IN FOCUS

Assessing Earthquake Hazards and Risk—What Are the Implications for the Commonwealth?

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Why study earthquakes?

Although for many people earthquakes may seem "out of sight, out of mind," they should not be ignored. Earthquakes have caused extensive damage and loss of life in the United States and abroad. Homeowners, businesses, emergency-response planners, structural and construction engineers, and government officials need scientifically sound assessments of earthquake hazards and risk. These assessments are used to establish design specifications for earthquake-resistant buildings and bridges and rates for insurance premiums.

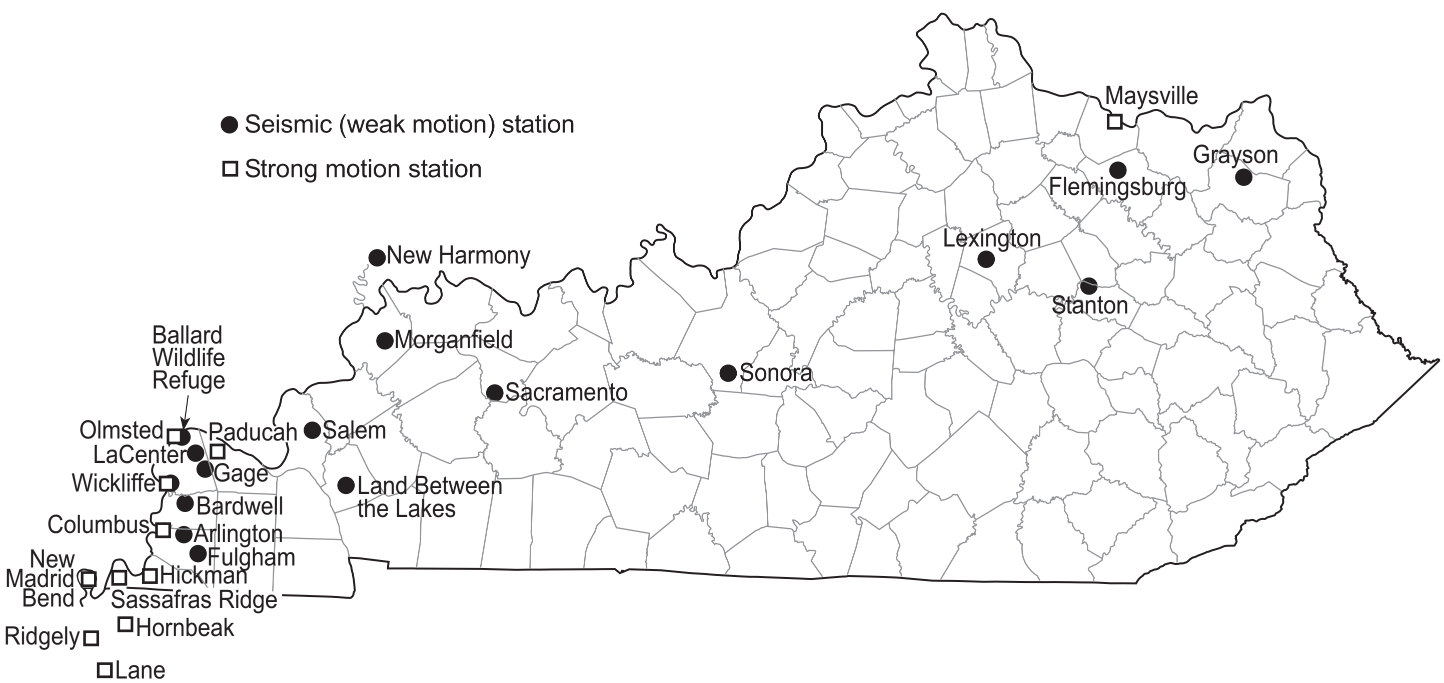
In California, many faults are at or near the surface, earthquakes are frequent, and there are many data for researchers to assess. In contrast, in the central United States, faults are deeper, earthquakes are less frequent, and there are fewer data. Earthquakes in California have been studied for almost 100 years using thousands of elaborate instruments. Extensive study of earthquakes in the central United States has been more recent, but a great deal of knowledge has been acquired in the last 20 years, and it has important implications for Kentucky.

Earthquake research in Kentucky

The Kentucky Geological Survey (KGS), in cooperation with the University of Kentucky (UK) Department of Geological Sciences, has been at the forefront of earthquake research in Kentucky. A key objective has been to provide information to public and private decision-makers preparing for infrequent but high-impact earthquakes. Western Kentucky and the New Madrid Seismic Zone, and more recently the Wabash Valley Seismic Zone, are the focus of this research.

