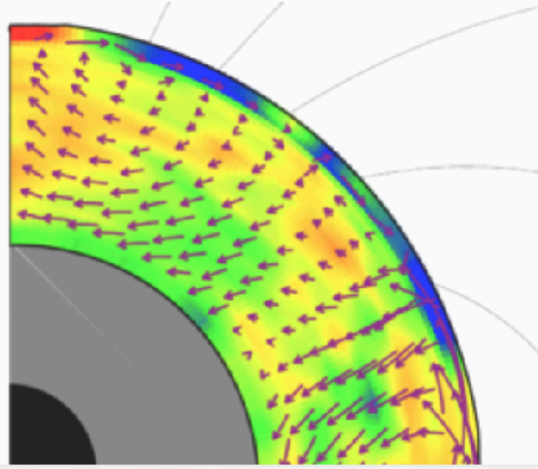
2 Interpreting Earth's clues

3 What happens with a lot of moving plates?

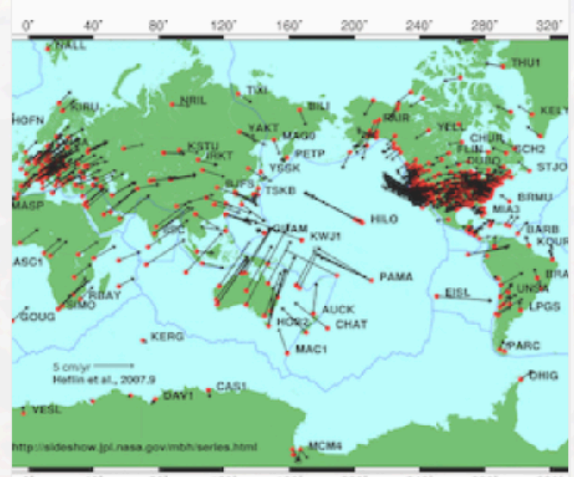
USGS Open-File Report 2010-1333 and CGS Special Report 221, Fig. 5D

Edit

4 What drives plate motion?

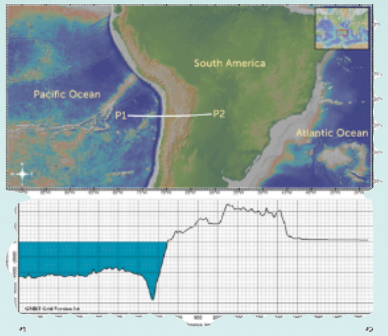


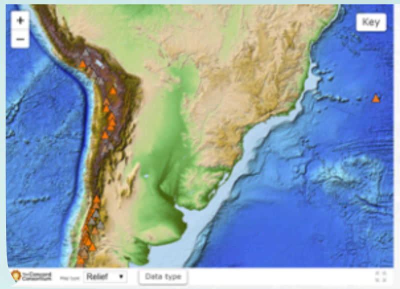
5 What will Earth look like in the future?

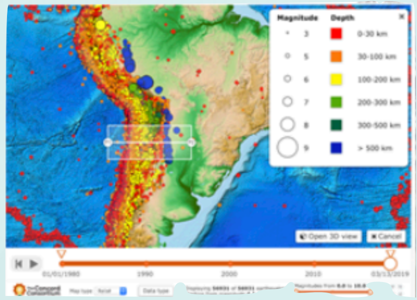


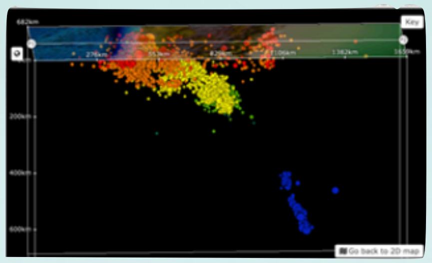
Recipe for a GEODE case study

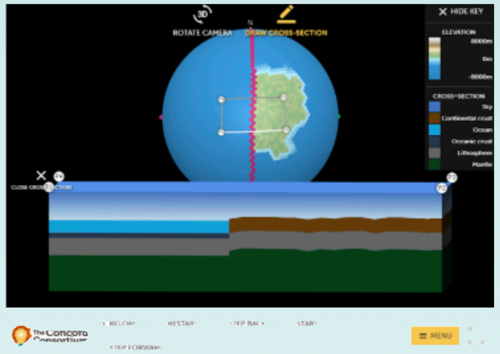
Analyze Topography → Identify data patterns → Hypothesize from data → Model tectonic plate motion → Explain mechanisms involved in real-world data and landforms

