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Earthquake Hazards Program

Where are the Fault Lines in the United States East of the Rocky Mountains?

Introduction

This message is intended for people who inquire where the fault lines are in some particular state east of the Rocky Mountains. Most such inquiries are actually stimulated by interest in earthquakes and earthquake hazards instead of geologic faults. Accordingly, what follows is slanted toward earthquakes. I've tried to make the message as non-technical as I can, so that it will be useful to the largest number of people. If you already have some background in geology, you might want to skim the early sections and concentrate on the last section titled Sources of Information.

The next section (Faults East of the Rocky Mountains) tells you where to find maps that show the locations of fault lines east of the Rocky Mountains. However, as I'll explain later (Faults and Earthquakes East of the Rocky Mountains), fault lines are not a particularly reliable guide to earthquakes or earthquake hazards east of the Rockies. The earthquakes themselves are the best guide. The last section (Sources of Information) describes various books, maps, and World Wide Web pages that show earthquake locations and estimates of earthquake hazards. Most of these books and maps should be available in large libraries, particularly libraries of universities that have geology departments. I'll also tell you where to buy copies yourself.

Faults East of the U.S. Rocky Mountains

Faults are different from fault lines. A fault is a three-dimensional surface within the planet Earth. At the fault, rocks have broken. The rocks on one side of the fault have moved past the rocks on the other side. In contrast, a fault line is a line that stretches along the ground. The fault line is where the fault cuts the Earth's surface. Faults come in all sizes, from small ones whose short fault lines you can see in a single road cut, to huge faults whose long fault lines can be seen best in pictures taken from orbiting satellites. Any particular block of the Earth has room inside for more small faults than big ones, so most faults are small. On continents, faults are everywhere, of all sizes, and they formed at many different times during the Earth's long history.

The largest and most important faults in each state are usually shown on the state's geologic map. A geologic map shows the locations of rocks of different kinds and ages. Because the geologic map shows the rocks that are exposed at ground level, the map also shows fault lines. However, many faults are entirely buried and do not reach ground level. Therefore, these buried faults have no fault lines, and they are usually not shown on geologic maps. If a buried fault is known at all, information about it is usually published in technical articles in geological journals.

Just as the U.S. government has a U.S. Geological Survey to serve the needs of the entire country, each state has a state geological survey or a state geologist to serve the citizens of the state. Most state geological surveys sell copies of the geologic maps of their states. Prices range from a few dollars to a few tens of dollars, depending on the size of the state and the complexity of its geology. The scales of the state geologic maps vary, and so do the sizes of the maps. Most are brightly colored sheets of paper several feet long and several feet wide. To contact any state geological survey or state geologist, see Sources of Information below.

Faults are typically shown on geologic maps as black lines. Be warned that, east of the Rockies, faults are usually not visible to a person standing on the ground. Partly that's because faulting breaks rocks and tends to grind them into small bits that decompose faster than the nearby, unfaulted rocks. The result is that most fault lines are obscured by thick soils. That's especially the case in the more humid eastern states, because moisture speeds up the decomposition. In the northern states, fault lines and the adjoining rocks are also likely to be covered by sand, clay, or gravel that were left by melting glaciers. Thus, in most places east of the Rockies, the presence of a fault is inferred by a geologist because rocks exposed here and there on both sides of the fault would usually not be found so close together. The geologist infers that the once-distant rocks have been brought close together by vertical or horizontal movement on a fault.

Earthquakes East of the U.S. Rocky Mountains

Earthquakes occur when the two sides of a fault slip suddenly past each other. East of the Rockies, most earthquakes probably occur by new slip on existing faults. The earthquake is generated when the two sides of the slipping part of the fault grind against each other and send out shock waves or vibrations. The vibrations travel through the Earth and, if they are strong enough, they reach ground level, and can shake and damage any man-made structures there. In general, the bigger the patch of the fault that slips, and the more it slips, the bigger the earthquake. Big faults can include big slipping patches and make big earthquakes. As explained earlier under Faults East of the Rocky Mountains, there are more small faults than big ones, and there are more small earthquakes than big ones.

The size of an earthquake is typically measured in two ways: magnitude and intensity.

Most earthquakes east of the Rockies are too small to be felt or to cause damage, and most earthquakes large enough to be felt are still too small to cause damage. Damaging earthquakes east of the Rockies are rare. Of those that do damage buildings or other man-made structures, most cause only slight, localized damage with few injuries. However, the U.S. east of the Rockies is such an enormous region that, every few years, even one of the rare damaging earthquakes can occur somewhere.

