Ohio Geology

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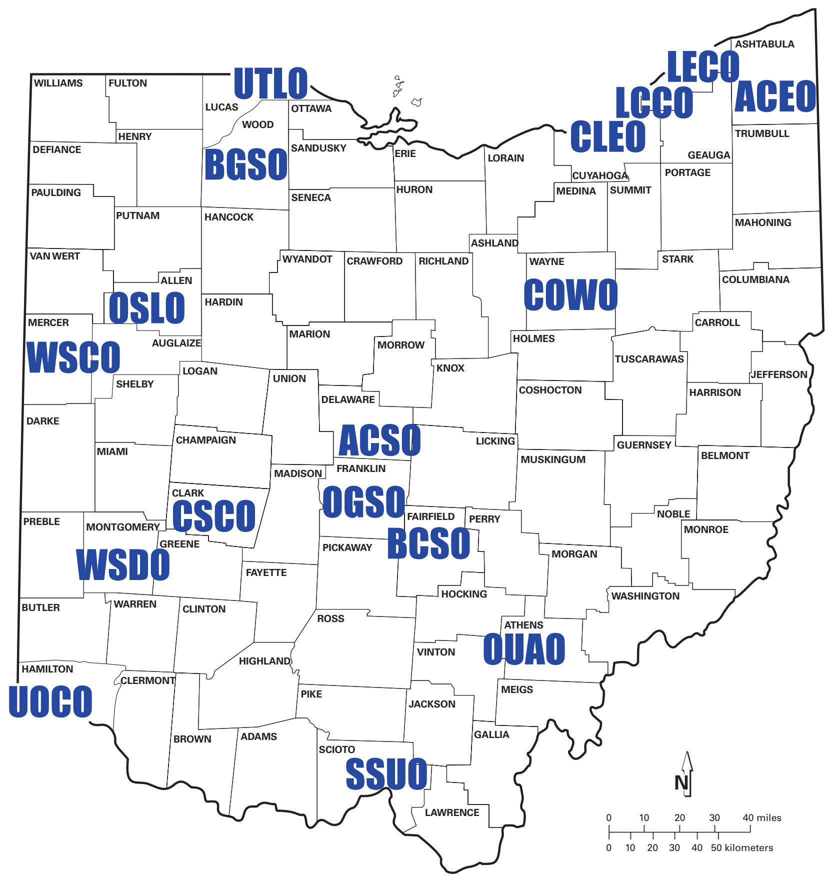
OHIOSEIS—THE OHIO SEISMIC NETWORK

by Michael C. Hansen, Senior Geologist & Ohio Seismic Network Coordinator

Although their physical and psychological effects may last for decades, earthquakes are among the most transient of geological phenomena. Earthquake waves pass through nearby locations in a matter of seconds and are gone forever. It may be years, decades, or even longer before another event is repeated in a particular location. In order to better understand earthquakes, it is necessary to capture a permanent record of these ephemeral waves so that an accurate location (epicenter), size (magnitude), depth, fault orientation and sense of fault movement, and many other parameters can be analyzed.

In 1999, the Division of Geological Survey organized a consortium of colleges, universities, and other institutions to host and operate modern digital seismograph stations for the newly created Ohio Seismic Network (OhioSeis). These 17 independently operated but interconnected stations provide continuous statewide monitoring for detection, location, and magnitude determination of earthquakes in Ohio and its border regions. This information is highly valued by the public; local, state, and federal government agencies; emergency planners; the media; and the geological community. Because earthquakes are publicly shared experiences that have a potential for destruction, there is an immediate demand for information about a particular event. In the long term, continuous monitoring results in a detailed database that permits intelligent planning for seismic-risk zonation, emergency preparedness planning, and scientific study of the structure of rocks deep beneath the surface of the state.

Recording and analyzing earthquakes is a relatively young science. The first seismographs were constructed between 1879 and 1890. Surprisingly, Ohio, a state with moderate seismic activity, was one of the first states to have a seismograph station. This station was put into operation in 1900 at St. Ignatius College (now John Carroll University) in Cleveland by Rev. Frederick L. Odenbach, S.J., a remarkable Jesuit priest who taught everything from English and philosophy to zoology and physics. Father Odenbach not only installed and operated a seismograph station but experimented with maintaining accurate time on his seismograms. At first he relied on a telegraph signal from the U.S. Naval Observatory and later on a radio signal to correlate with the accurate clock at the observatory. In 1909 Father Odenbach founded the Jesuit Seismological Service, a tradition of seismograph stations at Jesuit colleges and universities in the United States and Canada. The Seismological Observatory at John Carroll University operated until 1992.



