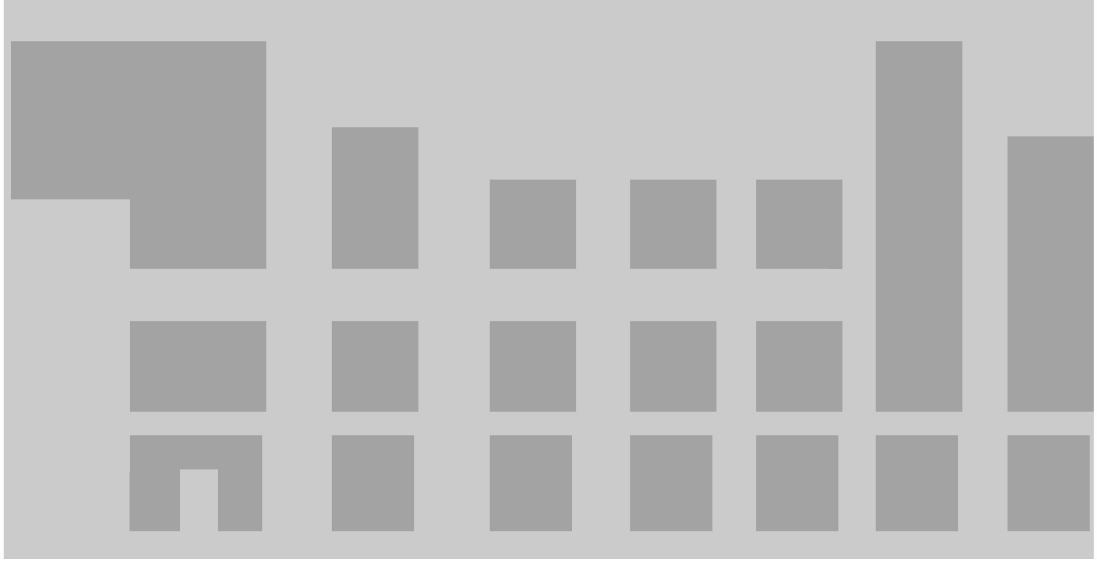
Part One

Geological Disasters



Unit One

Earthquakes

Learn About Earthquakes

An earthquake is ground shaking caused by a sudden movement of rock in the Earth's crust. Such movements occur along faults, which are thin zones of crushed rock separating blocks of crust. When one block suddenly slips and moves relative to the other along a fault, the energy released creates vibrations called seismic waves that radiate up through the crust to the Earth's surface, causing the ground to shake.

Text A Squeezing Water from Rock

Warming-up

Read these sentences and try to figure out the meaning of the underlined words or expressions from the context.

1. Survivors of the New Madrid earthquakes reported not only intense ground shaking and land movement, as would be expected during an earthquake, but also an unfamiliar phenomenon: water and sand spouting up through fissures, or cracks, in the Earth's surface. ( )

A. ranting B. mouthing off C. gushing D. talking back

2. Liquefaction occurs when an earthquake vigorously shakes and compacts water-saturated sediments. ( )

A. squeezes B. packs together C. impresses D. depresses

3. The water flow was significant enough to reactivate streams in previously dry river channels. ( )

A. react B. restore C. activate anew D. recover

4. Colleagues found that water expelled during the earthquake could be detected in imagery from NASA's Multi-angle Imaging SpectroRadiometer (MISR) satellite sensor. ( )

A. force to leave B. ejected C. kicked out D. released

5. MISR imagery, which is archived at the Langley Research Center DAAC, promises to be a boon to earthquake researchers seeking to minimize hazard risks. ( )

A. generosity B. benefit C. fragrance D. behalf

Squeezing Water from Rock

By Laurie J. Schmidt

On December 16, 1811, an earthquake estimated at magnitude 7.0 to 8.0 on the Richter scale rocked the frontier town of New Madrid, Missouri, in the central United States. It was the first of three powerful earthquakes that would shake the central Mississippi River Valley that winter. Damages were reported as far away as Charleston, South Carolina, and Washington, D.C. According to the U.S. Geological Survey, the

New Madrid events were the most powerful earthquakes in recorded U.S. history.

