

# Activities—SeismicWaves and SeismicEruption

PC-based visualizations from Alan Jones ([serc.carleton.edu/resources/23210.html](http://serc.carleton.edu/resources/23210.html))

Two highly effective visual aids to watch how waves propagate from an earthquake hypocenter to seismic stations throughout the earth and to see the changes in space and time earthquakes and volcanoes across the globe.

## Procedure

- 1) Software and other resources for each of these PC-based programs are on this DVD in the folder:

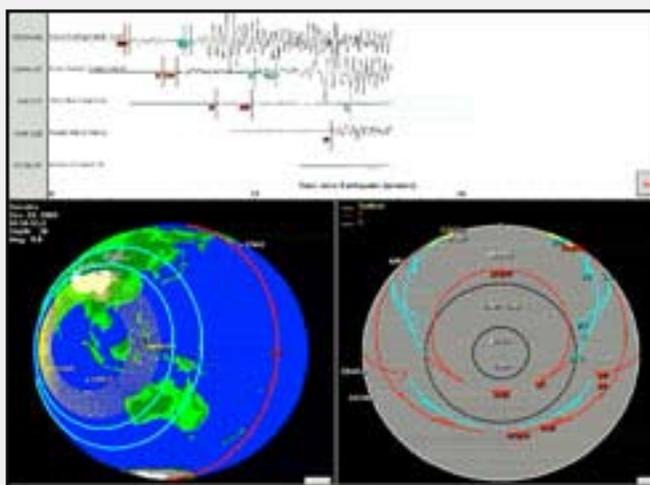
- **3. ACTIVITIES\_Earthquake & Tsunami**
- > ■ **4. ACTIVITIES\_Earthquake & Tsunami**
- > ■ **SeismicWaves and SeismicEruption**

or download from link on next page.

- 2) Instructions and worksheets for each activity follow this page; editable Word documents are in the above folder.

## Science Standards (NGSS; pg. 287)

- From Molecules to Organisms—Structures and Processes: MS-LS1-8
- Energy HS-PS3-2, MS-PS3-5
- Waves and Their Applications in Technologies for Information Transfer: MS-PS4-1, HS-PS4-1, MS-PS4-2, HS-PS4-2, MS-PS4-3, HS-PS4-5
- Earth's Systems: HS-ESS2-2



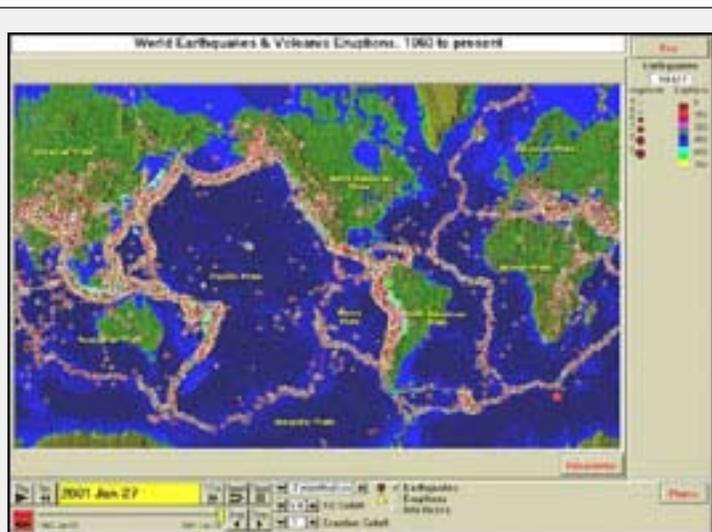
## SeismicWaves

Seismic Waves is a Windows program which illustrates how wave propagate from an earthquake hypocenter to seismic stations throughout the earth. One sees waves propagating out from the epicenter on a three-dimensional view of the earth at the same time one sees waves propagating through a cross-sectional view of the earth. These two wave propagation views are synchronized with actual event waveforms so that as a particular phase arrives at a station, one sees the effect on the seismogram.