ACSO Alum Creek (Ohio Earthquake Information Center)

OGSO	Ohio Geological Survey	**LCCO**	Lakeland Community College
ACEO	Ashtabula County EMA	**OSLO**	Ohio State University–Lima
BCSO	Bloom-Carroll Schools	**OUAO**	Ohio University
BGSO	Bowling Green State University	**SSUO**	Shawnee State University
CSCO	Clark State Community College	**UOCO**	University of Cincinnati
CLEO	Cleveland Museum of Natural History	**UTLO**	University of Toledo
COWO	College of Wooster	**WSCO**	Wright State–Celina
LECO	Lake Erie College	**WSDO**	Wright State–Dayton

Distribution and station codes of OhioSeis stations.

In 1927, Xavier University in Cincinnati established a seismograph station as part of the Jesuit network. This station continued operating until the late 1960's. A few other seismic stations have been intermittently active in Ohio. A station was established at Bowling Green State University in the 1970's and functioned until the mid-1980's. It is now once again active as part of the OhioSeis network. In the early 1980's, the University of Toledo installed a seismic station that continues to operate and is part of the OhioSeis network.

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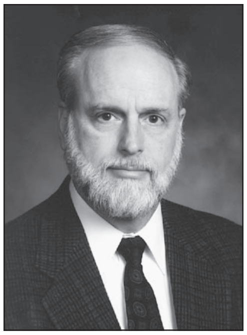

Thomas M. Berg, Division Chief and State Geologist

From The State Geologist...

Thomas M. Berg

OHIOSEIS—AN OUTSTANDING PARTNERSHIP BENEFITING OHIO CITIZENS

This issue of *Ohio Geology* focuses on the Ohio Geological Survey's development of the Ohio Seismic Network. After many efforts over the past quarter century, Dr. Michael Hansen has successfully established the seismic network named "OhioSeis." Citizens now have the benefit of a highly efficient and very effective monitoring system that will allow mapping and analysis of deep geologic structures in Ohio and more accurate delineation of earthquake-risk areas throughout our state. Most people do not consider Ohio a seismically risky state. What we need to understand is that, like other Midwestern states, earthquakes are not repeated often, but can be very high-impact events. Entire generations can pass with few serious events, but we cannot become overconfident and forget the devastating sequence of earthquakes during the winter of 1811-1812 near New Madrid, Missouri. In Ohio, we should not forget the 5.5 magnitude event of March 9, 1937, at Anna. The Ohio Department of Natural Resources now has a new capability to watch over the safety and welfare of Ohio's citizens and the state's infrastructure.

The Geological Survey would not have this capability without the generous and voluntary members of OhioSeis who, with Dr. Hansen, keep the system running. We are indebted to scientists at strategically located institutions across the state who volunteer time and computer equipment to make the seismic network function. I am proud to acknowledge the Ashtabula County Emergency Management Agency, Bloom-Carroll Schools, Bowling Green State University, Clark State Community College, the Cleveland Museum of Natural History, the College of Wooster, Lake Erie College, Lakeland Community College, The Ohio State University at Lima, Ohio University, Shawnee State University, the University of Cincinnati, the University of Toledo, Wright State University at Celina, and Wright State University at Dayton. I also extend my thanks to Dr. Larry J. Ruff at the University of Michigan for developing the low-cost system and to Ms. Candice E. Sherry of the Ohio Emergency Management Agency for obtaining grant funds from the Federal Emergency Management Agency.

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Angelena M. Bailey
1949-2000

It is with deep sorrow that we announce the death of Angelena ("Angie") M. Bailey on April 28, 2000, after a long and courageous struggle with cancer. Angie began her 23-year career with the Geological Survey in February 1978, as a typist in what was then the Subsurface Geology Section. From the beginning, Angie demonstrated that her work was of the highest quality. She was a very dedicated and loyal employee and involved in all aspects of the Survey. She served on numerous committees and took advantage of the opportunities to improve her job skills—as is evident by the many certificates and awards she received from various job-training classes and seminars. Angie became very proficient at several word-processing programs and readily taught other staff members the skills she had learned.

Angie's duties dealt largely with processing information about oil and gas wells in Ohio and responding to customer inquiries and requests. She became very knowledgeable about oil and gas information and was an integral member of the interdivisional Risk-Based Data Management System team that was responsible for computerizing this information. Angie's involvement in the oil and gas industry extended beyond work, as she was an active member of the Central Ohio Energy Affiliates, Association of the Desk and Derrick Clubs from 1986 to 1996.

Angie also served as the Geological Survey's coordinator for ODNR/American Red Cross blood-donor drives. In 1989, she received two Departmental awards in recognition of her continuing support of this program. In 1990, Angie received the Division's Employee of the Year award. This award is significant because recipients are selected from nominations submitted by fellow employees.

