Global GIS Lesson:

Exploring North American Earthquakes

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Loma Prieta, California, Earthquake October 17, 1989, Moss Landing. Damaged approach and abutment of the bridge linking the Moss Landing spit to the mainland near the Moss Landing Marine Laboratory. Liquefaction of the beach and Salinas River deposits caused ground cracking and differential settlement. Slide XV-2, U.S. Geological Survey Open-File Report 90-547. Open File Report-90-547 (http://130.11.57.28/of90547.htm), Digital File:tjc00009, ID. Tinsley, J.C. 9ct

Global GIS Lesson: *Exploring North American Earthquakes*

Description

In this lesson, students use Geographic Information Systems (GIS) together with the tools and data from the North America Global GIS CD to investigate earthquakes, volcanoes, and population from a local to global scale. The lessons can be used with other data in the Global GIS project to investigate earthquakes in other continents. Furthermore, the methods used here can be applied to other map themes contained within the North America Global GIS CD.

The lesson is organized into 7 parts:

Part 1—What's Shakin'?
Part 2—Digging Deeper
Part 3—The Loma Prieta Earthquake
Part 4—Investigating Your Community
Part 5—Earthquakes Everyday
Part 6—Analyzing Recent Earthquakes
Part 7—Earthquakes Respect No Boundaries

What is GIS?

Maps have always been powerful ways to represent information. A GIS combines the power of maps, satellite images, and aerial photographs with databases that store information behind the maps and images. One way to think about GIS is to break it up into its three initials. The "G" part of GIS could be a map, a three-dimensional representation of the Earth's surface, or an image. The "I" part of GIS is the Information, or the database, containing attributes behind each map feature. This could be the magnitude of an earthquake, for example, or the population of a country. The "S" part of GIS is invisible to the user, but this Systems part makes it possible to analyze the maps and attributes together.

Another way to think about GIS is to think of it in terms of computer hardware, software, methods, and a human explorer.   GIS requires computer hardware and software to use. In the case of this lesson, ArcReader and ArcView software from ESRI, Inc. will be used. GIS involves specific methods, or procedures. In this lesson, students will have the opportunity to use many of these procedures, such as querying, sorting, changing legends, creating buffers, and others. GIS also requires certain kinds of spatial data. These are produced by national governmental organizations such as the USGS, the US Census Bureau, NASA, and others, as well as tribal, state, and local government, nonprofit organizations, and private industry. However, the most important component of a GIS is the

user. It is the person that must make sense of what the GIS tools and methods are saying, and it is the person who must decide what action to take.

Why Use GIS in Education?

As the world becomes ever more monitored, mapped, and surveyed, students have the opportunity as never before to take advantage of the same tools that scientists are using. One tool essential for analyzing the Earth is a Geographic Information System (GIS). A GIS allows the user not just to create computerized maps, but also to *analyze* patterns, linkages, and trends that exist above, on, or below the Earth's surface. Oceanographers, geologists, geographers, seismologists, climatologists, biologists, chemists, zoologists, and other scientists regularly use GIS to help them make wise decisions about the planet. Why not tap into this powerful tool for teaching and learning?

A GIS user is not confined to the static content, locked scale, and symbols of a paper map. Rather, a GIS allows the user to create his or her *own* map—one that is customized to address the issues and problem at hand.

Analyzing the Earth with a GIS in the classroom provides for inquiry-based, problem-solving learning. Students ask a question, acquire the necessary tools and data to address the question, analyze the data using the GIS and other tools, and assess the results of their investigation. This may lead to further investigation and additional questions. In addition, learning with GIS allows for the integration of field data collection with Global Positioning Systems (GPS) to obtain the precise coordinates of where the data were collected. It also allows for interdisciplinary learning that is exciting and relevant to address the major issues of the 21st Century, such as biodiversity, population growth, climate change, natural hazards, and energy. In this lesson, students are given the opportunity to analyze a specific natural hazard—earthquakes—using GIS software and methods of analysis.

Problem Setting

Earthquakes in North America are costly in both lives and property. For the past 25 years, the average cost of North American earthquakes has been approximately $2.5 billion dollars per year in property and critical infrastructure damage. On average, 1,000 people have died in North American earthquakes each year for the past 25 years. As the population grows and development expands to cover more and more of the land area of North America, this average will grow as well.

In this earthquakes lesson, students are given a scenario where they must report on the distribution and frequency of earthquakes in North America related to cities, political boundaries, volcanoes, and fault lines. They analyze current

earthquakes from the Internet, and assess the hazards from a continental to a local scale, to their community.

Linkages to Science Standards

Teaching Standards

This lesson supports national teaching science standards because the lesson was developed as an inquiry-based approach to teaching. Specifically, it supports Teaching Standard A because it is interdisciplinary and nurtures a community of science learners. Teaching Standard B focuses on modeling the skills of scientific inquiry, which students do while analyzing earthquakes within a GIS environment. Teaching Standard C is supported because the questions use multiple methods of assessment, and many sections of the lesson do not have one "right answer;" rather, the questions encourage students to reflect upon their learning. It supports Teaching Standard D because through the Global GIS project, it makes the available science tools, materials, media, and technological resources accessible to students. Teaching Standard E is supported because students are encouraged to collaborate with each other, and because the lesson models emphasize the skills, attitudes, and values of scientific inquiry. In short, with GIS, constructivist teaching is supported because students are not memorizing facts, and the teachers' role changes to one of guiding the students in their inquiry.

