Visualizing Plate Movement

Grades
9-12

Overview:

Students use data from the Plate Boundary Observatory (PBO) to visualize plate movement in Google Earth.

Objectives:

The student will:
- download a Google Earth file from the Plate Boundary Observatory,
- view two and three dimensional representations of PBO data; and
- analyze vectors to determine the direction and rate of plate movement.

Materials:

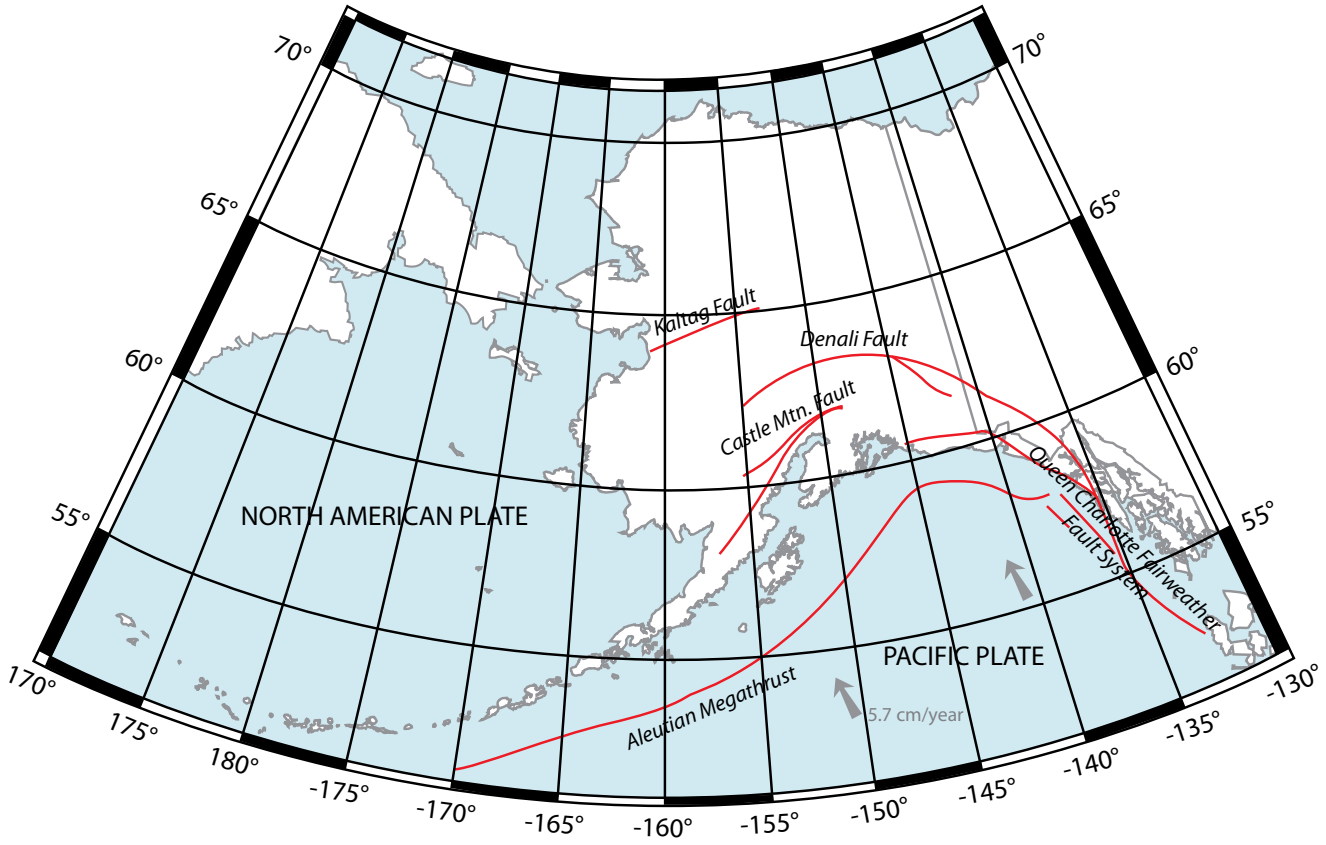
- Computer with Google Earth installed and Internet access
- STUDENT WORKSHEET: "Visualizing Plate Movement"

Whole Picture:

According to the Alaska Earthquake Information Center: "Alaska is situated in a unique and complex tectonic setting. At the southern edge of the state lies the boundary between the North American and Pacific plates. The Pacific plate is moving northwestward relative to, and being subducted under, the North American plate at an average rate of 5-7 centimeters per year. In southeastern Alaska, the plate boundary is defined by a series of strike-slip faults, known as the Queen Charlotte-Fairweather Fault system. Many of these faults continue through Canada and back into Alaska, creating some of the largest faults in the United States. In the eastern Gulf of Alaska, the plate boundary transitions into a continental collision of the Yakutat block with Alaska. Continuing westward, the Aleutian Megathrust subduction zone defines the remaining portion of the plate boundary in Alaska."