Angie truly enjoyed her years as a member of the ODNR and the Geological Survey families. She was always willing to assist any staff member or customer to the best of her ability. Angie's dedication, commitment, and unselfish devotion to her job and everyone she dealt with is witnessed by her many friends and lasting relationships. We will not forget her. Angie is survived by her two daughters, three grandchildren, her father, a brother, and a sister.

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The most intensive period of seismic monitoring in Ohio began in 1977 when the University of Michigan installed nine remote stations in western Ohio, in the vicinity of Shelby and Auglaize Counties, as part of a contract with the Nuclear Regulatory Commission (NRC). The purpose of this contract was to monitor seismic activity with regard to nuclear power plants that were being installed in the Midwest. The Anna Network, named after the Shelby County town that has suffered more earthquake damage than any other Ohio community, operated until 1992, when NRC funding was discontinued. In 1986, John Carroll University installed six seismic stations in northeastern Ohio in the aftermath of the January 31, 1986, earthquake (5.0 magnitude) that was centered just south of the Perry Nuclear Power Plant in Lake County. This network ceased operation in 1992 when the John Carroll Seismological Observatory closed.

During the late1980's, Ohio had as many as 16 seismograph stations in operation and enjoyed the capability of detecting and accurately locating most earthquakes in the state. However, even this multitude of stations left some areas of the state, particularly the southern half, without nearby stations and less than optimum potential for precise location of events. In addition, these stations were under the control and operation of three different institutions.

The 1992 closing of the Anna Network and the John Carroll Network essentially left Ohio with no in-state capability for detecting and locating small earthquakes. The state was dependent on a station at the University of Michigan, the single remaining Ohio station at the University of Toledo, and stations in northern Kentucky operated by the University of Kentucky for detection and location of small, local earthquakes. During this time the Survey was unable to respond authoritatively to citizen inquiries about perceived earthquakes. It is very possible that several small Ohio earthquakes occurred between 1992 and 1999 that were unrecorded or poorly located.

One example clearly illustrates this point. The Geological Survey of Canada (GSC) detected a small (3.2 magnitude) earthquake in northern Ohio on their southern Ontario stations on November 25, 1998. Because the Canadian stations are north of the epicenter and no stations to the south recorded the tremor, it was difficult for the GSC to get optimal triangulation for location of the event. The GSC preliminary location placed the event in northern Ohio approximately on the Summit-Medina County border. No reports from citizens or media were received by the Division of Geological Survey about this event. Telephone calls to police departments in the presumed epicentral area yielded no reports of an earthquake being felt at about 10 p.m. local time. The event remained puzzling until a few weeks later when a staff member noticed an article in her hometown newspaper, the Norwalk (Huron County) *Reflector*. The article, titled "Boom puzzles officials," clearly describes a small earthquake felt by residents in southern Huron and northern Richland/Crawford Counties. This area, which undoubtedly was the epicenter of the event, is more than 50 miles west of the preliminary instrumental location derived from seismic stations, all to the northeast. If a network of seismograph stations had been in operation in Ohio at that time, a more accurate instrumental location would have been possible soon after the event.

ESTABLISHMENT OF THE OHIO SEISMIC NETWORK

It has long been an objective of the Division of Geological Survey to have statewide coverage for detection and location of earthquakes in the state, in part to be able to respond to inquiries from the public about an unusual vibration or shaking that is perceived as a potential earthquake. Perhaps more importantly, geologists have begun to realize that Midwestern states, including Ohio, have the potential to produce damaging earthquakes. The record of more than 120 felt earthquakes in 200 years, 14 of which have caused moderate damage, indicates that Ohio does indeed have an earthquake risk. Because larger earthquakes are so infrequent, it is necessary to monitor small events in order to identify zones of activity and probable seismogenic faults. Perhaps eventually we will be able to evaluate the probable maximum size of a potential earthquake in seismically active areas of the state. Small earthquakes, including aftershocks from larger events, are therefore important in evaluating the seismic risk in a time frame of decades rather than centuries or millennia. In order to monitor these small events, seismic stations (preferably at least three stations for accurate location) must be located relatively close to the epicenter of the event.

When the Ohio Seismic Hazards Advisory Board was established by executive order in 1991 (see *Ohio Geology*, Summer 1993), one of the first goals of this organization was to establish a statewide seismic network. A major impediment to seismic monitoring has always been financial and, perhaps no less important, the availability of trained personnel to install and operate equipment and interpret data. Specialized, precision seismic instrumentation has always been expensive to purchase and costly to maintain. In addition, remotely located seismic stations must have their data telemetered, by dedicated phone line, radio transmission, or satellite links, to a central location for analysis and interpretation. In the early 1990's, when the Ohio Seismic Hazards Advisory Board made a recommendation for seismic monitoring to the governor's office, the cost was estimated to be about $50,000 per station; network telemetry would potentially cost an additional several thousand dollars per year. Furthermore, a seismologist and one or more technicians would be required to operate and maintain such a network. The seismic network proposal was not funded.

