Plate Tectonics and People

Earthquakes

Over the span of geological time, plate movements in association with other geological process, such as glacial and stream erosion, have created some of nature's most magnificent scenery. The Himalayas, Alps, and Andes are some spectacular examples. Yet earthquakes related to plate tectonics have caused terrible catastrophes, such as the magnitude 7.7 earthquake that struck the Chinese province of Haicheng in 1976 and killed an estimated 800,000 people.

Most earthquakes and vocanic eruptions do not strike randomly but occur in specific areas, such as along plate boundaries. One such area is the circum-Pacific *Ring of Fire,* where the Pacific Plate meets many surrounding plates. This ring is the most seismically and volcanically active zone in the world.

Because many major populations centers are located near active fault zones, such as the San Andreas Fault in California, millions of people have suffered personal and economic losses as a result of destructive earthquakes, and even more have experienced earthquake motions.

California will not suddenly "break off" and "fall into the Pacific" and the Earth will not "open up" along the fault and "swallow" up people, cars, and houses. However, the potential for destructive earthquakes is very real.

The horizontal movement of the San Andreas Fault is known as a *transform fault- boundary.* The fault zone separates the Pacific and North American Plates, which are slowly grinding past each other in a roughly north-south direction. Evidence of these movements can be found all along the fault zone. Topographic, geologic, and sometimes vegetation show change as a result of the fault. For example, the Crystal Springs Reservoir on the San Francisco Peninsula runs directly along the course of the San Andreas Fault. Topographically, this reservoir fills a long straight, narrow valley that was formed by erosion of the easily erodible rocks mashed within the fault zone.

Crystal Springs Reservoir

Movement along the San Andreas can occur either in sudden jolts or in a slow, steady motion called *creep.* These creeping segments are separated by segments of infrequent earthquake activity. Locked segments of the fault store tremendous amounts of energy that can build up for decades or even centuries, before unlashing devastating earthquakes. The Great San Francisco Earthquake of 1906 ruptured along a previously locked 430 km long segment of the San Andreas with an 8.3 magnitude.

The magnitude 7.1 Loma Prieta earthquake of October 1989 occurred along a segment of San Andreas Fault, which had been locked since the 1906 earthquake causing 62 deaths and over $6 billion in damages. The fault remains locked from Pt. Arena south through San Francisco and poses a potential destructive earthquake occurring in a much more densely populated area.

The lesser-known Hayward Fault running east of San Francisco may pose a potential threat as great or perhaps even greater than the San Andreas. It has characteristics similar to the fault that created the 7.2 magnitude earthquake that struck Kobe, Japan on January 16, 1995. Both have strike slip movements and are about the same length, 60-80 km., and cut through densely populated areas with many structures built on unstable bay landfill.

One of the costliest natural disasters in United States history occurred on January 17, 1994, when an earthquake with a magnitude 6.6 struck near Northridge, a city located in the populated San Fernando Valley, just north of Los Angeles, California. This disaster killed 60 people and caused an estimated $30 billion in damages. The Northridge earthquake did not directly involve movement along one of the strands of the San Andreas Fault system. It instead occurred along th Santa Monica Mountains Thrust Fault, one of several smaller, concealed faults called Blind Thrust Faults where one side of the fault moves upward over the other. Movement along a blind thrust fault does not break the ground surface, thus making it difficult or impossible to map these hidden, but potentially dangerous, faults.

Not all fault movement is as violent and destructive. Near the city of Hollister in central California, the Calaveras fault bends toward the San Andreas. With over 20,000 earthquakes a year (most of which cannot be felt by the residents), the fault creep is steady and slow posing no danger.

Earthquakes along the Atlantic seaboard of the United States are most likely related in some way to the westward movement the North American Plate away fro the Mid-Atlantic ridge.

East Coast earthquakes, such as the one that struck Charleston, South Carolina in 1886, are felt over a much larger area than earthquakes occurring on the We Coast. This is because the eastern half of the country is mainly composed of older rock that has not been fractured and cracked by frequent earthquakes. Roc that is highly fractured and crushed absorbs more seismic energy than less fractured rock. The Charleston earthquake with an estimated magnitude of about 7. was felt as far away as Chicago.

The most widely felt quakes in 1811 and 1812 were centered near the town of New Madrid, Missouri. Three earthquakes, felt as far away as Washington, D.C,. were estimated to be above 8.0 in magnitude. Below New York City is a network of intersecting faults, a few which are capable of causing earthquakes. The most recent earthquake to strike New York City occurred in 1985 and measured 4.0, and a pair of earthquakes 4.0 and 4.5 shook Reading, Pennsylvania, in January 1994.

