Name:_______________________________________ Date:________________________ Hour: __________

Activity - Using GPS Data and Geologic Markers to Track Plate Motion

Section	Points Received	Points Possible
Part A Analysis		**4.5**
Part B Analysis		**11.5**
Total		**16**

Introduction:

GPS satellites are used to track the position (or location) of many things on the surface of the Earth. You may have used a GPS in your car to find your current location and get directions to a different location. You may know how GPS data can be used to find the location of a cell phone. Believe it or not, GPS data can also be used to track the motion of tectonic plates! Permanent stations are securely attached to bedrock exposures and only move if the rocks themselves move. In this activity, you'll use GPS data to determine the movement of the land over an eight-year period in California.

Tables 10.1 and 10.2 show location data for two permanent GPS stations in California. Each year's location is measured relative to a "0" value for the station's position in 2004. A positive number indicates motion in the given direction. (For example, a value of 20 North means that the station has moved 20 mm to the north since 2004.) A negative number indicates motion in the opposite direction. (For example, a value of – 53 East means that the station moved 53 mm to the west since 2004.)

Table 10.1: GPS Station #1

DIRECTION	2004	2005	2006	2007	2008	2009	2010	2011	2012
North (mm)	0	29	54	82	108	136	165	192	220
East (mm)	0	−28	−53	−82	−110	−137	−166	−195	−220

Table 10.2: GPS Station #2

DIRECTION	2004	2005	2006	2007	2008	2009	2010	2011	2012
North (mm)	0	5	9	14	19	24	30	35	40
East (mm)	0	−7	−13	−20	−26	−32	−37	−42	−48

Procedure:

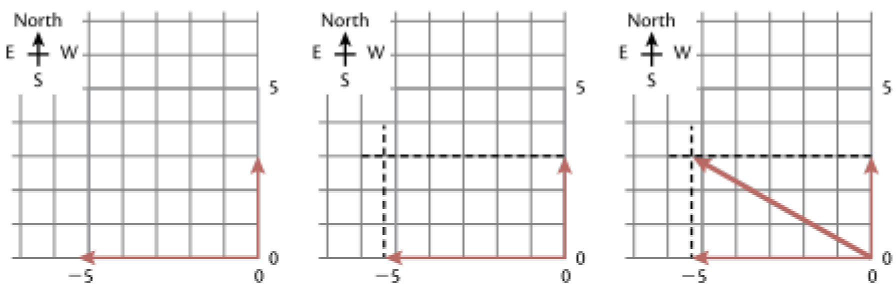
Part A: Plotting GPS Data

a) Determine the annual movement of each station by using the GPS data in Tables 10.1 and 10.2 above to complete the tables on Student Sheet 10.1. To find annual movement in each direction, subtract the previous year's value from the year you are calculating. For example, in 2006 at Station #1, the northward change is 54-29= 25 and the eastward change is (-53) – (-28) = (-25). After you have determined annual motion in each direction, don't forget to calculate the average for each station.

** To calculate average: add up all values and divide by total number of years (8).

b) Motion measurements taken in two directions can be combined into a single value by constructing a vector diagram. Using the grids on Student Sheet 10.1 and the average GPS measurements for Stations #1 and #2, follow the example in Figure 10.6 to construct a motion vector for each station.

** Sample Station Averages: Northward: 3.0, Eastward: -5.3



a. plot both averages

b. complete the rectangle

c. draw the diagonal combined vector

FIGURE 10.6
Example showing how to construct a vector from the sample station averages.

c) Student Sheet 10.1 includes a map of California showing the locations of both GPS stations. Draw the appropriate vector next to the location of each station. Make sure each vector is the same size and orientation on the map as on your grid.

Analysis Questions:

1. Describe the similarities and differences between the combined vectors for Stations #1 and #2.

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2. If the San Andreas Fault marks the boundary between the Pacific Plate (to the west) and the North American Plate (to the east), what do the combined motion vectors tell you about:

a. The overall motion of the Pacific Plate?

b. The overall motion of the North American Plate?

c. The motion of the Pacific Plate relative to the North American Plate?

3. The graphs in Figure 10.7 show ground movement over a 3-year period at a single GPS station in California. The two graphs show ground movement relative to north and east (like in Tables 10.1 and 10.2, before you drew the vectors).