At about the same time, in the early 1990's, Dr. Larry J. Ruff, seismologist at the University of Michigan, who had been of assistance to the Division of Geological Survey when he directed the Anna Network, began developing a low-cost, seismic-monitoring system that could be used in high schools, colleges, and other educational institutions to record earthquakes from around the world and view the seismic waves in near-real time. This system employed a very sensitive, but inexpensive, broadband seismometer, a Macintosh computer to record and archive data, and software written by Dr. Ruff to make all of the components work together and to view seismograms in both near-real time and in archived files. Dr. Ruff set up several seismograph stations that used his system at high schools and colleges in Michigan. He named this first, small network MichSeis and concentrated heavily on the educational aspects of earthquake monitoring.

We have all been bombarded with examples of how technology developed for a specific purpose ends up having multiple uses or uses far removed from the original intent. Two recent but now commonplace technologies allowed Dr. Ruff to develop accurate and fully functioning seismic stations.

First, and perhaps now the most familiar technological advancement, was the widespread availability of the Internet through high-speed (T-1 line) continuous connections, which now exist at almost every college and university, many secondary schools, government agencies, and many businesses. With this technology, each computer in a seismic network can be linked to the Internet so that data from any station can be viewed or downloaded for analysis at any time. Data telemetry, which only a few years ago cost thousands or even hundreds of thousands of dollars per year, has become inexpensive.

The second problem to be solved by Dr. Ruff was that of accurate, standardized time. To locate earthquakes accurately, every seismograph in the world must be on the same time standard. This standard is Universal Time (UT). Special clocks that use a National Bureau of Standards time signal broadcast from Colorado (WWV) or, more recently, signals from global positioning system (GPS) satellites have generally been used as the timing device for seismic stations. However, specialized seismic clocks are expensive (about $3,000). In keeping with the theme of a full-capability, but inexpensive seismograph system, Dr. Ruff began experimenting with adapting hand-held GPS receivers—which had now become widely available in sporting goods stores for boaters, hikers, hunters, etc. at a cost of about $200—as a source of the required precise Universal Time signal. Dr. Ruff succeeded in developing software that locks the time signal from a GPS unit into the seismogram.

Dr. Ruff was able to develop a complete, continuously telemetered, research-quality seismic station for a cost of less than $6,000, which includes the cost of a top-of-the-line Macintosh computer and monitor. In essence, a seismic station could now be deployed for about a tenth of the cost of a similar station only a few years ago. Most importantly, telemetry and operating costs are nominal.

By 1997, several unrelated events and circumstances changed the perspective on earthquake monitoring in the state. The U.S. Geological Survey released a new generation of seismic-risk maps for the United States that more accurately depicted the potential for damaging earthquakes in some areas, including Ohio. These new maps indicated to the Federal Emergency Management Agency (FEMA) that Ohio should be considered as an earthquake-prone state and could qualify for funding under the National Earthquake Hazards Reduction Program (NEHRP).

In 1998, NEHRP funding from FEMA was granted to the Ohio Emergency Management Agency (OEMA) for earthquake mitigation in the state. The Division of Geological Survey and OEMA have been partners in the past in addressing earthquake problems in Ohio. The mutual goal of a statewide seismic network was of the highest priority for both agencies in order to determine the location and magnitude of local seismic events, communicate information to the public about earthquakes, and to assess the long-term seismic risk in the state. In cooperation with OEMA, the Division of Geological Survey assumed the responsibility of designing, implementing, administering, and coordinating a statewide seismic network.

Because of a modest amount of funding ($78,000), limited personnel, and the need for a continuous, high-speed Internet connection, it was decided that placement of seismic stations should initially be at colleges or universities where, in addition to the above considerations, there would be a professor of geology or another science who would operate and maintain the station on a volunteer basis. Each station was implemented as a cooperative venture—OEMA provided FEMA funding to the Division of Geological Survey to purchase the seismometer and other equipment, and the college or university purchased the Macintosh computer and provided the Internet connection. This arrangement permitted the installation of more stations than if the Division/OEMA purchased all equipment. Sites for placement of seismic stations were selected first on the basis of proximity to seismically active areas and in configurations that optimized triangulation of earthquake locations, and secondly on the willingness of the institution to commit to the cooperative agreement and, of particular importance, the enthusiasm of individual faculty to volunteer to operate the station.