Survivors of the New Madrid earthquakes reported not only intense ground shaking and land movement, as would be expected during an earthquake, but also an unfamiliar phenomenon: water and sand spouting up through fissures, or cracks, in the Earth's surface. In a letter published in Lorenzo Dow's Journal, New Madrid resident Eliza Bryan wrote in 1816:

... the surface of hundreds of acres was, from time to time, covered over in various depths by the sand which issued from the fissures, which were made in great numbers all over this country, some of which closed up immediately after they had vomited forth their sand and water ...

Modern earthquake researchers refer to this expulsion of water and sand from the ground as earthquake dewatering, which results from liquefaction. Liquefaction occurs when an earthquake vigorously shakes and compacts water-saturated sediments. As the compaction process displaces the water between the sediment pores, water and sand shoot upward and out of the ground.

"Imagine a cube full of sand and water. If you press it in from both sides, you build up what's called pore-water pressure," said Martitia Tuttle, geologist and consultant for the U.S. Geological Survey. "It's like shaking a coke can—when the pressure builds up and you release it, the fluid comes shooting to the surface." These fountains of water can sometimes shoot as high as 30 feet into the air, according to Tuttle.

Tuttle is part of a team that has been studying liquefaction in the New Madrid region in an effort to identify large prehistoric earthquakes in the geologic record. "Interpreting historic and prehistoric earthquake events involves a lot of uncertainty, due to the lack of data," Tuttle said. "We often don't know precisely where the earthquakes occurred or how big they were." What researchers needed was a modern-day event in a similar environment with which to compare the New Madrid earthquakes.

On January 26, 2001, a magnitude 7.7 earthquake near the village of Bhuj, located in the Kachchh region of northwestern India, provided scientists with just that analogue. Considered one of the two most damaging earthquakes in India's recorded history, the Bhuj earthquake killed about 20,000 people and caused an estimated $3.3 billion in damages.

According to Tuttle and co-authors of a paper recently published in Eos, local residents and survey teams working in the area after the earthquake reported fountains of water and sediments surging from the ground during and immediately following the Bhuj earthquake. The water flow was significant enough to reactivate streams in

previously dry river channels.

"The Bhuj earthquake provided an opportunity to study an earthquake that was very similar to the New Madrid event—it was a very large earthquake, and it occurred in an intraplate-like setting," said Tuttle. The New Madrid and Kachchh regions are both located more than 185 miles from active plate boundaries.

"Before the Bhuj earthquake, there was a lot of debate in the seismological community about the magnitude of the New Madrid earthquakes, but based on the similarity in intensity between the New Madrid and Bhuj events, there is a growing consensus among scientists that the New Madrid earthquakes were probably larger than magnitude 7.5," said Tuttle. "The Bhuj earthquake is a modern event that helps us better understand the historic and prehistoric earthquake record in the New Madrid region."

But despite the unique study opportunity presented by the Bhuj earthquake, the area presented the researchers with some grave challenges. First, the Kachchh region of India is remote and difficult to reach. Second, it shares a politically sensitive border with Pakistan. These factors made it difficult for research teams to conduct field studies to verify liquefaction effects or the presence of water in some areas.

Bernard Pinty, research scientist at the Institute for Environment and Sustainability in the Joint Research Centre of the European Commission in Ispra, Italy, and colleagues found that water expelled during the earthquake could be detected in imagery from NASA's Multi-angle Imaging SpectroRadiometer (MISR) satellite sensor.

The MISR instrument, which flies aboard NASA's Terra satellite, views the sunlit face of the Earth at nine widely spaced angles simultaneously. As it passes over the Earth, its nine cameras successively view each piece of the planet's surface at a spatial resolution of 300 yards.

