# DISCOVER PLATE TECTONICS

Guided Inquiry · Synchronous · Online (may be easily modified to face-to-face instruction)

*This lab is meant to be delivered at the beginning of an Introductory Geology course. We assume little or no prior knowledge about plate tectonics. This lesson will carry foundational knowledge and skill building that will be returned to and built upon throughout the course.*

## Audience:

- High School/College Level Introductory Geoscience Students

## Learning Objectives:

- LO1: Summarize the theory of plate tectonics and use vector data to identify direction and rate of plate motions.
- LO2: Describe the features and processes found at different plate boundaries and explain why features are found in certain locations.
- LO3: Develop geoscientific skills: analyzing/interpreting data; reading maps; practicing quantitative skills; thinking in 3D.
- LO4: Develop professional skills: collaboration/teamwork; communication; peer review; create community.

## Intended levels of Inquiry included (per Buck et al., 2008):

- Break Out Room #1: open inquiry
- Break Out Room #2-4: guided inquiry
- Break Out Room #5: structured inquiry
- Supplemental Activities: Variable based on activity

## Expected Prior Knowledge:

- This is meant to be an introduction to plate tectonics and does not presume any prior knowledge about plate tectonics. Students will be working with maps, data, and google slides during these activities. Students should have an openness to scientific inquiry; basic observational and map reading skills; basic algebra skills.

## Expected Time for Lab:

- Approximately 3 hours - some activities could be split out to adjust time accordingly

## Materials Required:

- Internet access
- Computer with Zoom and ability for all to share screens
- Access to the LMS or other shared workspace
- Google Drive Access
- Google Earth for desktop (if planning on using GEODE activity)

## Accessibility Note:

- Some activities may not be a good fit for a class that includes vision-impaired students. The USGS may be able to provide alternate formats upon request.
- USGS Accessibility Statement
- Accessibility in Google Earth

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***Collaborative Google Slides:***

- *Before class, instructors will set up 2 Google Drive folders for their students to access and create a new Google slides file for each break out room group.*
- *Folder #1- Copy/Paste slide #2 from TTE Master Group Worksheet Plate Tectonics into each group's google slide set.*
- *Folder #2- Copy/Paste one slide (#9-20 a different slide for each group) from TTE Master Group Worksheet Plate Tectonics into each group's google slide set.*
- *Before the lab begins, make sure all the materials are uploaded into the shared workspace and that students have access to shared google slides for their groups.*
- *As the lab continues, the instructor will need to copy/paste new slides as needed into the existing slides created. See Instructor Slide Guides on the TTE Master Group Worksheet Plate Tectonics slide deck.*

***Break Out Rooms:***

*During class, instructors will need to create break out rooms into ~ 4 groups of 4 students each.*

- *In a class of 30: 8 groups of 4-5 students*
- *In a class of 50: 12 groups of 4-5 students*
- *In a class of 100: 24 groups of 4-5 students*

*It is recommended that the instructor always shares their screen and explains exactly what the students are to be doing in each break out room session before sending students into breakout rooms.*

***Opening** – Instructor: "The ring of fire has been the highlight in many songs, stories, and conversations but to geologists the ring of fire highlights a deep insight into how the world around us works. Have you ever wondered why we have so many earthquakes in California or why there are volcanoes surrounding most of the Pacific Ocean? Today we are going to discover what processes drive the surrounding landscapes that we have grown to know and love."*

## Break Out #1: Introductory Activity

30 minutes · Small group – full group · Level 2 open inquiry

- Instructor Share Screen:
  - Break Out #1 Google slide- ensure all students have access and point out basic functions.
  - Dynamic Planet map- how to read and make map observations (Legend, North arrow, scale, etc.).
- Map (15 minutes, small group)
  - Each group downloads the USGS Dynamic Planet map and answers the guided questions on their group's google slide. Each group will nominate a reporter for the presentation.
- Presentation (15 minutes, full group) (**Assessment**: Group inquiry)
  - A reporter for each small group reports to the whole class with the top 3 observations/questions that came out of their group.

- As groups are sharing their insights from the previous break out room activity, copy/paste a different "expert slide" to each group's slides for break out #2. For larger classes, you will have groups with the same assigned specialty.
  - Ex. For a class of 30 (8 groups): Group 1- slide 4, Group 2- slide 5, Group 3- slide 6, Group 4- slide 7, Group 5- slide 4, Group 6- slide 5, Group 7- slide 6, Group 8- slide 7.