## Resource for Mac Users

An animation of this program is on this DVD in the folder:

- **2\_Animations\_Earthquake & Tsunami** > ■ **SeismicWaves-PC Program animated**
- Before watching, read the file called: **ReadMe-AboutSeismicWaves.doc**

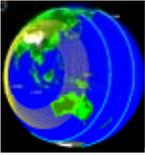


## SeismicEruption

A program for the visualization of seismicity and volcanic activity in space and time.

The program displays both earthquakes and volcanoes. The database of volcanism is from the Global Volcanism Program of the Smithsonian Institution. When the program is running, the user sees lights, which represent earthquakes, flashing on the screen in speeded-up time. The user can control the speed of the action. In addition, the program can show seismicity under the earth in three-dimensional and cross-sectional views.

Instructions and worksheets follow Seismic Waves activity



## TEACHER INFORMATION

### SEISMIC WAVES COMPUTER PROGRAM

#### Downloading program:

- Install using the CEETEP DVD because the one you can download for free from <http://pods.binghamton.edu/~ajones/> will not have the Haiti nor Chile quakes.
- To download from above site, scroll down until you find *Seismic Waves: A program for the visualization of wave propagation* and click on [SeismicWavesSetup.exe](#)
- It only works on PCs!

#### Suggestions on use:

- Prerequisite knowledge: seismic waves! Do slinky activity and animations first.
- Do whole group demonstration of how to use the program first.
- Review the buttons and controls, especially the "Pause/Resume" function.
- Speed slider is very helpful as well.
- As the quake runs its script, it will repeat the same quake over again.
- Break students into pairs to complete worksheet.
- Review key points upon completion of worksheet.

#### Further control of program:

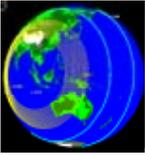
- On top menu bar, click "Options" for more functions on what to control or not.
- To use the worksheet, the Phases must be set to show the phases on the Earth and Cross-Section views, as well as "All" phases to be shown.
- Make sure "Run from Script" is NOT checked - otherwise it will cycle to the next quake in its script and won't repeat the same quake.

#### Extensions:

- Use the IRIS posters entitled: "Sumatra-Andaman Islands Earthquake ( $M_w=9.0$ )" and "Exploring the Earth Using Seismology"\* to show how seismic waves propagate through the Earth. It also shows how the time between P wave and S wave arrival times increases with distance. Both can be found at:  
<http://www.iris.edu/hq/publications/posters>
- Show students the Ripple Tank Applet: <http://www.falstad.com/ripple/>. This is an awesome little applet that can simulate how waves move through different media. Play around with the controls to edit walls and media. When manipulated correctly, it clearly shows shadow zones!

- \* "Exploring the Earth Using Seismology" resources are in the folder:

 **5. Maps & Posters** >  **Exploring Earth Using Seismology**



## WORKSHEET ANSWER KEY

### SEISMIC WAVES COMPUTER PROGRAM

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#### PROCEDURE:

Open program and click "Start" to see a world map with some major earthquakes shown.

With each quake you click on, the "Event Information" will appear.

After reading the event information, click "Go" and you get a yellow screen with an overall description of the quake's mechanics.

Click "Back" to start the animation of the seismic waves produced by the quake, with 3 different ways to view the earthquakes. Use the "Views" button on right to toggle between them:

(1) by seismometer stations around the globe

(2) by where the waves are traveling on the surface of the Earth

(3) where the waves are traveling inside the Earth.

Use the speed slider and "Pause/Resume" buttons to control speed of wave animations.

#### Questions 1 - 7 refer to the Near Central Coast of Chile Feb 27, 2010 quake.

1. How deep was the quake (#s are in kilometers) **59 KILOMETERS**
2. What was the magnitude (mag)? **8.3**
3. Read the info on yellow page. What two tectonic plates are involved with this quake?  
**NAZCA PLATE AND SOUTH AMERICAN PLATE**
4. What process is involved as one plate moves below another plate? **SUBDUCTION**
5. Large quakes have affected this region repeatedly. What years produced quakes large enough to cause tsunamis? **1906, 1922, 1960, 2010**
6. Click "Back" to start animation. What do the different colors of lines on the globes represent?

Red: **PRIMARY (P) WAVES**

Light Blue: **SECONDARY (S) WAVES**

Yellow: **SURFACE (L) WAVES**

4. Over time, what happens to the distance between the first red line and the first blue line as they move across the surface of the globe? Why does this happen?