The change in reflection at different angles provides a means for distinguishing different types of land surface covers. Since bright soils in India's Rann of Kachchh reflect most of the sun's near-infrared radiation, and water bodies absorb near-infrared radiation, MISR is able to detect the contrast and indicate where dewatering occurred.

According to Pinty, these features made MISR an ideal tool for studying liquefaction in the Bhuj earthquake. "MISR's multi-angle capability was instrumental in exposing the presence of free water close to the Pakistani border, a region where it is difficult, if not impossible, to take ground measurements," he said.

Most other satellite instruments only look straight down or towards the edge of the Earth. "It would take several more passes for another sensor to capture the entire region

that the MISR imagery covers," said Tuttle. "The MISR images enabled us to see a large area both during and immediately after the earthquake, and we could see that dewatering was occurring over a huge region."

Scientists now know that the New Madrid earthquakes were not geologic flukes; similar events have occurred repeatedly in the geologic past. In fact, the central Mississippi Valley experiences more earthquakes than any other region in the United States east of the Rocky Mountains.

The New Madrid Seismic Zone, which includes parts of Tennessee, Kentucky, Missouri, Arkansas, Illinois, Indiana, and Mississippi, harbors a large liquefaction field. Scientists estimate the probability of a magnitude 6.0 or greater earthquake occurring in the New Madrid Seismic Zone within the next 50 years at 25-40 percent, according to the U.S. Geological Survey. But a similar event would have much more serious consequences today.

In 1811—1812, the central Mississippi Valley was a remote frontier. Today, the region is home to millions of people and includes the metropolitan cities of St. Louis, Missouri, and Memphis, Tennessee. In addition, most buildings in the region were not built to withstand earthquake shaking, as they often are in California and Japan.

Buildings and engineered structures are at much higher risk in areas where liquefaction occurs, due to increased ground motion. "The liquefaction process is extremely damaging to all sorts of engineered structures; it has caused major destruction in both Anchorage and San Francisco," said Pinty.

"The ground failure that resulted from liquefaction during the New Madrid earthquakes was severe. We're talking about vertical displacement of 3 to 6 feet, and lateral displacement up to 33 feet," said Tuttle. "A recurrence of that type of event would have severe consequences for engineered structures."

According to Tuttle, in 1988 a magnitude 5.9 earthquake in Quebec, Canada, produced liquefaction. "Basements cracked, septic fields were disrupted, and people described water and sand shooting into their basements, out of their toilets, and into their bathtubs," she said. "And that was just a moderate-sized earthquake, not a big one."

MISR imagery, which is archived at the Langley Research Center DAAC, promises to be a boon to earthquake researchers seeking to minimize hazard risks. "The interesting thing is that this project started as an 'after hours' sort of activity," said Pinty. "But it soon acquired its own momentum, giving us results that are of significant relevance to earthquake study applications. Our findings revealed that MISR can detect water and moist conditions on terrestrial surfaces, even under unfavorable spectral

conditions."

"If we study modern earthquakes that produce liquefaction, we can better interpret the geologic record of liquefaction during past events. This helps us anticipate what is likely to happen in the future so that we can make informed decisions about reducing and mitigating hazards," said Tuttle.

"It's one of those things where people tend to think—if it hasn't happened during my lifetime, then it can't happen here," said Tuttle. "But the liquefaction field in the New Madrid region is very large. We're talking about a huge earthquake that could have a significant impact on society."

(1445 words)

From http://www.earthobservatory.nasa.gov

Notes

1. pore-water pressure 孔隙水压力

2. the Langley Research Center DAAC 兰利研究中心数据存档中心

Exercises

Ⅰ. Judge whether the following statements are True or False.

1. ( ) According to the U.S. Geological Survey, the New Madrid events were the most powerful earthquakes in recorded U.S. history.

2. ( ) What researchers needed was a past event in a different environment with which to compare the New Madrid earthquakes.