Professional Development Standards

Teaching with GIS support the vision of professional development standards for the teaching of science. Specifically, in the learning of science content through inquiry standard, GIS was created as an inquiry-based, problem-solving tool. It was not something "made up" for the classroom. Rather, teachers using GIS are themselves learning science content in the same way as a scientist in government, business, or a nonprofit organization does everyday on the job. Furthermore, the development of the understanding and ability for lifelong learning is supported because GIS is not a "plug and play" CD. It is a *system*, and indeed, geographic information *science* is a science in its own right. Therefore, teaching with GIS cannot be dismissed as easy. It is hard work, but in so doing, teachers learn continual reflection, new strategies, best practice, and learning alongside the students. Despite the hard work, most teachers using GIS in the classroom indicate that it is a worthwhile endeavor.

Science Content Standards

Investigating the Earth with a GIS supports science content standards. For example, the "unifying concepts and processes" standard is integrated into the lesson in that students are provided with a system, a way of organizing their data

within a GIS. They are also provided evidence for earthquake and volcano hazards as real scientific data. Students *examine evidence* and *explain the distribution of phenomena* across Earth's surface. They *measure* phenomena and they analyze *changes* over time and space.

Investigating Earth with a GIS also addresses the science as inquiry standard, because students learn scientific concepts (plate tectonics) by developing the skills scientists use on the job. GIS is a real-world tool used by thousands of scientists daily. The process of inquiry within a GIS is more important than the "final answer" that the students provide. GIS-driven inquiry gives students an appreciation of scientific investigation, because it is the same tool that scientists use. Using GIS, students ask questions, acquire or generate necessary data, analyze the data, draw conclusions, and ask new questions. They conduct their own investigations in a hands-on way. In so doing, they are developing skills necessary to become independent inquirers about the natural world.

Students using GIS through this lesson begin to see that their analysis hinges largely on the quality of the data provided. They learn to be critical of the data. Too often, when data are viewed on the computer, they are considered to be perfect; without error. However, computer-based data are no more accurate or precise than the paper maps and original sources they were derived from. This is especially important with map data because maps are representations of the Earth. They all contain inaccuracies because they are based on specific map projections, which distort the three-dimensional earth to depict it on a two-dimensional paper map or computer screen. Being critical of data and recognizing the limitations of data and analysis are essential science learning skills.

Using this CD and lesson, emphasis is on investigation and analysis, rather than on demonstration. The GIS skills the students are learning are in context with the lesson on seismicity, and they are using multiple skills—process, computer, analysis. Instead of simply providing answers to questions, students are communicating science explanations about science content through their maps, tables, and charts from GIS. Their conclusions must be backed by real-world data.

The lesson supports the physical science standards because students learn about tectonic forces, motions, and patterns, and the structure of the earth system. The science and technology standards are addressed because students learn science *through* GIS *technology.* Natural hazards are a component in the science in personal and social perspectives standards, and with this lesson, students assess risks and benefits of living with earthquakes, and the relationship of earthquakes to cities and critical infrastructure such as roads, utility lines, and railroads.

GIS Skills Involved

1) Navigating through and effectively using a GIS interface and software.
2) Changing map symbology to create different thematic maps.
3) Manipulating tabular information, including selecting attributes, querying tables, and sorting tables.
4) Querying map data, including proximity analysis.
5) Downloading and formatting data from the Internet for use in GIS.
6) Changing map projections.
7) Creating new information from existing data.

Options for Running the Software:

1. For users who have installed ArcView Data Publisher, start the "North America Global GIS" icon from the Windows start bar under the 'Global GIS' folder. ArcView Data Publisher users will not be able to complete parts 6 and 7 of this lesson.

2. Users who own a version ArcView 3.x can open the ArcView GIS project named "Namerica_global_gis5_v3.apr" directly off the Global GIS CD. This will give the user the opportunity to save his/her project.

- Notes: Before starting, please see http://www.agiweb.org/pubs/globalgis/ under "support and downloads" for any data updates or project updates. The ArcView project delivered on this disk is not compatible with ArcView version 3.0 because of the use of the MrSid image format. ArcView version 3.1 and higher will work. Thus, for Macintosh ArcView version 3.0, users will need to download a compatible Macintosh project, which removes the MrSid image references from the AGI site mentioned above.

Investigation

The U.S. Geological Survey was created in 1879 to help understand the geologic, biologic, hydrologic, and geographic characteristics and phenomena of the planet. Included in this mission is a thorough understanding of earthquakes. To help assess where and why earthquakes occur in North America, the U.S. Geological Survey has hired you as an earth systems scientist to provide them a report that will include the distribution, frequency, and causes of earthquakes in North America, specific regions of the continent, and the state where you attend school. Included in the report must be an analysis of the depth and magnitude of the earthquakes, and the locations and characteristics of cities, volcanoes, and faults in relationship to earthquakes.

As noted above, earthquakes cause millions of dollars of property and critical infrastructure damage each year. "Critical infrastructure" refers to large-scale systems that local, regional, and national governments build across the landscape. These include roads, airport runways, powerlines, gas pipelines, water pipelines, sewer lines, railroads, fiber optic cable, broadband Internet lines, telephone lines, shipping docks, power stations, radio and television transmission towers, and canals.

0) List three kinds of critical infrastructure that could be destroyed or damaged during an earthquake. For each, describe why the destruction of these infrastructure resources is so disruptive to local, regional, and national government and commerce.

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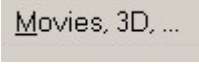
━━━━━━ **Part 1: What's Shakin'?**

In this part, you will examine earthquakes across North America, noting their distribution, magnitude, and depth, and also examining certain regions on the continent.