**THE DISTANCE BETWEEN THE LINES INCREASES BECAUSE THE P-WAVES ARE FASTER AND SPREAD FURTHER AND FURTHER APART FROM THE S-WAVES.**

5. Look at the seismograph of the Limon Verde Calama, Chile - LVC-LHZ (at the top of the seismograph list). Sketch what it looks like from 0 to 20 minutes in the space below.

6. Using the Speed slider or the Repeat button, look for what color of waves is causing the big huge movements on the Limon Verde seismometer. Compare the seismograph to the surface view. Is it the S waves or the Surface waves that are causing the big movements on the seismograph? **THE SURFACE WAVES CAUSE THE MOVEMENTS**

7. About how long did it take for the P waves to hit the seismometer in Harvard, Massachusetts, USA? **ABOUT 11 MINUTES**

Go back to the World Menu and click on the Haiti 2010 quake.

8. What were the depth and magnitude? **13 KILOMETERS, 7.0**  
9. The yellow info page says "the plate boundary is dominated by left-lateral strike slip motion . . ." What type of plate boundary produces strike slip motion? **TRANSFORM**

Look on the Earth Cross-Section view. You can see the main layers and what happens as the waves travel in there and bounce around. You will see the waves changing names as they hit different parts of the Earth's interior. Use the speed slider control to help.

10. Which waves are moving out first from the earthquake? **P WAVES**  
11. What happens to the P waves when they hit the outer core? (more than one thing happens - notice what goes through the outer core) Why does that happen?

**THE P-WAVES, AS THEY HIT THE BOUNDARY TO THE OUTER CORE, CREATE A SECOND SET OF P-WAVES FROM THE IMPACT. THEN S-WAVES ALSO COME OUT FROM THE IMPACT AND GO BACK UP THROUGH THE MANTLE. THIS IS DUE TO THE DIFFERENCE IN MATERIAL BETWEEN MANTLE AND CORE.**

12. Watch the first set of blue S waves coming out of the quake. What happens to those waves when they hit the outer core? What does this say about the consistency of the outer core?

**AS THE S-WAVES HIT THE BOUNDARY, THE IMPACT CREATES ANOTHER INNER-EARTHQUAKE AND A SECOND SET OF P-WAVES THAT GO THROUGH THE CORE. S WAVES CAN'T GO THROUGH LIQUID, SO IT SHOWS THAT THE OUTER CORE IS MADE OF LIQUID MATERIAL.**

13. Some of the waves get renamed, like PKIKP. What does that mean? Click on the info button in the corner for an explanation. What does the 'K' mean? What does the 'I' mean? So where exactly has the PKIKP wave been moving through?

A grey rectangular button with the word "Info" in red text.

**P MEANS P-WAVE, AND K MEANS 'OUTER CORE' AND I MEANS 'INNER CORE' SO A PKIKP WAVES IS ONE THAT STARTS IN THE MANTLE, GOES THROUGH THE OUTER CORE, THROUGH THE INNER CORE, THEN THE OUTER CORE, AND INTO THE MANTLE.**

Try a few different earthquakes. Click on World Menu to choose them.

13. After looking at a few, compare all the quakes to the Bolivia quake in 1994. What was different about the quake in Bolivia?

**IT WAS VERY DEEP, SO NO SURFACE WAVES WERE CREATED.**

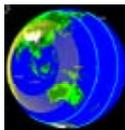
14. When are you looking at different quakes, click on the Event Info button → to tell you some interesting facts. Click on the Kobe 1995 quake. Summarize what happened in that earthquake. Why was this quake particularly bad?

A grey rectangular button with the words "Event Info" in red text.

**THE QUAKE WAS PRETTY BIG, AND BECAUSE OF ITS LOCATION, IT CAUSED MANY CASUALTIES.**

15. Which quake shown had the largest magnitude, and how big was it? **SUMATRA, 9.0**

**SEISMIC WAVES  
COMPUTER PROGRAM**



Name: \_\_\_\_\_ Class \_\_\_\_\_

Today's Date: \_\_\_\_\_ Due Date: \_\_\_\_\_

**PROCEDURE:**

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Use the speed slider and "Pause/Resume" buttons to control speed of wave animations.