***Transition*** *– Instructor: "In the geosciences, there are many areas of expertise. You will be placed into small expert groups to study different phenomena related to plate tectonics."*

## Break Out #2-4: Discovering Plate Boundaries (Jigsaw Activity)

80 minutes · Small group – full group – small group · Level 1 guided inquiry
(Created by Angela Daneshmand modified from Discovering Plate Boundaries, Rice University)

- Instructor Share Screen:
  - Break Out #2 Google slide- ensure all students have access to folder #1 and point out basic functions.
  - Jules Verne Voyager Junior- how to manipulate features/data/legends shown.
- Break Out #2 Expert groups (25 minutes, small group)
  - Groups will learn and work together to understand their expert roles once they encounter the maps/worksheets in their breakout rooms.
  - Instructor (and TA(s) if available) rotates around the groups or monitors the shared Google slides to facilitate observations/answer questions.
  - Expert groups will each have a google slide with specific instructions for their specialty:
    - Group 1: Seismology
    - Group 2: Volcanology
    - Group 3: Geochronology
    - Group 4: Geography/Topography
  - Each expert group navigates to the Jules Verne Voyager website and manipulates the map to find their specific data sets to make observations and answer the guided questions in the shared google slide.
  - Make sure all members of the group understand how to read their data and can explain it to another student who has never seen the data before.
- Break Out #3 Expertise Sharing Set Up (5 minutes)
  - Establishing the new break out rooms may take some time (especially if in a larger class). When students return from Break Out #2, it is recommended to give them a short 5-minute break or inform them it may take a few minutes to set up the new break out rooms.
  - How to set up the new break out rooms:

- Keep the same groups listed and add additional groups to double the number of groups.
- In a class of 30 people: 8 expertise groups, then add 8 more groups = 16 total groups.
    - Assign each person in the first four groups (Groups 1-4) to groups 9-12.
        - Ex. Group 1 has 4 people: 1 person goes to group 9, 1 person to 10, 1 person to 11, 1 person to 12.
        - Group 2 has 4 people: 1 person goes to group 9, 1 person to 10, 1 person to 11, 1 person to 12, etc.
    - Assign each person in the next four groups (Groups 5-8) to groups 13-16.
        - Ex. Group 5 has 5 people: 1 person goes to group 13, 1 person to 14, 1 person to 15, 2 people to 16.
        - Group 6 has 4 people: 1 person goes to group 13, 1 person to 14, 1 person to 15, 1 person to 16, etc.
- Each group (9-16) should have at least 1 person from each expertise, if done correctly.

- Instructor Share Screen:
    - Break Out #3 google slide- ensure all students have access to folder #2 and their new "mixed group" slides.
- Break Out #3 Expertise Sharing (Jigsaw) (15minutes, new small group)
    - Each group finds their "*All 4 Maps*" in the shared Google slides where each box represents a different data type.
    - Each expert in the group explains the data represented for their particular region and expertise (5 minutes).
    - Groups use their combined expertise to answer the guided questions in the google slides (10 minutes).
- Presentation (10-15 minutes, full group)
  (Structured Learning; Assessment: Group Understanding).
    - As the timer nears its end for breakout #3, copy paste slide 21 from TTE Master Group Worksheet Plate Tectonics into each group's Google slide set. They will be filling this slide out whilst their peers are presenting.
    - Using shared screen, four different groups will present their findings to the class:
        - Divergent Plate Boundary
        - Transform Plate Boundary
        - Convergent Boundary with Subduction
        - Convergent Boundary without Subduction

- ***Structured Learning****: Instructor will further explain the plate boundary and help the students complete the chart. Instructors should also cover active/passive margins and features that are found at each.*
- ***Address Common Misconceptions:*** *Only continents move (both oceans and continents move), continents are "floating" on the mantle, plate boundaries are always at the edges of continents (not always the case).*

- Instructor Share Screen:
  - Break Out #4 Google slide- ensure all students have access to the mystery plate boundary slide in their shared Google slideset.
  - Instructors should explain what a cross section is and show students how to use the "scribble tool" on google slides to create a rough sketch of a cross section.
- Break Out #4 Mystery Plate Boundary Activity (20 minutes, small group)
  (Assessment: Application of knowledge)
  - Each group will be assigned a location map of a mystery plate boundary and answer guided questions on the shared google slideset.
  - Based on the topography each group will:
    - Determine the geographic location and type of plate boundary shown.
    - Discuss features of a cross section perpendicular to the plate boundary and explain how they came to their conclusions.
    - Draw a labeled cross section across the mystery plate boundary they were assigned.