After accessing the Global GIS interface, you will be viewing the "G" part of GIS with the map on the right side and a set of tools across the left and the top.

Turn off (uncheck) all themes except for the following:

- shaded relief base (at the bottom of the table of contents)
- earthquakes 1973-1994 (about 1/3 down on the table of contents)

Access the Movies, 3D menu at the top Movies, 3D, … and run nam_eq_anima.avi. Use the slider bar to position the movie at specific years you wish to investigate further.

1) What years do the earthquakes cover?

2) The USGS seismologists want you to make three observations about the *spatial pattern* of earthquakes that you notice as they occur across the North American continent. Consider the extent of the earthquakes, and specific areas of North America where earthquakes occur more often.

3) Make three observations about the *magnitude of earthquakes* and where earthquakes of certain magnitudes occur across North America. Do large earthquakes only occur in specific regions? If so, where are they?

4) Do any specific years seem to have more earthquakes than others, or would you say that about the same number of earthquakes occur each year?

Close the movie and return to your GIS. Now you can further analyze the earthquake theme and draw some conclusions.

5) Do more earthquakes occur near oceans or in the interior of the North American continent? Why?

6) Do more earthquakes occur near the Pacific Ocean to the west of North America or near the Atlantic Ocean to the east of North America? Why?

7) Compare the number of earthquakes that occur in the oceans versus land.

8) Compare the Atlantic versus Pacific Ocean earthquakes.

9) What feature runs down the middle of the Atlantic, and why is it so prone to earthquakes?

10) What particular hazard exists to people when an earthquake occurs in the ocean?

11) In what part(s) of North America would people need to be concerned about earthquakes occurring in the ocean?

Make volcanoes visible by checking the box to the left of the theme name.

12) Make three observations about the pattern of volcanoes in North America.

13) The USGS wants you to determine the relationship of earthquakes and volcanoes. Examine at least three different places around North America and investigate the spatial relationship between earthquakes and volcanoes. Do volcanoes and earthquakes occur in the same places? Include the three places you examined, your conclusions about the relationship, and why you believe the relationship either exists or does not exist.

Single click on the earthquakes theme so that it becomes raised up, or "active."

Click on the tables tool in Global GIS Tools to access the table--the "I" part of GIS, that is, the information in the table.

Each row in the table represents one earthquake in the dataset.

14) Look in the upper left part of your screen under ArcView GIS. How many earthquakes are recorded in this dataset?

15) Approximately how many earthquakes are recorded during an average year? Show how you determined this answer.

Click on the "magnitude" field and sort it in descending order. Navigate to the top of the table and click on the row containing the earthquake with the highest magnitude to select it. You may have to select the black selection arrow to select a row. The row will appear in yellow.

16) What is the magnitude of this earthquake?

Close the table. In the Global GIS Tools box, on the right side of Viewing Tools, go to "More Tools." Select the "Zoom to Selected" tool in the Global GIS Tools box:
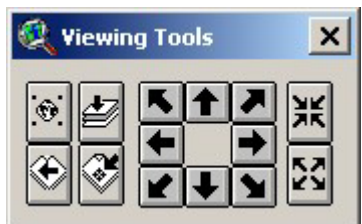
Use the "zoom into center" button a number of times to zoom into your selected earthquake.

Turn on the themes political boundaries, and political boundary labels.

17) In which country did the largest earthquake occur?

Access the earthquakes table again and clear your selection.

Select the field "km" in the table. This represents the depth of the earthquakes in kilometers underneath the surface.

Click on the "km" field and sort it in descending order ▤. Navigate to the top of the table and click on the row containing the earthquake with the greatest depth to select it. ▶ ▶ ❶ The row will appear in yellow.

18) What is the depth of this earthquake?

Close the table and select the "Zoom to Selected" tool in the Global GIS Tools box ◈. Use the "zoom into center" button ✖ a number of times to zoom to your selected earthquake.

19) In which country has the deepest earthquake occurred?

20) In what continent is this country?

Pan ✋ to the United States.

21) You are asked to list in your USGS report that states you consider to be most vulnerable to earthquakes. List the top three states, and your reasons for including them.

Pan ✋ to the western side of the United States to the area of California. You could turn on the US Counties theme to see California counties all in the same color.

22) You receive an email from the USGS seismologists that ask you to determine four major areas of California where most earthquakes occur. What four areas will you list in your report?

Turn on major cities and turn off earthquakes. You might have to zoom in to see the labels.

Zoom to the center of the Pacific Coast of the United States, central California and Nevada.

Use the "Create Profile" tool [Create Profile] and draw a line from Carson City, Nevada, southwest to San Francisco, California. Choose to profile the data set "elevation."

23) Describe how the land elevation changes from Carson City to San Francisco.

Turn earthquakes back on.

24) Examine the earthquakes across your profile. What kind of terrain is more prone to earthquakes—valleys or mountains? Why?

Zoom out to California, turn off earthquakes, and note the location and names of the 6 major cities.   Turn earthquakes back on.

25) Of the 6 major cities in California, indicate in your report to the USGS the 2 cities that you consider to be the most vulnerable to an earthquake. Indicate why you consider them to be the most vulnerable.

26) Congratulations! You have completed the first part of the assignment and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

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——————— **Part 2: Digging Deeper**

In this part, you will examine the relationship between earthquakes and cities, and investigate earthquakes in a specific area in California.

Click on the Advanced Interface button at the bottom of the Global GIS Tools window. You will notice the additional tools now at the top of your computer screen.

Make major cities the active theme by clicking once on it. Clear any previous city selections .