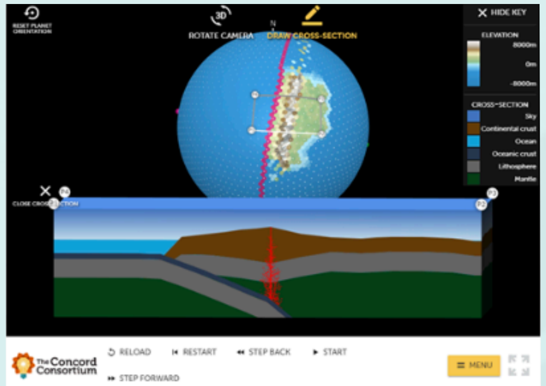








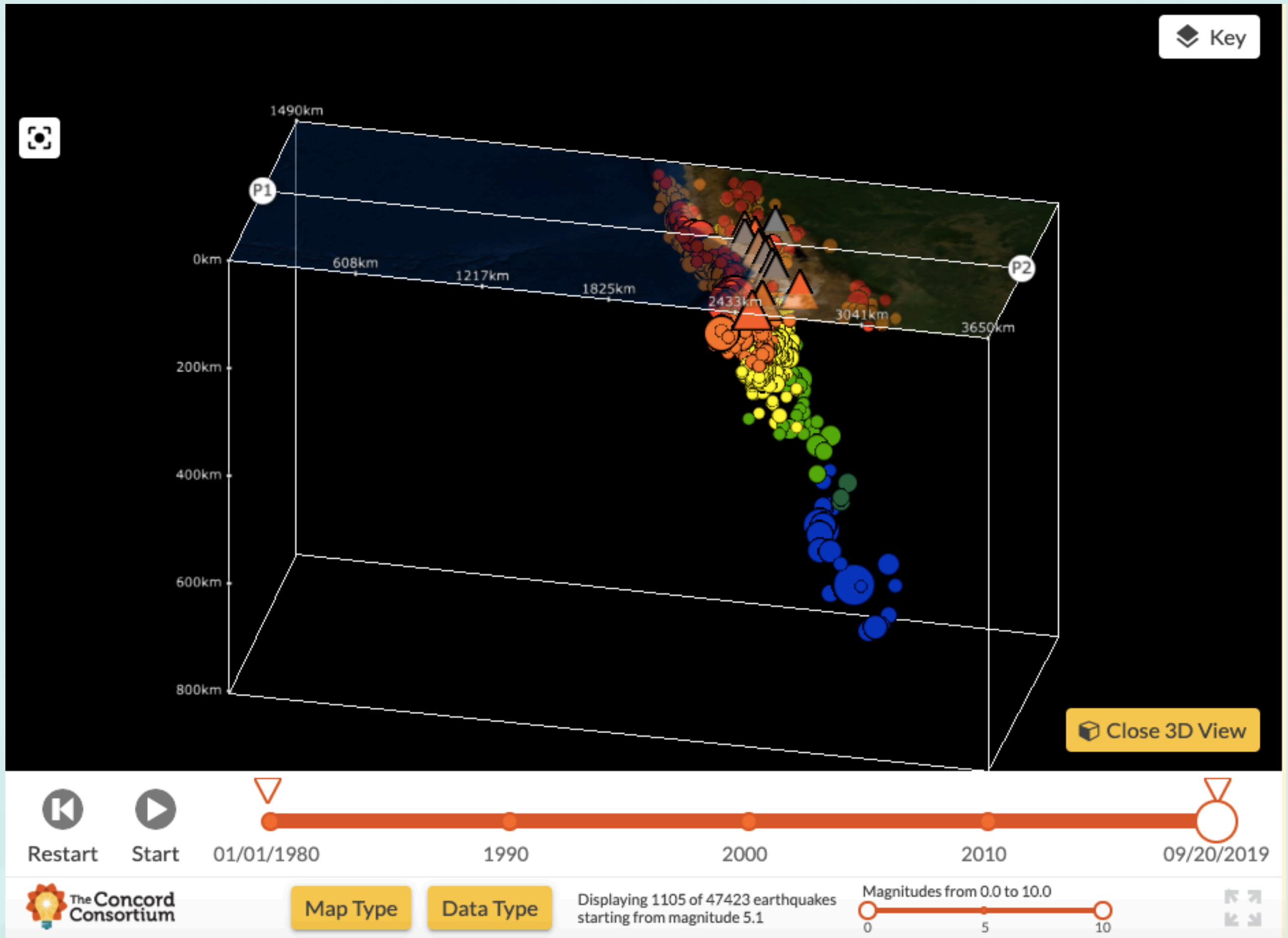




The GEODE Tools

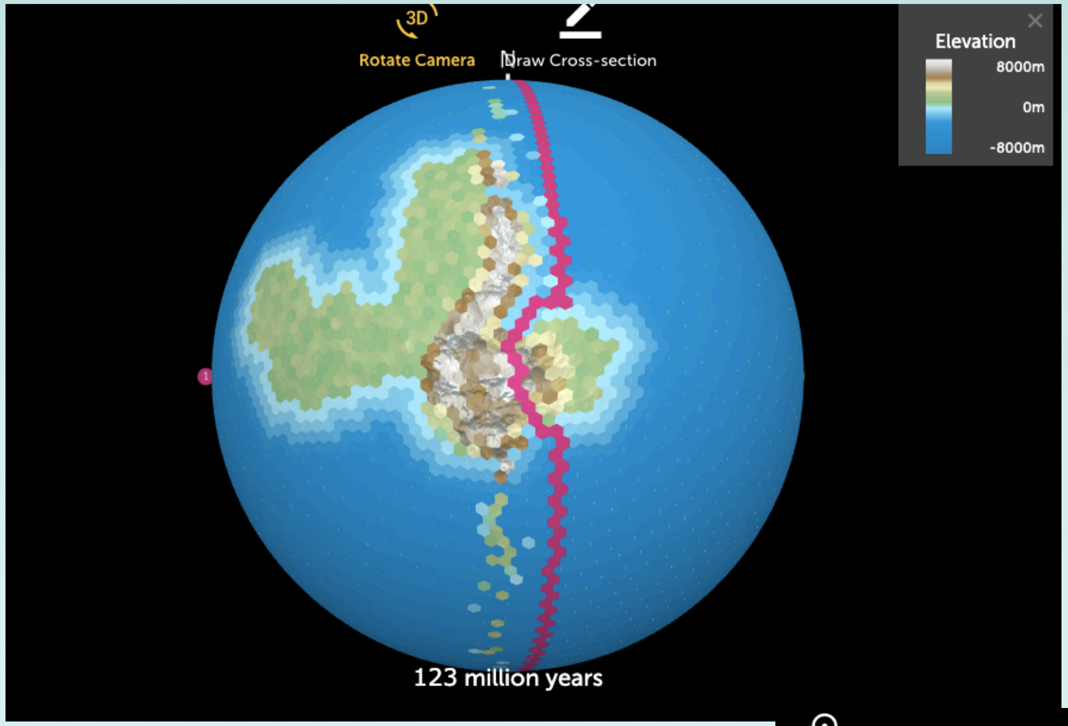
Seismic Explorer uses publicly available data from the USGS in an online data visualization tool which integrates earthquake, volcano and plate motion data sets. Students can select which data to view, and look for patterns in the data.