A wealth of data has been acquired from the Kentucky Seismic and Strong-Motion Network, established in late 1980 and jointly operated by the Department of Geological Sciences and KGS. The network has 21 stations that can monitor any earthquake occurring in or around Kentucky with a magnitude greater than 2.0, as well as major earthquakes in the central United States and many around the world. The strong-motion network is designed to record ground motion from strong earthquakes in the New Madrid Seismic Zone, which stretches from just west of Memphis, Tenn., into southern Illinois. The Kentucky strong-motion network is the largest in the United States outside of California, and we have just installed seismometers at Sassafras Ridge, in Fulton County, Ky., to a depth of 850 feet. This is the deepest seismometer east of the Rocky Mountains.

Since March 2002, near real-time seismic records for 10 stations across the state are available on the KGS Web site at www.uky.edu/KGS/geologichazards/geologichazards.html. This online access to data is valuable to researchers, as well as the general public. Its value became apparent as hundreds of people visited the site at the time of the magnitude-5.0 earthquake on June 18, 2002, whose epicenter was in the Evansville, Ind.–Henderson, Ky., area. The site was very popular again when a magnitude-2.9 earthquake struck on January 3, 2003; its epicenter was in New Haven, about



30 miles west of Henderson, Ky., and 25 miles northeast of Harrisburg, Ill.

Challenges in research

Geologists who study earthquakes (geophysicists and seismologists) face a great challenge, because earthquakes happen infrequently and without any advance warning. This makes estimating earthquake hazards and risk difficult. The task is further complicated by engineering and economic factors that also need to be considered.

The earthquake effect that has the most impact is ground motion, caused by waves created by an abrupt movement of a fault. Ground motion is usually expressed as a percentage of the acceleration of gravity (g). One g is 32 feet per second squared. Imagine a building or a bridge accelerating at that rate, or even a fraction of 1 g. This is equivalent to accelerating your car from a dead stop for a distance of 100 meters in 3.2 seconds. A ground-motion acceleration of only a fraction of 1 g in the horizontal direction can cause buildings to separate from their foundations or collapse—somewhat analogous to rapidly pulling a carpet from underneath someone who is standing; that person will most likely fall (Pipkin and Trent, 2001).

Seismic hazard maps and construction

Seismic hazard maps published by the U.S. Geological Survey (USGS) predict ground motion for different locations in the nation. These maps are the basis for seismic design found in the Recommended Provisions of the National Earthquake Hazards Reduction Program, the International Building and Residential Codes, and the American Society of Civil Engineers' national design load standard. The information on seismic-hazard maps is used by engineers and others in the design of residential and commercial buildings, bridges, highways, dams, and pipelines.

The information is important for safety reasons. It also has major implications for economic development. If the hazards are overestimated, unnecessarily stringent building standards may result, which increases construction costs and insurance premiums. This, in turn, can have a negative impact on economic development. Overestimation can be a deterrent to expansion or upgrading of existing facilities, as well as a deterrent to new businesses that might otherwise locate in a region. Underestimating hazards can pose safety problems, if communities are not adequately prepared to withstand the predicted impact of an earthquake. A balance based on sound science must be struck between safety and economic development.

The development of seismic hazard maps depends upon many factors, including the nature of the bedrock and soils. In the region of the New Madrid Seismic Zone, limestone and sandstone bedrock are covered by a thick blanket of unconsolidated sediments. The unconsolidated or loose sediments above the bedrock can amplify ground motion. Geologists can estimate the amplification that is expected.

The seismic hazard map currently used for seismic safety regulation shows the probabilistic ground motion with a 2 percent probability of being exceeded in 50 years. Produced by the USGS in 1996, the map predicts very high ground motion in the Paducah area of western Kentucky, even higher than some places in California that are more seismically active. This has been the subject of considerable debate and discussion among seismologists. This subject was a hot topic at a recent workshop held in Lexington, November 18, 2002, to discuss maps for seismic hazard and design. The workshop abstracts are published in a new KGS publication, "The Kentucky NEHRP Seismic Hazard and Design Maps Workshop: Proceedings" compiled by Zhenming Wang. A PDF file of this publication is available on the KGS Web site at www.uky.edu/KGS/pubs/lop.htm.

Research collaboration for the Commonwealth

Geologists at KGS and the UK Department of Geological Sciences are working with the Kentucky Natural Resources and Environmental Protection Cabinet; Kentucky Department of Housing, Buildings, and Construction; State Building Commissioner; Structural Engineering Association of Kentucky; USGS; and others to develop a realistic seismic hazard map for western Kentucky based on sound science. For more information about this and other areas of seismic research, please visit the KGS Web site at www.uky.edu/kgs, or contact John Kiefer, Zhenming Wang, or Ed Woolery at 859.257.5500 or by e-mail at zwang@kgs.mm.uky.edu, kiefer@kgs.mm.uky.edu, or woolery@uky.edu.

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