3. ( ) The Bhuj earthquake is a modern event that helps Tuttle better understand all the historic and prehistoric earthquake record.

4. ( ) Minorities of satellite instruments look straight down or towards the edge of the Earth.

5. ( ) Scientists estimate the probability of a magnitude 6.0 or greater earthquake occurring in the New Madrid Seismic Zone within the next 50 years.

Ⅱ. Choose the best answer to each of the following questions.

1. About the New Madrid earthquake in 1811, which of the following is not mentioned in the passage? ( )

A. It was estimated at magnitude 7.0 to 8.0 on the Richter scale.

B. It rocked the frontier town of New Madrid, Missouri, in the central United States.

C. The New Madrid events were the most powerful earthquakes in recorded U.S.

history.

D. It was the first powerful earthquake that has shaken the central Mississippi River Valley.

2. When does liquefaction occur? ( )

A. Dewatering results from liquefaction.

B. When the compaction process displaces the water between the sediment pores, water and sand.

C. When an earthquake intensively shakes and compacts water-saturated sediments.

D. None of the above.

3. What are the grave challenges of the researchers despite the unique study opportunity presented by the Bhuj earthquake? ( )

A. The Kachchh region of India is remote and difficult to reach.

B. It shares a politically sensitive border with Pakistan.

C. Both A and B.

D. None of the above.

4. About the features of MISR, which of the following is incorrect? ( )

A. It views the sunlit face of the Earth at nine widely spaced angles simultaneously.

B. MISR is an ideal tool for studying liquefaction in the Bhuj earthquake.

C. As it passes over the Earth, its nine cameras successively view each piece of the planet's surface at a spatial resolution of 300 yards.

D. It is able to detect the contrast and indicate where dewatering occurred.

5. What do Pinty's findings reveal? ( )

A. That MISR imagery benefits their team a lot.

B. That MISR can detect water and moist conditions on terrestrial surfaces, even under unfavorable spectral conditions.

C. That MISR can predict liquefaction.

D. That they can anticipate what is likely to happen in the future.

Ⅲ. Discuss the following questions.

1. What do you know about the New Madrid quake in the early 19th century America?

2. How could Tuttle know more about historic and prehistoric earthquakes?

3. Which earthquake provided scientists with just analogue? How?

4. Accordingly, what do scientists know about the New Madrid quake?

5. According to Tuttle, can they anticipate what is likely to happen in the future?

Text B Can We Save California?

Warming-up

Read these sentences and try to figure out the meaning of the underlined words or expressions from the context.

1. Bridges will buckle. Apartment buildings will pancake.( )

A. clasp B. fasten C. heave D. collapse

2. These tectonic plates are constantly jostling each other, like rafts crowded into a small pond, and it's along the boundaries where they meet that most quakes are born.( )

A. propelling B. conflicting C. thrusting D. shoving

3. The earth lurches from time to time because its outer shell is broken into 11 huge, solid plates.( )

A. moves abruptly B. throws C. disrupts D. tosses

4. They're moving inexorably in opposite directions.( )

A. relentless B. unforgivingly C. grimly D. stubbornly

5. Scientists studying the phenomenon found that the fluids were lubricating the fault boundaries, allowing them to slip past each other.( )

A. rubbing B. lubing C. sticking D. staining

Can We Save California?

By Dick Thompson

Sometime in the next 30 years, according to the most recent forecast from the U.S. Geological Survey, a large portion of the San Francisco Bay Area will jump more than 3 ft. in less than 30 sec., shaking the ground for perhaps 100 miles and triggering an earthquake with a magnitude of 6.7. Bridges will buckle. Apartment buildings will pancake. The dorms at the University of California, Berkeley, will roll like barrels on a wave. Water, power and transportation lines will be cut. The subway that runs under the bay could be a death trap. By the time the dust settles, more than 100,000 people will be homeless. Economic losses will total at least $35 billion. The human cost will be immeasurable.