***Transition*** *– Instructor: "You've come up with some fantastic ideas on how to determine just how fast these plates are moving. Let's go back to the Dynamic Planet Map and investigate plate movement using GPS vector data."*

## Break Out #5: GPS Data and Plate Motion

25 minutes · Small group – full group · Level 1 guided inquiry
(Modified by Beth McLarty Halfkenny from EdGEO Bringing the Earth To Life)

- Video: Measuring Plate Tectonics with GPS
- Instructor Share Screen:
  - Break Out #5 google slide and map- ensure all students have access to the GPS data and Dynamic Planet map slides in their shared google slideset.
  - Instructors should re-introduce GPS vectors and demonstrate how to draw them in the google slides before sending students into their breakout rooms.
- Vectors on Maps (15 minutes, original small group)
  - Each group will return to their breakout rooms to work on the Dynamic Planet Map.

    - Build very rough vectors of direction and distance traveled at some of the GPS stations on the chart.
    - Discuss what is happening at various plate boundaries as they see the directional motion.

- Discussion/Presentation (10 minutes, full group)
  (Structured Learning; Assessment: Ability to understand data)
    - Using the shared screen, students from different groups will present/discuss their
    - findings.
    - ***Structured Learning****: Instructor will correct inaccuracies and expand on ideas.*
    - ***Address Common Misconceptions:*** *Motion of the crust is vertical (it is lateral), plate movement is extremely fast (it occurs slowly about the same time it takes for fingernails to grow).*

## Supplemental Activities

30-60 minutes · Small group – full group – individual · Variable levels of inquiry
These optional activities may be used at the end of this lab as time permits. They may also be useful as a way to connect this lesson to the next lab or a way to assess retention of material.

- Grand Tour of the Ocean Basins (Google Earth)
    - Created by Angela Daneshmand to complement Declan G. De Paor's Google Earth files and user guide https://serc.carleton.edu/geode/activities/217479.html
    - Using the resources found on GEODE, groups or individual students will investigate different regions of the Earth's oceans.
    - Instructors may encourage students to take this brief tutorial on using Google Earth.
- Plate Tectonics Transect Creation
    - Modified from McConnell et al., 2021 https://serc.carleton.edu/4937.1291
    - Students will analyze a figure depicting the plate tectonics of the Pacific Northwest and draw a cross section of a transect across two plate boundaries.
- Calculations of Plate Movement Speed (Quantitative Analysis)
    - Modified from Heather Gingerich, Department of Earth Sciences, The University of Western Ontario http://www.ontariogeoscience.net/lessonplans/hot-spots.html
    - Hawaiian Islands Plate Motion
    - Students will calculate the rate of plate motion using the ages and distances of islands and calculate the time for the oldest seamount in the Emperor Chain to be subducted.

## Assessment: Exit Ticket

15 minutes · To be completed prior to leaving the lab · Individual Assessment
(Created by Angela Daneshmand)

- LO1: List the three main types of plate boundaries and describe the direction of plate movement for each

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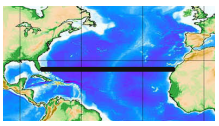
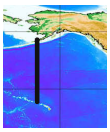
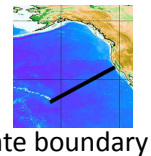
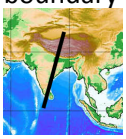
- LO1: In your own words, explain how you go about calculating speed of plate motion (velocity):

- LO2: If you were to walk from Florida to Morocco, which type of plate boundary would you walk across and which features would you see at this plate boundary? 

- LO2: If you were to walk from the Aleutian Islands to Hawaii, which type of plate boundary would you walk across and which features would you see at this plate boundary? 

- LO2: If you were to walk from Hawaii to Central California, which type of plate boundary would you walk across and which features would you see at this plate boundary? 

- LO2: If you were to walk from the Indian Ocean to China, which type of plate boundary would you walk across and which features would you see at this plate boundary? 

- LO3: Thinking about the geoscientific skills you started building today (geoscientific skills: analyzing/interpreting data; reading maps; practicing quantitative skills; thinking in 3D), describe one geoscientific skill you learned and how you may use it in your future life/career:

- LO4: Thinking about the professional skills you refined today (professional skills: collaboration/teamwork; communication; peer review; create community), describe one skill you used, how you used it, and how you can use this skill in your future life/career:

- Is there anything regarding plate tectonics that you are still unclear about?