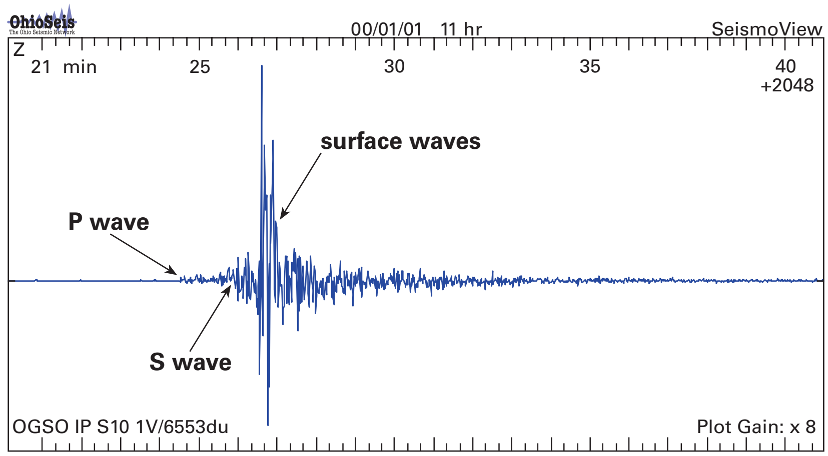
By the end of 1998, cooperative agreements with 14 institutions had been worked out and equipment had been purchased. Dr. Ruff conducted a training session in late December 1998 at the Ohio Emergency Management Agency headquarters in Columbus. At this session, each station operator received the equipment and was instructed in the setup and operation of the hardware and software. By the first week in January 1999, most stations were on line and operating.

IMPLEMENTATION AND OPERATION OF THE OHIO SEISMIC NETWORK

A significant challenge in the installation and operation of the OhioSeis network has been the fact that none of the station operators, including personnel from the Division of Geological Survey, are trained earthquake seismologists. Indeed, there are currently no active earthquake seismologists at any educational/government institution in Ohio. However, Dr. Ruff's choice of hardware, and his user-friendly software, are intended to be operated by individuals with little seismological background. Interpretation of seismograms, of course, requires experience and training, and Dr. Ruff has made a concerted effort through annual training sessions and posting of interpreted seismograms on his Web site (http://geo.lsa.umich.edu/MichSeis/) to provide essential information to station operators. He has developed a software program (Epilocator) that can be used to locate regional earthquakes and determine their magnitudes.

Although this system is inexpensive, comparatively easy to install and operate, and can be placed in fairly noisy locations, it performs remarkably well and is recording research-quality seismograms on a regular basis. OhioSeis stations have recorded regional earthquakes in the 3.0- to 3.9-magnitude range from western Illinois, New Madrid, Missouri, and the New York-Canadian border. Quarry/strip-mine blasts in various parts of the state are regularly recorded by OhioSeis stations. Although not a primary function of the OhioSeis network, moderate to large earthquakes from around the world are regularly recorded by OhioSeis stations. We record nearly any earthquake above 6.0 magnitude and many that are in the 5.0 to 6.0 range. It is a spectacular, and even chilling, experience to watch the waves from a major, distant earthquake scroll across the computer screen in near-real time. In 1999, it was sobering to see real-time earthquake waves from events in Colombia, Turkey, and Taiwan and realize that thousands of people were dying as these waves were displayed on the computer screens. Many of the educational institutions have found that recording of these frequent, large, distant earthquakes has been an educational experience for their students. Digital, broadband seismograph stations such as those used by the Ohio Seismic Network are the next-generation concept in high-quality, low-cost seismic monitoring. The U.S. Geological Survey recently issued a report (Circular 1188) on the status of seismic monitoring in the United States and has proposed that many existing seismic networks still using 1960's-vintage instruments need to be upgraded to modern broadband instruments.

As we have discovered, detection and especially location of small, local earthquakes are not always a simple matter, especially earthquakes that are below 3.0 magnitude. Many people are unaware that for each whole-number increase on the magnitude scale, the energy of an earthquake increases by about 30 times. Put another way, a 3.0-magnitude earthquake is about 30 times larger than a 2.0-magnitude earthquake. Because the scale is logarithmic, a 4.0-magnitude earthquake is about 900 times larger than a 2.0 event. Because this energy dissipates so quickly, locating small