Make earthquakes the active theme by clicking once on it. Clear any previous earthquake selections .

Under the Theme pull-down menu, press "Select By Theme" to discover how many earthquakes are within 50 kilometers of major cities.
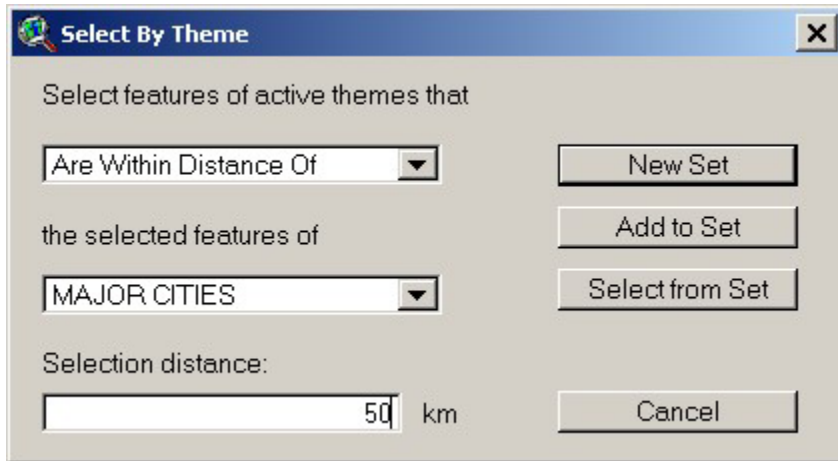
Examine the resulting earthquake table . Look in the upper left of your computer screen.

27) How many earthquakes resulted from your query of the data?

28) What percentage of North American earthquakes are within 50 kilometers of major cities? Show how you determined this answer.

29) Make 3 observations about the pattern of earthquakes near California cities.

30) Compare the amount of earthquakes in Alaska versus California. Which state would you say receives the most earthquakes?

31) Which state would you say receives the most publicity about earthquakes in newspapers, television, radio, and on the Internet?

32) Compare your answers to the two previous questions. Did you write a different answer for the two questions? If so, why do you suppose this is the case?

As you move around the map, notice the latitude and longitude values to the upper right of the view (map) window.

Zoom to the earthquakes at 36.91 north latitude and 121.65 west longitude. Set the scale to 1:10,000. There will be two earthquakes at this exact spot.

33) Identify these earthquakes and indicate their magnitudes:

Click on "Global GIS Help" **Global GIS Help** in Global GIS Tools. Go to "Datasets" and select the earthquakes theme.

34) What field name contains the *time* when the earthquakes occurred?

Based on this information, go back to your map and examine the time when the three earthquakes occurred. List the earthquakes below in the order of their occurrence.

35) Were these earthquakes associated with the same seismic event? Explain your answer.

36) What is an aftershock?

37) Do you think the earthquakes you are examining include an aftershock? If so, which earthquake was an *aftershock* of the first?

38) Notice the "feature search radius settings" near the bottom of the Global GIS Tools window.

Feature Search Radius Settings
☑ Draw radius on map during rep
Km 50 ⊞ Drag a new radi
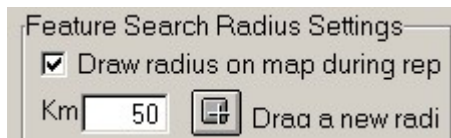
Drag a new search radius – a circle -- from these two earthquakes until the circle just touches the Pacific coastline. This should be a 13 kilometer search radius, and the number 13 should appear in the kilometers field.

Generate a map report and click on the earthquake on the map again. Print the map report of this area.

39) Summarize what this report tells you in your own words.

You need to assess possible damage from future earthquakes in this region in your report, in terms of roads, airports, and population.

40) What is the 1998 population within 13km of these earthquakes?

41) Who, in your opinion, are the most vulnerable segments of the population to earthquakes?

42) How far is the nearest road from the earthquakes?

43) Do you think roads could be damaged by earthquakes? Name three ways roads could be damaged.

44) How could the disruption of transportation affect evacuation from an earthquake and rescue operations?

45) What is the name of the nearest airfield to these earthquakes? How far is it from the earthquakes?

46) Do you think an airfield could be damaged by an earthquake? Describe three ways air services could be disrupted.

47) Congratulations! You have completed the second part of your mission and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

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In this part, you will investigate one of the worst earthquakes ever to strike the United States, assess critical infrastructure, and assess the relationship of fault lines to earthquakes.

The USGS has indicated that your report needs to include an analysis of the following earthquake: In October 1989, as over 62,000 fans filled Candlestick Park for the third game of the World Series baseball game and millions of San Francisco Bay Area workers were commuting home, a major earthquake struck. This was the Loma Prieta Earthquake, damaging many neighborhoods in San Francisco and Oakland, and collapsing a major portion of an interstate highway in Oakland, killing many of the drivers.

Make themes you have been working with the active theme by clicking once on it. Use shift-click to select multiple themes. Clear any previous selections .

Open the earthquake table .