Earthquakes in Alaska primarily occur along the faults in south-central Alaska and the Aleutian Islands. These earthquakes can, and have, generated tsunamis that have had a devastating effects on Alaska and worldwide.

Major Alaska Faults



The Plate Boundary Observatory is actively studying the deformation across the boundary zone of the Pacific and North American plates. They monitor an array of Strainmeters and Global Positioning Systems to determine the strain fields and plate movements. Currently there are maintaining and monitoring over 1000 GPS stations.

The Google Earth KMZ file from PBO uses vector arrows to display the data. Vectors illustrate both magnitude and direction. Longer vector arrows represent a greater magnitude of movement, while shorter arrows represent less movement. The 2-d vectors represent horizontal movement, and the 3-d vector adds a vertical component. When using the 3-d visualization, an up arrow indicates the area is uplifting, and a down arrow indicates the area is subducting.

The velocities are at right angles to one another (N-S and E-W). Students could use the Pythagorean theorem to find the resultant velocity of the station nearest their community.

Students should be familiar with using Google Earth before doing this lesson.

Activity Preparation:

If not already installed, download and install the program Google Earth at http://earth.google.com for each computer. Click the **Download** button, then the **Agree and Download** button to start the download. For Macintosh computers double click the downloaded file to extract it then drag the Google Earth icon to the Applications folder. For PC's double click the downloaded file to install it. Double click on the Google Earth icon to launch the program.

Make a color copy or transparency of the lesson so students can see the red arrows.

Activity Procedure:

1. Ask students what the term “plate tectonics” means. Ask what plate they are on and if they think the plate is moving. If so, in which direction is it moving?
2. Distribute the STUDENT WORKSHEET: “Visualizing Plate Movement.”
3. Guide students through downloading the KMZ file from the Plate Boundary Observatory website.
4. Have students follow the directions on the STUDENT WORKSHEET to complete the lesson.

Answers:

1. *Answers will vary.*
2. *Answers will vary.*
3. *Answers will vary.*
4. *Answers will vary.*
5. *Answers will vary.*
6. *Answers will vary. California is seismically active and densely populated, so understanding plate boundary movements could help save lives from resulting earthquakes that occur along those boundaries. It is also more economically feasible to set up and maintain the GPS stations as compared with Alaska.*
7. *Northwest.*
8. *The coast is moving faster.*
9. *There is no uniform direction.*
10. *Northwest.*
11. *Northwest.*
12. *West.*
13. *California is moving northwest. Alaska is moving in different directions, depending on what part of the state you look at.*
14. *Answers will vary.*
15. *Yes, the answers should agree.*
16. *Uplifting.*
17. *Subducting.*
18. *Subducting.*
19. *Uplifting.*
20. *Answers will vary. Alaska is complex, with movement in many different directions, and both uplifting and subduction occur within the state.*

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Introduction

The lithosphere of Earth is broken into large tectonic plates. Alaska is tectonically complex with several major plates moving along plate boundaries within and near the state. Earthquakes, volcanoes, mountain building, and oceanic trenches occur along these boundaries. Alaska has all of these. The Plate Boundary Observatory (PBO) has placed over 1000 GPS stations in the western United States to study the movement of the Pacific and North American plates. Follow the directions below to view PBO data in Google Earth.

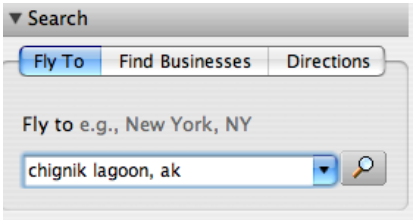
Directions

STEP 1. Launch a Web browser and go to the Plate Boundary Observatory website at http://pboweb.unavco.org/. From the Data Access drop down menu click on **GPS Products**.

STEP 2. On the GPS Products page click on the **KMZ** file under Network Velocity. Click **OK** to Save the File.

STEP 3. Launch Google Earth. From the menu **File** → **Open** the KMZ file that was downloaded.

STEP 4. Type the name of your community in the search box, then press return.



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STEP 5. Using the navigation tools find the closest vector (red arrow) to your community.

Example of the vector near Chignik Lagoon.

NOTE: The red arrow represents a velocity vector. Velocity is the rate of movement in a direction. Vectors represent the magnitude and direction of station movement with arrows. A longer arrow represents greater movement.

If the East Velocity is a positive number the station is moving east by the mm per yr rate. A negative number indicates that the station is moving west. A negative North Velocity number means the station is moving south.

The vectors represent the rate, and direction of movement of the plate at that location.

STEP 6. Hover the mouse over the base of the vector. When the hand turns to a pointer click the mouse.

STEP 7. From the balloon enter the following information:

1. The station code _____
2. East Velocity _____
3. North Velocity _____
4. Up Velocity _____
5. Summarize the plate movement near your community. (Example: The station is moving downward toward the southeast.)

   _____

Viewing California

STEP 8. Zoom out and navigate to California. There are many GPS stations located in California.