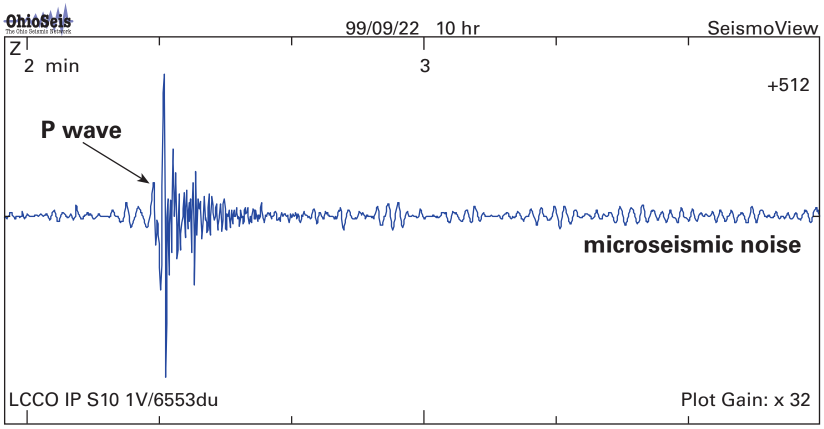


Seismogram of a 5.2-magnitude earthquake recorded by OhioSeis stations on New Year's Day, 2000. This moderate-sized event was centered in the Temiscaminque region of Quebec, more than 400 miles from the nearest OhioSeis station.

earthquakes requires seismograph stations that are close to the epicenter. We designed the configuration of the OhioSeis network to maximize our capability to record these small events in Ohio and will continue to add stations in favorable locations.

Another, real-life aspect of recording earthquakes is that they do not always follow publicly perceived, textbook models. Most people envision earthquake waves as resembling the ripples in a pond when a stone is thrown into quiet water. In reality, earthquake waves may be focused in particular directions that are controlled by local geology or fault orientation. We saw a dramatic example of this directional focus on September 22, 1999, when a small (~2.8 magnitude) earthquake was felt about 6:00 a.m. (local time) in a small area east of Cleveland. This event was picked up on several seismograph stations operated by the Geological Survey of Canada on the north side of Lake Erie. A preliminary location based on Canadian data placed the event beneath Lake Erie about 10 miles offshore from Fairport Harbor (Lake County). Only two nearby OhioSeis stations recorded the event (a third station was not operating) because the energy was apparently focused northward. When seismograms from the two OhioSeis stations were downloaded (after fixing an untimely computer problem) the instrumental location of the event, using both OhioSeis and Canadian data, was placed near Eastlake (western Lake County), precisely in the 5- by 7-mile felt area of the event. Had only the Canadian stations—all north of the event—been used for location and not the OhioSeis stations to the southeast and west of the epicenter, the instrumental location of the event would have remained nearly 20 miles northeast of its actual location.

This example clearly illustrates the need for multiple, widely distributed seismograph stations for not only detecting small, nearby earthquakes but also for accurate location of these events. It is a common assumption that if an earthquake is plotted on a map and identified as being instrumentally located, then that location is highly accu-



Filtered seismogram of the September 22, 1999, Eastlake earthquake east of Cleveland. This small (~2.8 magnitude) earthquake occurred only about 6 miles from OhioSeis station LCCO at Lakeland Community College in Kirtland. The seismogram shows the S-wave arriving almost immediately after the P-wave.

rate. Seismologists, of course, have extensive data that allow other seismologists to ascertain the reliability of a location, but maps used for public overview or even decisions on seismic risk do not always reflect the uncertainties and ambiguities associated with map placement of an epicenter. One of the goals of OhioSeis is to increase accuracy of locations of future earthquakes in the state. To this end, we hope to add additional stations in critical areas as funding and time permit. It is very probable that some institutions will add OhioSeis stations at their own expense, considering the low cost of these installations. One OhioSeis station, Bloom Carroll Schools in Fairfield County, purchased all of the hardware through funds raised and provided by parents and local businesses.

The Ohio Seismic Network has been a challenging and exciting venture. Although we average only a few earthquakes in the state each year, we are ready to capture these transient waves for both current and future study. Answers to long-asked questions about the occurrence, frequency, intensity, and perhaps even predictability of earthquakes are not simple. It is only through continuous, long-term monitoring that we will accumulate a database that may one day provide these answers, as well as more immediate ones concerning the size and location of a particular earthquake.