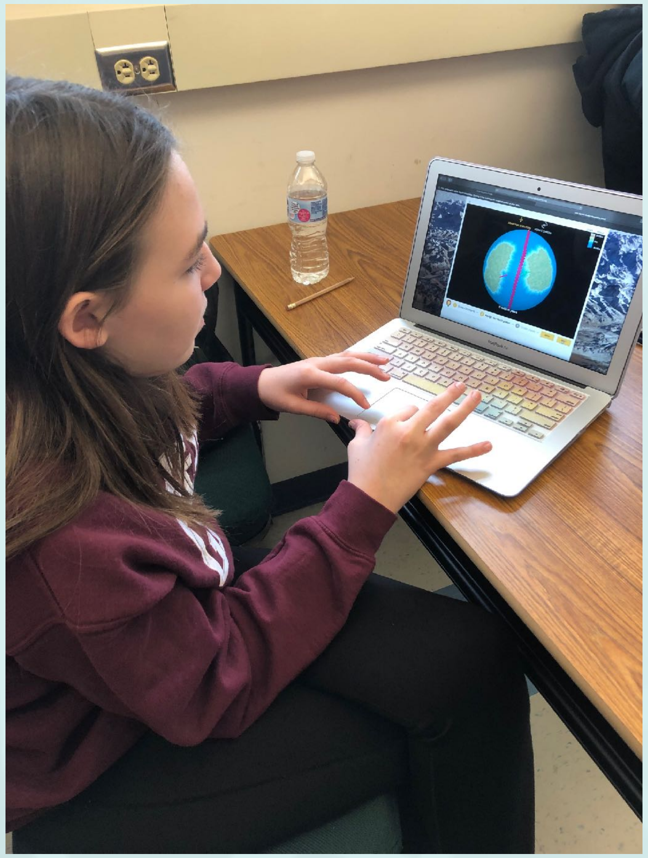
Seismic Explorer can also help students visualize data representing underneath the Earth's surface through cross sections like the one at the right which focuses a section of the Andes Mountains. Students can see that there are increasingly deeper earthquakes moving east, and that volcanoes are above earthquakes at specific depths.