The biggest challenge scientists now face is not studying how earthquakes occur but in trying to predict them. Since the 1980s, geologists and seismologist hav been intensively studying a segment of the San Andreas fault near the small town of Parkfield, located about halfway between San Francisco and Los Angeles, t detect the physical and chemical changes than might take place – both above and below the ground – before an earthquake strikes. The Parkfield segment has experienced earthquakes measuring a magnitude of 6.0 about every 22 years.

An international team has begun drilling a 1.4-mile deep hole along the San Andreas Fault near Parkfield. When the drilling is done, the team will install a variet of underground instruments that will help scientist better predict the timing and severity of earthquake activity along the 800-mile long fault. This will only set the stage for an even more ambitious drilling project called the San Andreas Fault Observatory at Depth (SAFOD). The only observatory of its kind in the world, SAFOD will penetrate a seismically active fault zone giving scientists a unique opportunity to continuously monitor a section of the fault where earthquakes actually happen.

Volcanic Eruptions

As with earthquakes, volcanic activity is linked to the plate tectonic processes. Most of the world's active, above sea level volcanoes are located near converge plate boundaries where subduction is taking place. However, much more volcanism is taking place unseen, under the oceans, mostly along the oceanic spreading centers.

Subduction-zone volcanoes like Mount St. Helens, Washington State, and Mount Pinatubo (Luzon, Philippines) are called composite cones and typically erupt with explosive force.

Mt. Pinatubo eruption.

The direct impact of volcanic eruptions has an obvious effect on the people that live near them. Since the year 1600, almost 300,000 people have been killed by volcanic eruptions. Most of these deaths are caused by pyroclastic flows and mudflows, deadly hazards that accompany explosive subduction-zone volcanoes. Today, there is scientific evidence for possible eruptions along the Juan de Fuca ridge where seismic signals typical of submarine eruptions were detected. In

Iceland, where the Mid-Atlantic ridge is exposed on land, voluminous but non-explosive eruptions are typical. An explosive eruption in 1783 is still considered or of the worst disasters in Iceland's history. About 9,000 people – almost 20% of the population – died of starvation, because their livestock perished from grazing on grass contaminated by fluorine-rich gasses emitted during an eight-month eruption.

Tsunamis

Major earthquakes that occur along subduction zones can trigger tsunamis and pose a potential danger to coastal communities. Tsunamis are often mistakenly called "tidal waves" when in fact they have nothing to do with tidal action. Rather, tsunamis are seismic sea waves caused by earthquakes, underwater landslides, and, infrequently, from the eruption of island volcanoes.

The waves generated by these events race across the ocean at speeds of more that 800 km per hour, which is comparable to the speed of a commercial jetliner To someone on the open sea, the presence of a tsunami would be to barely lift the boat. However, when the wave reaches shallower water near the coastline and touches bottom, it increases in height piling up an enormous wall of water. In 1883 the eruption of the Krakatau Volcano, located in the Suna Straits betwee the islands of Sumatra and Java, Indonesia, washed away 165 coastal villages killing 36,000 people.

The International Tsunami Information Center was created in 1965 to help provide early warnings of approaching tsunamis. Warnings of location, wave height, and direction are immediately broadcast to alert communities that may be in harm's way.

Natural Resources

Many of the Earth's natural resources of energy, mineral, and soil are concentrated near past or present plate boundaries. Volcanoes that can cause so much damage and death also benefit people. Over thousands and millions of years, the physical breakdown and chemical weathering of volcanic rocks have formed some of the most fertile soils in the world.

Most of the metallic minerals mined in the world, such as copper, gold, silver, lead, and zinc, are associated with magmas found deep within the roots of extinct volcanoes located along subduction zones.

Oil and natural gas are the products of the deep burial and decomposition of accumulated organic material in geological basins that flank mountains ranges formed by plate tectonic processes.

Geothermal energy can also be harnessed from the Earth's natural heat associated with active volcanoes or geologically young inactive volcanoes still giving off heat at depth.

Conclusion

The long-term benefits of plate tectonics should serve as a constant reminder to us that Earth occupies a unique niche in our solar system. Understanding plate tectonics and its consequences has reinforced the notion that the Earth is an integrated whole, not a random collection of isolated parts. The global effort to better understand this revolutionary concept has helped to unite the earth science community and underscore the linkages between the many different scientific disciplines. Now in the 21st century, when the Earth's finite resources will be further strained, we must become more resourceful in reaping the long-term benefit of plate tectonics while coping with the short-term impact of earthquakes and volcanic eruptions.

USGS science for a changing world
Presented in cooperation with the U.S. Geological Survey
Produced by Prince William Network / PO Box 389, Manassas, VA 20108 / 703-791-7328 / pwninfo@aol.com
Website designed by Filnet Incorporated