6. Why do you think there are so many stations located in California?

   _____

   _____

   _____

7. In which direction is California moving? _____

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STEP 9. Zoom in to an Eye alt of approximately 200 miles. The **Eye alt** information is located at the bottom right of the Google Earth window.

STEP 10. Compare the length of the vectors along the coast from San Francisco to Los Angeles to the length of the vectors inland from Sacramento to Bakersfield.

8. Which part of California is moving faster, the coast or inland?

   _____

Explanation: The San Adreas Fault runs through California. The plate west of the fault moves at a different rate than the east side. This causes strain and when the ground moves to release the strain, an earthquake results.

Viewing Alaska

STEP 11. Navigate back to Alaska. Move around the state and look at the direction of the arrows.

9. What direction are the arrows pointing in Alaska? _____

10. What direction is Kodiak Island moving? _____

11. What direction is the eastern part of the Aleutian chain moving near Chignik Lagoon, Perryville, and Sandpoint? _____

12. What direction is the western part of the Aleutian chain moving near Adak and Atka Island?

    _____

13. Compare the plate movement in California and Alaska. What general direction, if any, is California moving and what general direction, if any, is Alaska moving?

    _____

    _____

    _____

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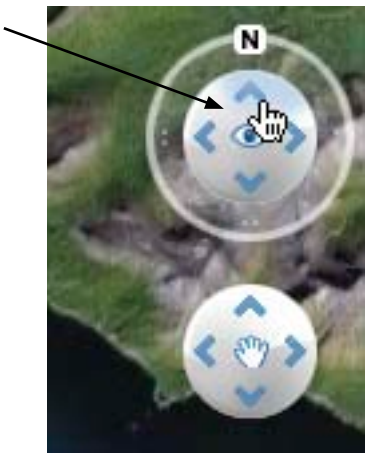
Viewing Velocity in 3D

STEP 12. In the Google Earth sidebar under PBO Velocity click the **2-d folder off**, expand the 3-d folder and click the **PBO 3-d Velocity Vectors**. All other folders should be off (not checked).

In the 3-d view the velocity vectors will show the vertical component. A vector pointing up indicates it is uplifting (moving up), and the Up Velocity is a positive number. A vector that is pointing down indicates the plate is subducting (moving down), and the Up Velocity is a negative number.

STEP 13. In Google Earth go back to your community and view the velocity vector. Use the Look joystick control to tilt the view so you can see the vector from the side.



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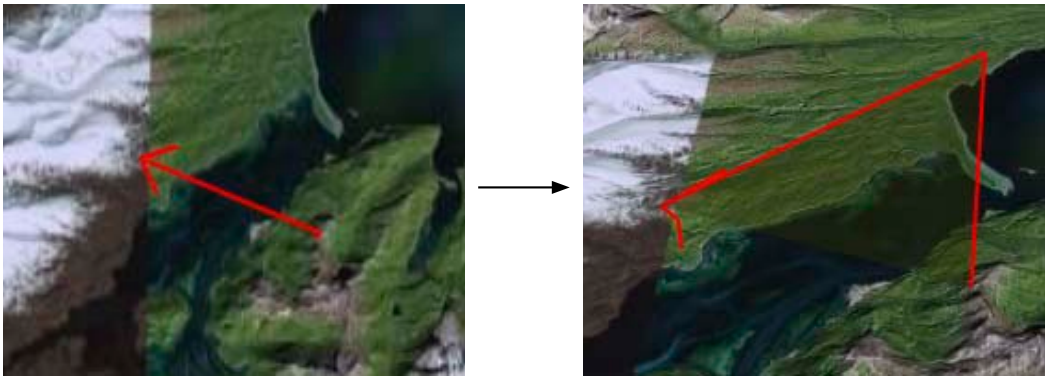
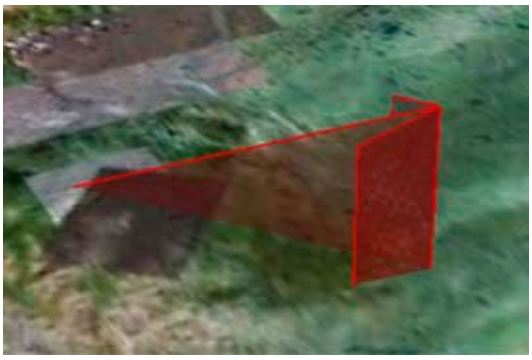


Vector from above. Vector from the side.



Example of upward movement.

14. Is the vector pointing up, down or is it parallel with the ground? _____

15. Does the direction of the arrow agree with the your answer to #4? For example, if the Up Velocity is a positive number is the arrow also going up? _____

STEP 14. Navigate to the following places, view the velocity vectors, and determine whether the plates are subducting or uplifting based on the direction the arrows are point. Complete the table.

	Place	Subducting or Uplifting?
16.	North end of Kodiak Island	
17.	Eastern part of the Aleutian Chain	
18.	Western part of the Aleutian Chain	
19.	Southeast Alaska (Northern part)	

20. What can you conclude about plate movement in Alaska?

_____

_____

_____