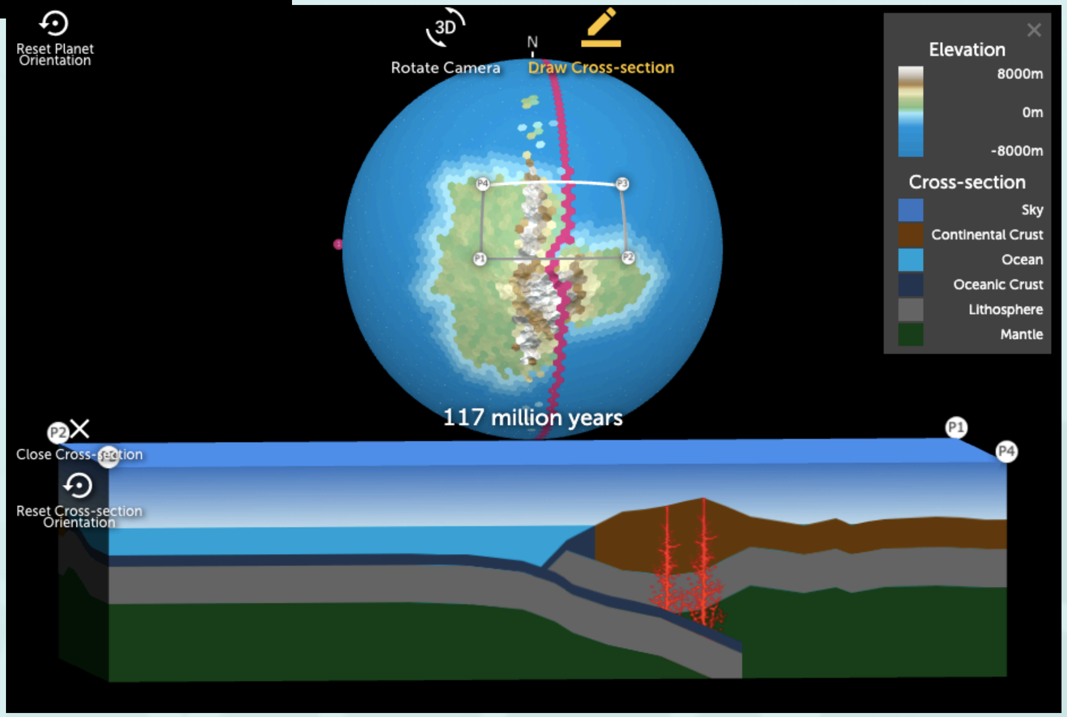


The GEODE Tools

Tectonic Explorer is an interactive dynamic plate tectonic model of an Earth-like planet which allows students to manipulate the density of plates, number of plates, and direction of forces. Students can also create cross sections to see not only the surface level changes as the plates interact but also the subsurface changes, such as rifts and subduction.







By Elemaki - Own work, CC BY 3.0, Link

Theory & Background

This activity is designed around real-world case studies of convergent boundaries. The case studies exploring the formation of the Andes Mountains and the Aleutian Islands follow similar patterns.

First, students look at the distinctive landforms by analyzing geographic profiles. Students then look at earthquake and volcano data associated with these landforms.

After exploring the Andes and Aleutians, students hypothesize about how plate interactions can form areas like the Andes Mountains and the Aleutian Islands. Students then use Tectonic Explorer to test their hypotheses.

The case study later in the activity, exploring the formation of the Himalayan Mountains, requires students transfer what they have learned in the first two case studies to puzzle through a slightly more complex modeling of what occured in that location. (See the Theory and Background tip on page 5 of this activity.)

It is important to help students discover the connections between the real-world data and the motion of plates as they use the tools provided in the activity.

Correct | Distractors

Question #1

At what point on the geographic profile does the land elevation rise above sea level?

- ✖ 670 km
- 740 km
- ✖ 1040 km

Check answer

Students may see an increase from the low point as being above sea level (670 km) or the highest point as the point at which sea level is breached (1040 km).

In each case, direct their attention to the y-axis. Ask: What elevation represents sea level? Encourage them to re-read the introduction before the profile map.

Correct | Teacher Tip

Question #2

How far from Point P1 is the lowest point on the geographic profile of the Andes?

- 0 km
- 670 km
- 1040 km

Check answer

Draw students' attention to the y-axis scale. What do negative numbers mean? What do positive numbers mean? How could you find the lowest point?

Teacher support material

Alongside the student version of the curriculum, teachers have access to their own specialized version of the curriculum where they can get theory and background about the curriculum, pedagogical supports, exemplar answers and reasoning for acceptable answers in multiple choice questions.

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Questions?

https://learn.concord.org/geo-platetectonics

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Explore our free STEM learning resources ↗

GEODE

Transforming geoscience education with interactive models for exploring plate tectonics.

FOCUS AREA
STEM Models & Simulations

SUBJECT
Earth & Space Science

GRADE
Middle School