**Questions 1 - 7 refer to the Near Central Coast of Chile Feb 27, 2010 quake.**

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4. What process is involved as one plate moves below another plate? \_\_\_\_\_

5. Large earthquakes have affected this region repeatedly. What years produced earthquakes large enough to cause tsunamis? \_\_\_\_\_

6. Click "Back" to start animation. What do the different colors of lines on the globes represent? Red: \_\_\_\_\_

Light Blue: \_\_\_\_\_

Yellow: \_\_\_\_\_

4. Over time, what happens to the distance between the first red line and the first blue line as they move across the surface of the globe? Why does this happen?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

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**Look on the Earth Cross-Section view.** You can see the main layers and what happens as the waves travel in there and bounce around. You will see the waves changing names as they hit different parts of the Earth's interior. Use the speed slider control to help.

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15. Which quake shown had the largest magnitude, and how big was it? \_\_\_\_\_

# SEISMIC ERUPTION PROGRAM

## Downloading program:

- Get from either the CEETEP DVD or download file [SeismicEruptionSetup.exe](http://pods.binghamton.edu/~ajones/SeismicEruptionSetup.exe) from <http://pods.binghamton.edu/~ajones/>

## Suggestions on how to use program:

- As introductory activity to show relationships of quakes and volcanoes.
- As instructive tool to look for specific topics
- As summative activity of plate tectonics
- Start by doing demonstration of program and how to operate it. Then have groups complete worksheet.
- There are an infinite number of things to play with. You could have different groups look at different areas to look for patterns.
- The EQ cutoff alone could be used to show patterns of large or small quakes
- One very cool feature is the 3-D views. Under North American Group, then Alaska Group. Look at the Cook Inlet Cross Section to see a perfect image of a subducting plate! Compare it to the Cook Inlet 3-D.
- Compare the cross section of Cook Inlet to the Loma Prieta group. To get to Loma Prieta, go to the World Menu, then North American Group, then United States Group, then California Group, then Loma Prieta Group. The Loma Prieta cross section and 3-D show a much shallower transform strike slip event along a single pane compared to the deep angled subduction zone of the Cook Inlet.

## Controlling program:

- The top menu bar has plenty of ways to control things, such as sound, time, speed, views - play around with those to find what is possible
- Things to note:
- Sound has importance - higher tones indicate smaller quakes
- Interactive 3-D - can set up 3D views to show what you want
- Map - Make Your Own Map - use this feature to highlight an area to focus on
- DO NOT "Redraw" Map - it will make the screen black with no way to change it back!
- When you slow up or slow down (rewind or fast forward) the quakes and volcanoes do not reset - it's best to repeat.
- To speed up or slow down, it's best to the use events/time buttons on the bottom.

## To use worksheet:

- Do a "World" run first and play it about 1month/sec. Repeat, and have kids look for patterns/observations and write down on #1.
- Show how to control speed - that's the most important control on here!
- Note that depth of quakes is shown by different colors - especially key when looking at subduction zones.

# WORKSHEET ANSWER KEY

SEISMIC ERUPTION PROGRAM Name: \_\_\_\_\_ Per: \_\_\_\_\_

Today's Date: \_\_\_\_\_ Due Date: \_\_\_\_\_

This computer program is a compilation of earthquakes and volcanic eruptions since 1960. You'll be amazed. Listen carefully to the first set of directions from the teacher before you do anything else.

1. Now that you have seen the program run, write down your initial thoughts.

ANSWERS WILL VARY.

2. By the end of the program, how many earthquakes have occurred?  
Note that these are just those that are above a magnitude 5 (you can just start to feel a magnitude 4 quake) **IN THE NEIGHBORHOOD OF 75,000 QUAKES IN 50 YEARS  
- ABOUT 1,500 A YEAR OF MAG 5 OR GREATER!**

3. Play the program again by clicking 'Repeat.' Write down at least 8 observations. If you want to pause the program, click on 'Pause' - this only works for about 30 seconds, though. Another way to pause it for longer is to change the number of events per second with the up/down arrows.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_

4. At the very end of the program, some colored lines appear on the map. What are those lines? What do the different colors of lines mean?