Faults and Earthquakes East of the U.S. Rocky Mountains

In general, east of the Rockies, individual known faults and fault lines are unreliable guides to the likelihood of earthquakes. In California, a large earthquake can generally be associated with a particular fault because we have watched the fault break and offset the ground surface during the earthquake. In contrast, east of the Rockies things are less straightforward, because it is rare for earthquakes to break the ground surface. In particular, east of the Rockies, most known faults and fault lines do not appear to have anything to do with modern earthquakes. We don't know why. We do know that most earthquake locations cannot be measured very accurately east of the Rockies. Earthquakes typically occur several miles deep within the Earth. Their locations, including their depths, are usually uncertain by a mile or more. Although the larger faults extend from their fault lines downward deep into the Earth, their locations at earthquake depths are usually wholly unknown. The uncertain underground locations of earthquakes and faults make it terrifically hard to determine whether a particular earthquake occurred on a particular known fault. We also know that there are many faults hidden underground that are large enough to generate damaging earthquakes, but which are also too small to extend from earthquake depths all the way up to ground level where we have the best chance of seeing the faults. These hidden faults are likely to be at least as numerous as the faults we know about. Accordingly, an earthquake is as likely to occur on an unknown fault as on a known fault, if not more likely. The result of all this is that fault lines east of the Rockies are unreliable guides to where earthquakes are likely to occur.

Accordingly, the best guide to earthquake hazard east of the Rockies is probably the earthquakes themselves. This doesn't mean that future earthquakes will occur exactly where past ones did, although that can happen. It means that future earthquakes are most likely to occur in the same general regions that had past earthquakes. Some future earthquakes are likely to occur far from past ones, in areas that have had few or no past earthquakes. However, these surprises are not too common. Most earthquakes tend to occur in the same general regions that are already known to have earthquakes.

Even if we could pin an individual earthquake on an individual fault, that would still be only part of the answer we want. There is, in general, no reliable way to know where or when the NEXT damaging earthquake will occur, and that is the earthquake that is of the greatest interest to society.

Sources of Information

State Geological Surveys:

As mentioned earlier under "FAULTS ...", each state has a state geological survey or a state geologist. The state surveys sell geologic maps of their states. Many state surveys also have booklets on the earthquakes of their state, as well as lots of other information on their state's faults, rocks, minerals, general and environmental geology, natural resources, and natural and environmental hazards. Your state's geological survey or state geologist can tell you what books, maps, and other information are available, how to obtain them, what they cost, and which ones are free.

U.S. Geological Survey:

State Earthquake Maps:

During the late 1970's and throughout the 1980's, the USGS published a series of black and white maps showing the earthquakes of each state. Each map shows one state with the locations of its earthquakes, at a scale of 1:1,000,000 (1 inch on the map represents about 16 miles on the ground, and 1 cm on the map represents 10 km on the ground). The map also contains a list of the earthquakes, their sizes, their locations, when they occurred, and damage descriptions for the larger earthquakes. Most maps are about the size of the top of a desk, although maps of big states and states with unusually many earthquakes can be on two sheets of paper instead of one. Each map is titled "Seismicity of the state of XXX". All the maps were published in the USGS map series Miscellaneous Field Studies Maps. You can inquire about price and ordering information at 1-888-ASK-USGS. Copies might be in local libraries.

Earthquakes of the Whole U.S.:

In 1993, Carl Stover and Jerry Coffman published USGS Professional Paper 1527, "Seismicity of the United States, 1568-1989 (Revised)". You can inquire about price and ordering information at 1-888-ASK-USGS. Copies might be in local libraries, particularly any libraries that are official repositories of USGS publications. This 418-page book summarizes all damaging earthquakes that are known to have occurred in the U.S., starting with the first settlements in a particular area and ending at the end of 1989. Each state's damaging earthquakes are summarized in one chapter, with a page-sized map showing locations and sizes of the earthquakes, a list of them, and short summaries of their damage. Bits and pieces of the book are reproduced in some of the state pages on this site.

U.S. Earthquake Hazards:

Every few years the USGS produces a national map of seismic hazards. The current map was published in 2002. The maps are at a scale of 1:7,000,000 (1 inch on the map represents about 110 miles on the ground, 1 cm on the map represents 70 km on the ground), so there is not much detail for any particular state. This map is probably your best single reference for earthquake hazard in a particular state, but it is technical in nature because it is aimed at engineers who design buildings and other structures. You can examine copies by going to our home page, and then to the site index, to any state's "Earthquake History", and to "USGS National Seismic Hazard Mapping Project". You will find a series of U.S. maps that show estimates of the likely levels of shaking that can be anticipated from earthquakes in the next 50 years. The estimates are expressed in terms of engineering measures of shaking, but you can make sense of them qualitatively, by comparing the values that are shown for the area of your interest with the values that are shown for other parts of the country with which you might be familiar. In general, areas with higher hazard are shown in warm colors, and areas with lower hazard are shown in cool colors. Of course, no one can predict the future, and earthquake prediction remains beyond our present knowledge, so these maps express the hazard as probabilities. For example, some of the maps show the strength of shaking that has one chance in ten (a probability of 0.10) of being exceeded in the next 50 years. Perhaps the most widely used map is the one listed first, "Peak Acceleration (% g) with 10% Probability of Exceedance in 50 Years".

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