ACKNOWLEDGMENTS

Installation of the Ohio Seismic Network has been a team operation and its success is the result of efforts from many people. We thank Dr. Larry J. Ruff of the University of Michigan for developing this concept, training us in its implementation, and working closely with us on many challenges. Bill King of FEMA gave us full support in developing the OhioSeis concept. Both Dale Shipley, former Director of OEMA and now director of FEMA Region V, and his OEMA successor, James Williams, have supported and promoted OhioSeis. Candice Sherry, earthquake planner with OEMA, has been instrumental in implementing and maintaining the network and has given us full support and encouragement from the beginning. Glenn Larsen and Mac Swinford of the Division of Geological Survey have been of tremendous assistance in managing and implementing OhioSeis. Lastly, we gratefully acknowledge the dedication and efforts of our volunteer station operators: Robert Bartolotta and Joseph DeRocher, Cleveland Museum of Natural History; Jeffrey Bauer, Shawnee State University; Robert Benz, Lake Erie College; Douglas Green and Gregory Nadon, Ohio University; Attila Kilinc, University of Cincinnati; Mark Kleffner, Ohio State University–Lima; David Miller, Clark State Community College; Richard Schmidt, Lakeland Community College; Edward Somppi, Ashtabula County Emergency Management Agency; Donald Stierman, University of Toledo; Kenton Strickland, Wright State University–Lake Campus; Kris Thrush and Bob Rower, Bloom-Carroll Schools; Robert Varga, College of Wooster; Robert Vincent, Bowling Green State University.

FURTHER READING

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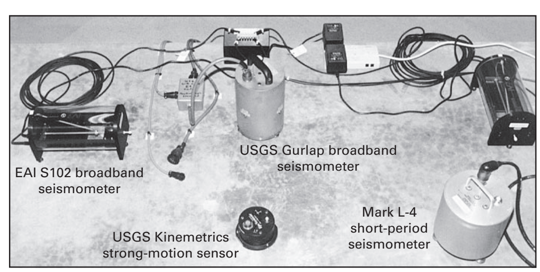
THE OHIO EARTHQUAKE INFORMATION CENTER

As part of the mission of the Ohio Seismic Network, the Division of Geological Survey established the Ohio Earthquake Information Center to serve as a focal point for dissemination of earthquake information about the state. The functions of the OEIC are broad and include coordination of seismic monitoring in Ohio, answering public and media inquiries on all aspects of earthquakes, producing publications and a Web site, and providing timely and accurate information to the public, media, government, and scientific community when an Ohio earthquake occurs.

The Ohio Earthquake Information Center is



Seismic-instrument pier at the Ohio Earthquake Information Center. Seismometers include broadband instruments operated by the Ohio Geological Survey and the U.S. Geological Survey, and a USGS strong-motion sensor.

headquartered at the Survey's core-repository facility at Alum Creek State Park (see *Ohio Geology*, 1999, No. 4). A small room adjacent to the lobby houses an instrument pier, computers, and communications equipment, which can be viewed by the public through a window. Displays relating to earthquakes, including a near-real-time display of ground motion at the site, will be featured in the lobby. In addition to three seismometers deployed as part of the Ohio Seismic Network, the room houses instruments provided by the U.S. Geological Survey for a U.S. National Seismic Network (USNSN) station. The USGS data are telemetered via satellite to the National Earthquake Information Center in Golden, Colorado.

Although the Ohio Earthquake Information Center is staffed only on an intermittent basis, Division personnel at the Survey's Fountain Square offices can remotely monitor seismic activity, telephone messages, and e-mail inquiries directed to the OEIC. When an Ohio earthquake occurs, staff will be on site to coordinate public and technical information. Contact information:

Ohio Earthquake Information Center
Division of Geological Survey
3307 S. Old State Road
Delaware, OH 43015
Phone: 740-548-5979
FAX: 740-657-1979
E-mail: ohioseis@dnr.state.oh.us

COMPONENTS AND CONFIGURATION OF OHIOSEIS STATIONS

seismometer The instrument that measures ground motion and converts these movements into a signal that can be displayed on a computer screen. Traditionally, seismometers are expensive, delicate, precision instruments designed to be placed in an underground vault at a remote location or in a deep borehole far below cultural noise. In contrast, Dr. Larry J. Ruff focused on producing research-quality seismograms using equipment in a price range that was affordable for nearly any institution. Dr. Ruff helped design the Engineering Acoustics, Inc., S102 broadband seismometer, developed by EAI president Thomas H. Ensign. These hand-built instruments currently cost about $1,650 each. The S102 seismometer is designed to be placed within a building environment, where temperature extremes and humidity are not excessive, and preferably in a comparatively quiet location on the lowest floor of the building. Buildings tend to be noisy places as people move around, doors open and shut, and a myriad of other activities take place on a daily basis. The S102 filters out much of this cultural noise because it is designed to record at frequencies at which earthquakes occur. The S102 is a single-component seismometer that records in the vertical (z) axis. The seismometer can be placed up to 300 feet away from the computer.

analog-to-digital board An internal computer board that translates the analog electrical signal from the seismometer into a digital signal that can be used by the computer software. OhioSeis uses a 16-bit board from National Instruments, Inc. This component is comparable in price to the S102 seismometer.