**LINES APPEAR TO SHOW PLATE BOUNDARIES - DIFFERENT KINDS OF BOUNDARIES ARE SHOWN IN DIFFERENT COLORS; CONVERGENT - YELLOW, DIVERGENT - RED, TRANSFORM - BLUE**

5. What do the different colors of dots represent?

**DIFFERENT COLORS REPRESENT DIFFERENT DEPTHS OF QUAKES. THE DEPTH KEY CHANGES DEPENDING ON LOCATION OF QUAKES.**

6. What is the pattern between the lines and the earthquakes and volcanoes? What does this mean?

**A VAST MAJORITY OF VOLCANOES OCCUR IN SAME LINEAR PATHWAY AS EARTHQUAKES. THE TWO USUALLY GO HAND IN HAND, AND ARE CAUSED BY TECTONIC PLATE MOMEMENT.**

7. What do the different colors of triangles mean for volcanoes?

**LIGHT GRAY - NOT ERUPTING. RED - LAVA ERUPTIONS. YELLOW - EXPLOSIVE ERUPTIONS. PINK - BOTH LAVA AND EXPLOSIVE. DARK GRAY - UNKNOWN TYPE.**

Talking about volcanoes . . . let's look at Mt. St. Helens. Go to the World Map (click "Back" until you get to World Menu). Click "North American Group" and then "Pacific Northwest Group" and then "Mt. St. Helens." Click on "Mt. St. Helens." Note the EQ cutoff is at 4.0. Let the program run through once and watch. Click "Repeat" to watch again.

8. When do the earthquakes start in 1980? MARCH 21, 1980

9. What happens on May 18<sup>th</sup>? And then what happens to the number of earthquakes after that?

THE MOUNTAIN ERUPTED ON MAY 18<sup>TH</sup> AND ALL THE EARTHQUAKE ACTIVITY BASICALLY CAME TO A HALT, WITH VERY FEW HAPPENING AFTER THE QUAKE.

10. Why do you think that happens?

PRESSURE UNDER THE VOLCANO WAS INCREASING BEFORE THE ERUPTION. AFTER THE ERUPTION RELEASED ITS PENT UP PRESSURE, THE ACTIVITY DECREASED.

11. Find where it says 'EQ Cutoff'. That's where you can change how big the earthquakes have to be before they got a dot on the program. Change the EQ Cutoff (by using the arrows) to 7.5. Then run the program again. It might help to uncheck the Eruptions. Watch how many big quakes there have been. Magnitude 7.5 is a HUGE quake. Where are most of these large quakes?

A VAST MAJORITY OF THEM ARE ON THE RING OF FIRE. OTHERS ARE ON CONVERGENT BOUNDARIES IN ASIA AND EUROPE.

12. Now let's play with a certain region. First change the EQ Cutoff back to 5.0 and hit 'Pause'. From the World Menu, click South America. You'll have to be very patient with controlling the time on this. We want to focus on late February 2010. Speed up the events until Feb 2010, and click "Pause". Put the events to 5 hours/sec. Then hit "Play" and watch what happens. Describe what happens on Feb 27<sup>th</sup> and then for a few days and even weeks after the 27<sup>th</sup>.

THERE IS A VERY LARGE 8.0 MAGNITUDE QUAKE ON THE 27<sup>TH</sup> AND THEN A LARGE NUMBER OF QUAKE FOLLOW AS AFTERSHOCKS, MOST OF THEM SMALLER, BUT SOME PRETTY LARGE.

13. What do you think that was happening to explain the patterns?

AFTER THE BIG QUAKE ON FEB 27<sup>TH</sup>, THERE WERE A LARGE NUMBER OF AFTERSHOCKS AS THE PLATES READJUSTED TO THEIR NEW LOCATION AND STRESS LEVELS.

14. Now you can adjust a variety of things until your teacher gives you further instructions.

**SEISMIC ERUPTION PROGRAM**

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Today's Date: \_\_\_\_\_ Due Date: \_\_\_\_\_

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  7. \_\_\_\_\_
  8. \_\_\_\_\_
  
  
  
  
  
  
  
  
  
  
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