Query ⌖ the table to find the Loma Prieta earthquake by its date and magnitude, as follows. Be sure to enter the information by clicking on the field names and equals sign.
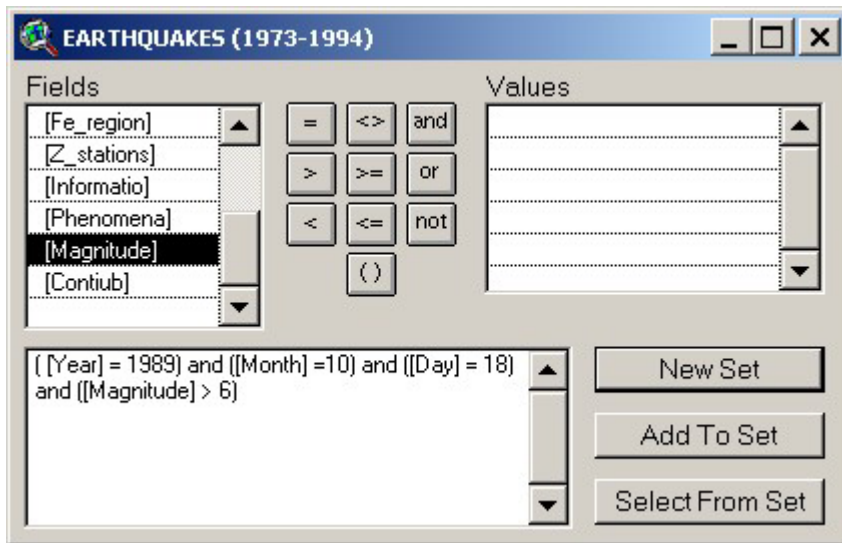
Zoom to the Loma Prieta epicenter at a scale of 1:1,000,000. The scale is in the upper right of the map. You can type in the exact scale as 1000000 if you wish in the scale box.

48) In what part of California did this earthquake occur?

49) Use the identify button 🛈 with the US Counties theme active to answer the following: In what county did the earthquake occur?

50) What direction from San Francisco was this earthquake's epicenter?

51) Use the measure tool 📐, answer the following. How far was the epicenter from San Francisco?

52) Based on what you just measured, discuss how an earthquake occurring many miles from San Francisco and Oakland could have caused damage in those cities.

Earlier, you considered the disruption that earthquakes pose to critical infrastructure. Turn on the airfields theme and name the nearest airfield to the earthquake.

53) Use the measure tool 📐 to measure the distance to this airfield.

54)   Find the airfield at latitude 37.36 north and 121.93 west, the nearest international airport to the epicenter. What city is the airport associated with?

55)   Have you ever flown into this airport? Ask to find out if any of your classmates have flown into this airport.

56)   Make roads, railroads, and utility lines visible. Make at least four observations about the proximity of these features to the earthquake.

57) Have other earthquakes occurred in this area of California, or was the Loma Prieta earthquake an isolated case?

58)   Turn on the US Faults theme and discuss the relationship between earthquakes in this part of California and fault lines.

59) Based on your investigations, indicate in your report to the USGS what you consider to be the two main reasons why this earthquake in October 1989 caused more damage and death than others in this area.

60) Do some research on the Loma Prieta earthquake and indicate your findings below.

61)   How does your research enhance what you learned about Loma Prieta through GIS?

Next, you will examine faults in relationship to earthquakes throughout North America.

Turn off all themes except faults, Alaska faults, US faults, earthquakes, and the shaded relief base.

Zoom out to all of North America using the globe symbol on the Global GIS Tools menu.

It is difficult to detect the relationship of earthquakes and faults, because of the large number of earthquakes. Reduce this number by clicking on "earthquake tools" in your Global GIS window. Show magnitudes between 6 and 9, as follows:
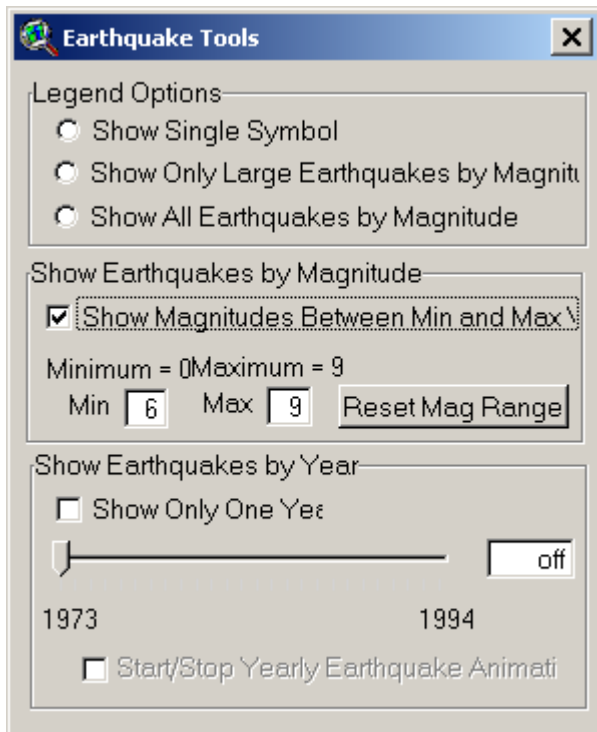
62) Describe the relationship between fault lines and earthquakes. Consider these questions in your narrative: Do earthquakes usually, or always occur near fault lines? Do earthquakes ever occur away from fault lines? If so, where? Do you think this map shows ALL of the faults in North America, or just a few? How does this affect your answer?

63) Turn on earthquakes between 4 and 9, instead of 6 and 9. Does this affect your answer, above? Why or why not?

64) Turn on cities. Discuss the relationship between cities and fault lines for your report to the USGS.

65) Congratulations! You have completed the third part of the assignment and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

─────── **Part 4: Investigating Your Community**

In this part, the USGS needs you to report on your own community's vulnerability to earthquakes.

Make the themes you have been working with the active theme by clicking once on it. Use shift-click to select multiple themes. Clear any previous selections using the clear selection tool ▣.