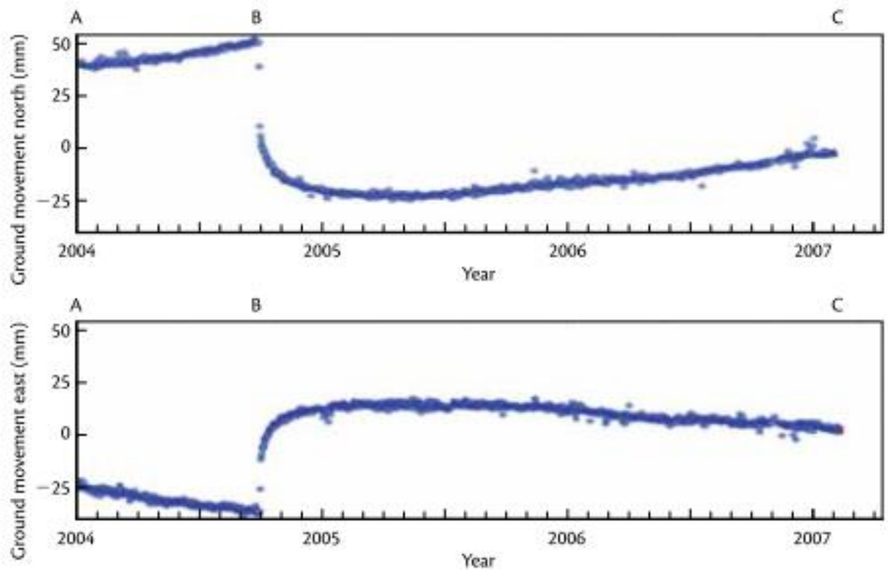


FIGURE 10.7
These graphs show horizontal ground movement over a 3-year period at a GPS station in California.

a. What is happening with ground movement between point A and point B?

b. What happens at point B?

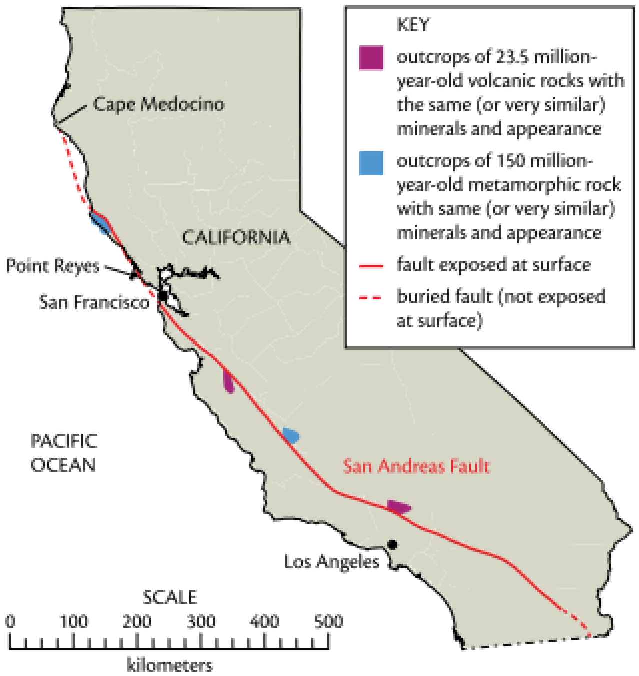
c. What is happening with ground movement between point B and point C?

d. What do you think might be a possible explanation for the sudden change in late 2004 at point B?

e. Compare the trend in ground movement before and after point B.

Part B: Using Geologic Markers

Rocks can also be used to track and measure the motion of tectonic plates. Rocks can be unique – in appearance, in the types and percentages of the minerals they contain, or both. Radioactive elements in certain minerals found in some rocks can also be used to determine when those rocks were formed. When you find two rocks that are very similar in age, appearance, and minerals, there is a very high probability that those rocks were formed in the same location, and so they are called **geologic markers.**



4. Look carefully at the location of the volcanic rocks that are geologic markers shown in purple (darker shading) on the map to the left.
   a. How many locations are east of the San Andreas Fault? ______________________________
   b. How many are west of the San Andreas Fault? ______________________________
   c. How might you explain your observations from a and b? ______________________________
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5. Look carefully at the location of the metamorphic rocks that are geologic markers shown in blue (lighter shading) on the map in Figure 10.8.
   a. How many locations are east of the San Andreas Fault? ______________________________
   b. How many locations are west of the San Andreas Fault? ______________________________
   c. Does your explanation from Question 4c still make sense? Explain why or why not.
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6. Use the information on the map and the equation to fill in the table below.

Rate of motion (km/million years) = Distance moved (km) ÷ Elapsed time (millions of years)

Table 10.3: Movement of Geologic Markers

GEOLOGIC MARKER	AGE OF ROCK (million years)	DISTANCE BETWEEN ROCK LOCATIONS (km)	RATE OF MOTION (km/million years)
Volcanic (purple)			
Metamorphic (blue)			

7. Describe the similarities and differences between the rates of motion derived from the volcanic and metamorphic marker rocks.

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8. Movement along the San Andreas Fault began about 28 million years ago. Judging from your data, does this information make sense? Explain why or why not?

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9. Compare the relative rate of plate motion along the San Andreas Fault as determined by GPS data with that derived from the geologic marker data.
    a. Explain why your results from these two sources are basically the same, quite similar, or different

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    b. Describe any advantages and disadvantages with using GPS data compared to geologic marker data.

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10. Two rival colleges, UCLA and UC Berkeley, are on opposite sides of the San Andreas Fault Zone. UC Berkeley is on the North American Plate, 550 km northwest of UCLA, which is on the Pacific Plate. If your great, great, great, grandchildren go to one of these colleges, how far will they have to travel to visit their rival college:
    a. 1,000 years in the future? ______________________
    b. 500,000 years in the future? ______________________
    c. 10,000,000 years in the future? ______________________
11. Based on what you've learned about ground movement in California from this activity, what do you think could be the cause of earthquakes in California (be specific)? Do you think another earthquake could happen?

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