global positioning system (GPS) receiver This component locks precise Universal Time onto the seismograms. OhioSeis uses a hand-held Garmin II Plus GPS receiver. To receive the GPS satellite signals, an external antenna is connected to the unit by a standard coaxial cable. OhioSeis stations have successfully used up to 80 feet of cable without significant signal loss. The small antenna (designed for boats) must be placed where it has a relatively unobstructed view of the sky so that it can receive signals from three or more satellites in the GPS constellation. The GPS receiver, antenna, and other components cost less than $400.

software Dr. Ruff has developed interfacing computer software programs that enable all of these components to work together to record, file, display, and analyze seismic data. *SeismoGraf* writes the seismogram files into folders in the station directory and in the Web Pages directory, where they can be viewed from another computer via the Internet. *SeismoView* is used to view files generated by SeismoGraf. These files can be viewed on the station computer screen or on another station computer that is linked to the Internet. *GPSgraf* uses signals from the GPS satellites to lock absolute time in SeismoGraf. *Epilocator* is used to determine the location and magnitude of local and regional events.

A detailed explanation of the Macintosh-based software is given on the MichSeis Web site (http://geo.lsa.umich.edu/MichSeis/). A video featuring Dr. Ruff explaining and demonstrating OhioSeis hardware and software is available for a nominal fee from the Division of Geological Survey. For more information contact Michael C. Hansen, telephone 614-265-6580, email mike.hansen@dnr.state.oh.us.

Engineering Acoustics, Inc., model S102 broadband seismometer used by OhioSeis stations.

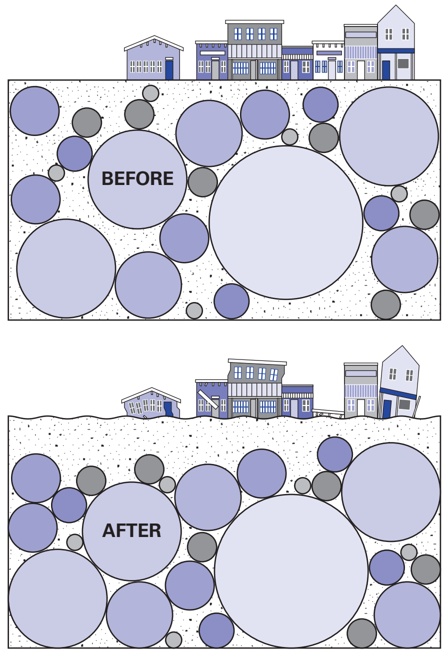
HANDS-ON EARTH SCIENCE

Modified from a classroom lesson prepared by Wendy Gerstel, Washington Division of Geology and Earth Resources

SHAKE, RATTLE, AND LIQUEFY

Background:

In Ohio, the effects of an earthquake commonly are amplified in areas underlain by sandy unconsolidated sediments in modern river valleys, such as along the Ohio River, or in buried glacial valleys, such as those in many parts of Ohio. When such sediments liquefy, they lose their structure and strength. During earthquake shaking, the individual grains of sand within a deposit collapse on each other. Any structure built on sandy sediments can sink or collapse. Picture a container of balls of different sizes—baseballs, golf balls, marbles. If they were transported by water into the container and then deposited, they would settle with spaces between them. Some of the spaces would be filled with water, some with air. When you shake the container, the balls settle against each other, and the water and air are forced to the surface. That is exactly what happens in a sediment-filled valley. The valley is a large "container" holding gazillions of "balls" or grains of sand. Shaking the container simulates an earthquake.



Purpose:

We know that flat river-valley bottoms are prone to flooding, but we think of them as being geologically stable. This experiment demonstrates what happens to sandy soils when they liquefy. You will create a model river valley, then watch how and why houses get damaged or collapse during an earthquake in a seemingly stable geologic environment.

Equipment needed:

- glass baking pan (must use glass so contents of pan can be observed)
- enough dry sand to fill pan 1-2 inches deep
- a few toy houses or wooden blocks
- water

Procedure:

1. Evenly pour the dry sand into the pan.
2. Mark the level of the sand on the side of the pan (use a washable marker).
3. Place houses or blocks gently on the surface.
4. Slowly add water until about two-thirds of the thickness of the sand is saturated.
5. Gently shake the table on which you have placed your pan (or gently shake the pan itself).

Observations:

You should see the following:

- The water will work its way to the surface, flooding the area around the houses.
- The houses will start leaning over and sinking into the sand.
- The volume of the sand should decrease by a small amount. Note where the surface is after shaking in relation to the mark denoting the surface before shaking.

Variation:

Try the experiment using clay or gravel to separate sand layers and represent different types of sedimentary layers. Watch what happens to the water and the surface of your model of a river valley. Compare what happens to the water when using different materials.

Source: Earth Connections No. 2, published in Washington Geology, v. 27, no. 2/3/4, December 1999, Washington Division of Geology and Earth Resources.

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