Zoom [Viewing Tools] to the state where you go to school (or your country if you live in Canada, Mexico, or Central America).

Make earthquakes the active theme by single clicking on it.

Label the magnitudes of the earthquakes.

66) In what country do you live?

67) In what state or region do you live?

68) Describe what you consider to be the major natural hazards faced by your community, and where you consider earthquakes to be in this list of hazards.

69) Describe the pattern and the number of earthquakes in your country, state, region, and community.

70) Use the select feature button to draw a box around the earthquakes that are in your region or state. After selecting the earthquakes, access the table. Look in the box in the upper left that indicates how many earthquakes are selected. How many earthquakes occurred in your selected region? Include a description of how much land you included in your selection box in your answer.

71) How do the pattern and number of earthquakes in your area compare to what you learned earlier about the pattern and number of earthquakes in Alaska and California?

Examine the earthquake map theme legend.

72) What is the range (minimum and maximum) of earthquakes that you are examining?

In the Global GIS Tools box, select the Earthquake Tool.

Click the "Show Magnitudes Between Min and Max" button and set the minimum magnitude to 6 and the maximum to 9. Press "Reset Mag Range" to reset the map, as follows:
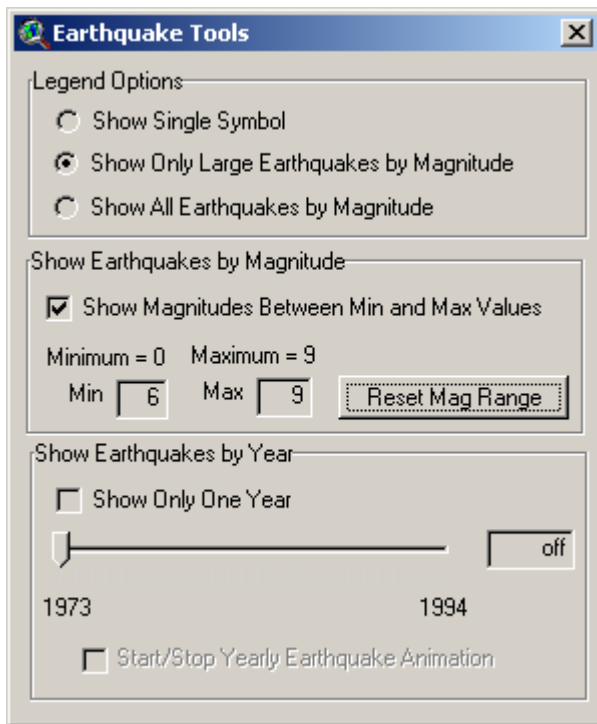

73) Where do most of the large (at least magnitude 6) earthquakes occur?

74) Do the large earthquakes have the same pattern of occurrence in North America as those that you examined earlier that included magnitude 4 and 5 earthquakes? Why or why not?

Zoom closer to your own community at a scale of approximately 1:700,000.

75) Now that you know how to move to specific earthquakes, generate a search radius, as follows:
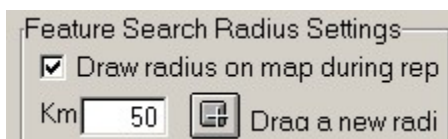
Next, generate a report [image], generate a report for the earthquake nearest your community. Print the report and make at least five observations for your report for the USGS about the vulnerability of your own area—its population, roads, airfields, dams, and other critical infrastructure.

76) Describe the earthquake nearest your community: Indicate the location of your school and community area, the direction from your school, the date it occurred, the magnitude, the depth, and the time of day it occurred.

77) Does anything surprise you about the earthquake event? Do you remember the earthquake? Did it cause any damage? Ask someone in your community to determine if they remember it; if you can find someone, indicate their response. If not, do some research on the earthquake and report the findings.

78) Congratulations! You have completed the fourth part of the assignment and are contributing much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

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──────── **Part 5: Earthquakes Everyday**

In this part, you will examine earthquakes by country in North America, and compare recent earthquakes to your existing data.

Make the themes you have been working with the active theme by clicking once on it. Use shift-click to select multiple themes. Clear any previous selections using the clear selection tool .

Make political boundaries and political boundary labels visible by checking the small boxes to the left of the theme names.

79) What country will you list in your report to the USGS that appears to suffer the most earthquakes?

80) Name two reasons, based on your observations of the map, why more earthquakes occur in this country than any other.

Make US Counties visible. With this map theme, notice that each state's counties are one color.

81) What state will you indicate to the USGS has the most earthquakes?

82) Name two reasons why you believe more earthquakes occur in this state than any other.

83) Did any US states experience *no* earthquakes? Give two reasons for your answer.

84) Change the legend from magnitude that you have been analyzing to examine the depth ("km" field) of earthquakes. Do this by double-clicking on the theme name to pull up the legend editor. Change the field name to depth, as follows:
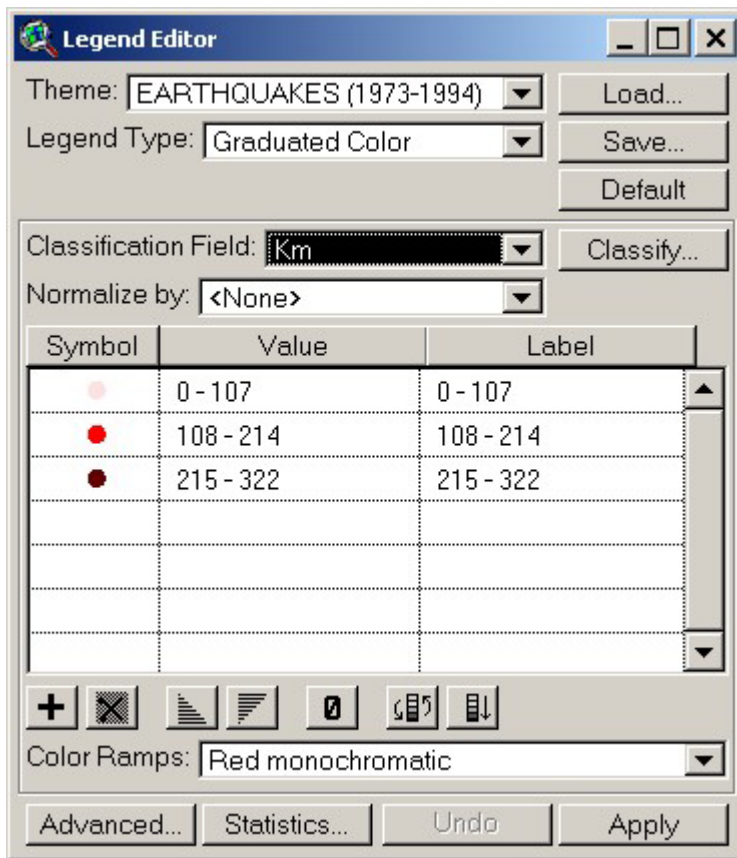
Use this new legend by clicking on Apply.

Your new map represents the depth under Earth's surface at which the movement occurred, in kilometers underneath the surface.

85) Describe the pattern of the depth of the earthquakes and their distribution across North America.

86) Is there a relationship between magnitude and depth? Why or why not?

87) What is the relationship between magnitude to the plate boundaries? Why? You may need a reference for plate boundaries on a map, in a textbook, or on the Internet.

88) What is the relationship between depth and the plate boundaries? Why?

89) Are certain types of plate boundaries associated with certain earthquake magnitudes and depth? Summarize what you know and can find out about this topic.

Minimize your GIS session.

Access the USGS National Earthquake Information Center by using an Internet browser. This is the site in Golden, Colorado, that collects seismic information from all over the world.

http://neic.cr.usgs.gov

Select "Current Worldwide Earthquake List."

```
2003/08/02  11:52:26   51.31N   150.41E  539.9   4.4   SEA OF OKHOTSK
2003/08/02  10:18:37   42.98N    17.77E   10.0   4.7   BOSNIA AND HERZEGOVINA
2003/08/02  06:31:11   37.64S   175.83E  217.0         NORTH ISLAND OF NEW ZEALAND
2003/08/02  02:43:09   18.24S   177.91W  401.6   4.5   FIJI REGION
2003/08/02  00:53:10   47.09N    74.96E   33.0   4.4   CENTRAL KAZAKHSTAN
```

Last 8-30 Days of Earthquake Activity * Large/Noteworthy Earthquakes in 2003

Maps of Current Worldwide Earthquakes * Maps and Lists of Current U.S. Earthquakes

Earthquake List Only * Earthquake Map Only (new window) * Comma-delimited Earthquake List

CLICK ON AN EARTHQUAKE BELOW FOR MORE INFORMATI

90) Examine this list. How many days does this information cover?

91) Does the number of earthquakes surprise you? Why or why not?

92) Are you familiar with any of these earthquakes? Did you hear about any of them on the radio, the newspaper, or on the Internet?

93) How many earthquakes appear in the list? [a]

94) How many earthquakes occur each day?   Show your work.

95) Examine the information about the list on the NEIC web site. Does the list indicate ALL recorded earthquakes, or just the major ones? What is the cutoff criterion?

96) What percentage of earthquakes in the list occurred in North America? Show how you determined your answer.

97) Does the pattern of new earthquakes in North America fit the pattern you have been analyzing using your GIS tools and methods? Why or why not?

98) Indicate at least three things that you have learned about earthquakes in North America from this lesson to this point.

99) Indicate at least three things that you have learned about GIS in this lesson to this point.

―――――― **Part 6: Analyzing Recent Earthquakes**

Only users who have a full version of ArcView can continue with this section.

In this part, you will incorporate the recent earthquakes as recorded on the USGS National Earthquake Information Center into your GIS so that you can further analyze them.

On the site:

http://neic.cr.usgs.gov

There are choices at the end of the current earthquakes list. Select "comma-delimited earthquake list" to see it in the web browser window.

Using File, Save As, save the resulting file that appears in the list as a *plain text file* (not HTML, MS Word, or anything else) in an appropriate folder on your computer named "current.txt"

Back in your GIS session, access the project window by going to the Window pull down menu and selecting the APR file:
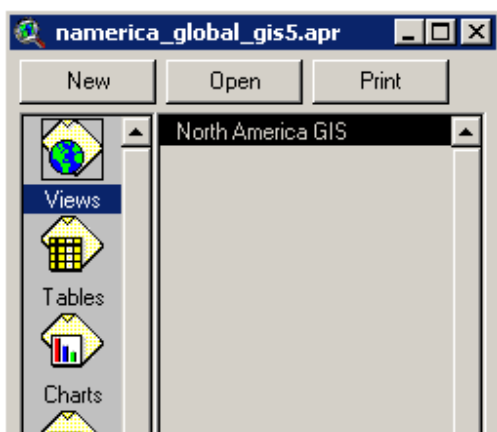
Click once on Tables in the **project** window.

Click Add.

100) What kind of file did you save above (.dbf, INFO, or .txt?) _____ **[b].**

101) In the lower left of the window, change the field to your answer in **[b].**

Find your text file in your folder and click OK.

Your table name should now appear in the list of tables along with a window with the data.

Go to the Window pull down menu. Click on the view window to make it active. This window should be named "North America GIS."

Go to the View menu on the top and select *Add Event Theme.* Find your table current.txt.

Think of the Cartesian coordinate system from mathematics. Draw it below.

102) Which field is "x" - longitude or latitude?

103) Which field is "y" - longitude or latitude?

In the dialog box, indicate the correct fields for latitude and longitude based on your answers above.

Make the new theme appear by clicking on the small check box next to it.

104) Access the table. How many earthquake epicenters are in your view?

105) How does this answer compare to your answer in **[a]** above? Why?

106) How does the spatial extent of the current earthquakes compare to the spatial extent of the North America data? Why?

107) Compare the pattern of earthquakes over the past week to the earthquakes from North America dataset.   How many earthquakes last week were in North America?

108) Do the new earthquakes follow the existing pattern? Why or why not?

109) Create a print of your map. All the information you wish to include in the final plot will be in a "layout." Zoom to your state or region. Determine which themes you would like shown in your plot.

Click on View -- > Layout.

Use the "T" button to add text to your layout.

Type in text. You should include the following items for your final map:

Your name(s).
Title of Map.
Date the map was created.

Print your layout to a printer by accessing: File--> Print.

110) Save your project using File→ Save As. Place it in an appropriate folder. What is your project's name?

GIS allows for spatial data to be viewed in different map projections. Next, you will change the projection of your data so that you can examine North America's earthquakes from the west coast.

Change the "projection" under View-->Properties to a **custom** orthographic projection, with a central meridian of 120 west longitude and a reference latitude of 20 degrees north.

Using this new projection, answer the following questions.

111) How does this compare to your old projection?

112) Scroll your mouse in the view. Are the coordinates in the upper right still in latitude and longitude? Why or why not?

113) Congratulations! You have completed this part of the assignment and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

_____

Only users who have a full version of ArcView can continue with this section.

————— Part 7: Earthquakes Respect No Boundaries

In this part, you will determine how many earthquakes occurred in each country through advanced GIS investigations.

The USGS says they need to focus research on the countries that contained the most earthquakes from 1973-1994.   How will you find this information? To solve this problem, first examine the table associated with the earthquakes 🖩.

114) Does this table indicate which country the earthquakes occurred in?

Therefore, you need to join the country information from the administrative boundaries file to the earthquakes data so that you can determine which earthquakes were inside each country.

First, save your project again.

Make themes you have been working with the active theme by clicking once on it. Use shift-click to select multiple themes. Clear any previous selections .

Go to the File-->Extensions menu.

Add the "GeoProcessing" extension. This adds a choice to the "view" menu.

Access the geoprocessing extension by pulling down: View--> GeoProcessing Wizard. This is the new menu choice that you added by accessing the geoprocessing extension.

Go to: Assign Data by Location, and click Next.

Next: Assign data **to** earthquakes **from** administrative boundaries.

115) Examine the earthquakes table. What new fields have been added?

Click on the field "admin_name".

Go to Field --> Summarize. Give the resulting file and appropriate name (such as quakesbycountry.dbf) and location and click "OK". Do not fill out anything else in the dialog box.

Examine your new table. Sort the table on "count".

116) What does the count in the FIRST row of the summary table represent?

117) Which administrative area had the most earthquakes? Why?

118) Does this match what you expected? Why or why not?

119) How many were there in that administrative area?

120) Go to the map and access the administrative boundaries theme. Find out where this state is, and indicate the pattern of earthquakes there.

Go back to your quakesbycountry table.

121) What state in *Mexico* experienced the most earthquakes?

122) Go to the map and access the administrative boundaries theme. Find out where this state is, and indicate the reasons for the frequency of earthquakes there.

124) Which province or territory in **Canada** experienced the most earthquakes?

125) Go to the map and access the administrative boundaries theme. Find out where this area is, and indicate the reasons for the frequency of earthquakes there.

126) What administrative areas in **the Caribbean Sea** experienced the most earthquakes?

127) Go to the map and access the administrative boundaries theme. Find out where this country is, and indicate the reasons for the frequency of earthquakes there.

128) Were any states in the USA without earthquakes? Why? Include in your answer how you found out this information.

129) Were any states in Mexico without earthquakes? Why?

130) Were any provinces or territories in Canada without earthquakes? Why?

Save your project, close your project, and exit ArcView.

131) Congratulations! You have completed the assignment and are ready to submit your results to the USGS. You have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

Most surprising:

Most interesting:

Most significant:

132) Indicate at least three things that you have learned about earthquakes in North America from this lesson to this point.

133) Indicate at least three things that you have learned about GIS in this lesson to this point.

134) Give a presentation on earthquakes in North America to your class, school, or community group. Include in your presentation:

--Why earthquakes are a serious international natural hazard.
--Where earthquakes occur in North America
--The relationship of cities, volcanoes, fault lines, and other features to earthquake epicenters
--How GIS can aid in analyzing earthquakes and other spatial phenomena.
--What you think the national and international community should do about earthquake preparedness.

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Loma Prieta, California, Earthquake October 17, 1989. Crack system near Summit Road, half a mile southwest of Highway 17. View is northwest. A wide zone of dominantly extensional cracks passes several feet in front of the house. Figure 10-A, U.S. Geological Survey Circular 1045. Circular-1045 (http://130.11.57.28/ci1045.htm), Digital File:pla00036, ID. Plafker, G. 36