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Identification and Mitigation of Geologic Hazards

An important and practical application of geology is identifying hazardous natural phenomena and isolating their causes in order to safeguard communities. According to the USGS, the average economic toll from natural hazards in the United States is approximately $52 billion per year, while the average annual death toll is approximately 200.[1] The primary causes are earthquakes, landslides, and flooding, but other events, such as subsidence, volcanic eruptions, and exposure to radon or asbestos, also pose considerable danger. Awareness of the potential hazards that persist in areas under consideration for both private and community development is critical, and so geological consultants and engineers are called in to survey land development sites and assist building contractors in designing structures that will stand the test of time.

EARTHQUAKES AND VOLCANOES

In the average year, some 12 million earthquakes occur worldwide but most of them are low in magnitude.[1] Earthquakes are generally concentrated along tectonically active plate boundaries where numerous faults exist (normally near the edges of continents, Fig. 1). As nearly half of the world's population resides in coastal areas, and because earthquakes are of such a scale that they can affect several communities si-multaneously, the risk to human life is obvious.[2] The largest recorded earthquake to hit the North American continent had a magnitude of 9.2, which occurred on March 27, 1964 in Anchorage, Alaska. It devastated the town and surrounding area, and could be felt over an area of half a million square miles.[2] Land-slides caused most of the damage, while a 30-foot high tsunami generated by an underwater quake leveled coastal villages around the Gulf of Alaska, killing more than 100 people.[2]

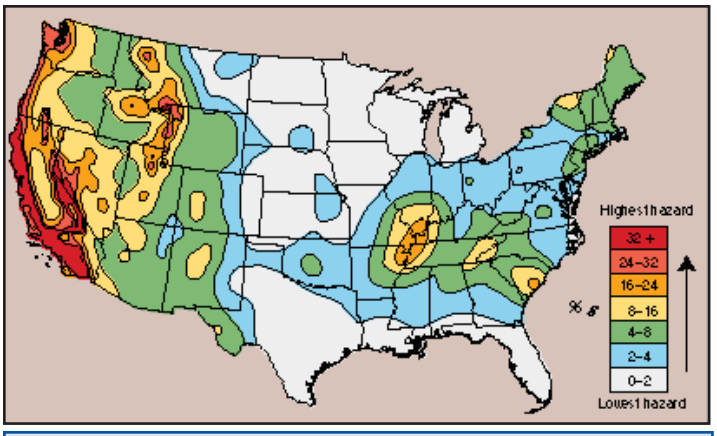


Figure 1. Quake Zones

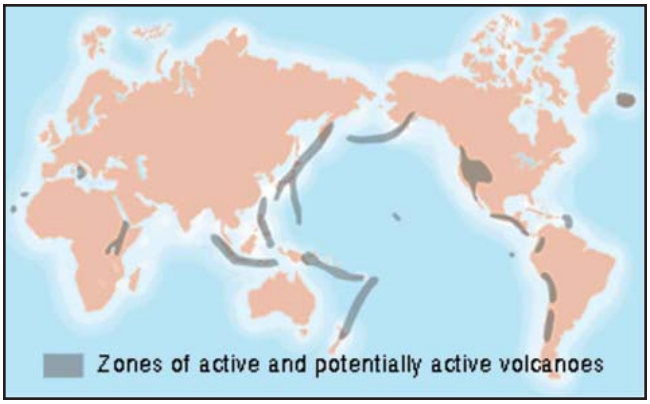


Figure 2. Volcano Zones

Less frequent, but just as destructive are volcanic eruptions. Approximately 700 potentially dangerous volcanoes are active in the world today, collectively initiating approximately 50 eruptions each year.[3] Surprisingly, the United States is ranked third most volcanically active country in the world, with most of the activity being concentrated along the Pacific coast (part of the Pacific Ring of Fire, Fig. 2). In addition to lava flows, other volcanic hazards include lahars, which are mud and ash flows (either hot or cold), and clouds of poisonous gas and dust.[3] Unlike most other natural disasters, volcanic eruptions can affect the entire planet; for example, the 1815 eruption of Tambora (in Indonesia) exploded with the energy of 10,000 atomic bombs, releasing a layer of ash that shrouded the earth and caused a lowering of the average global temperature by 2 degrees Fahrenheit for 2 years.[3]

The role of geologists in mitigating such hazards is difficult. While great progress has been made in predicting the incidence of volcanic eruptions, our ability to predict earthquakes is inadequate. Despite these difficulties, generalities can be made. Earthquake occurrence is concentrated around, but not confined to, the rim of the Pacific Ocean in an area known as the circum-Pacific belt; this also happens to be the area of greatest volcanic activity (the Pacific Ring of Fire). The geologic activity in this region is produced by the movement of the Pacific plate underneath the continents surrounding the Pacific Ocean. The understanding of plate tectonics within the field of geology explains how and why these earthquakes and volcanoes take place.

LANDSLIDES AND SUBSIDENCE

Landslides are a group of hazards that include both fast- and slow-moving debris flows associated with the onset of other natural phenomena, such as earthquakes, volcanic eruptions, floods, and wildfires, as well as slope instability created by industrialization processes.[1] Landslides and avalanches produce over $2 billion in building and highway losses and about 25-50

Photo by J. T. McGill, USGS

deaths annually in the United States.[4] The vulnerability of future landslide occurrence is directly related to the location and frequency of past slide events.[5] The four most landslide-active locations in the United States are California, Alaska, Washing-ton, and Utah.[1]

Subsidence, or the localized sinking of the land surface, can be induced by a number of factors, including tectonic shifting, collapse of soluble rock (karst topography), removal of underground water supplies, earthquakes, and underground mines.[3] Soil expansion due to the absorption of water, can cause homes and buildings to heave or buckle, and in the United States, causes more than $2 billion in damages to highways and buildings annually.[3]

Field evaluation of slope stability through the examination of materials and processes that comprise and affect them, allows geologists to estimate their potential hazard and suggest ways to counteract or minimize their occurrence. Geologic maps already in existence can be used to detect areas where swelling soils, subsidence, and landslides may be problematic.

FLOODING

More than 3 million miles of rivers and streams flow throughout the United States, resulting in nearly 10 percent of the land surface to be prone to flooding.[2] Average annual flood losses in the U.S. are more than $3 billion today, a substantial in-crease from the less than $100,000 at the beginning of this century.[2] This rapid rise can be attributed to population growth and an unawareness of the inherent dangers of building on floodplains and in flood-prone areas. Assessing the risk of large floods is very difficult because of the unpredictable nature of weather patterns.

The most intense form of flooding, called *flash flooding*, results from tremendous amounts of water raining down over a localized area in a short amount of time. Heavy runoff can pick up loose material and transport it quickly downslope in the form of mudflows, another geologic hazard.

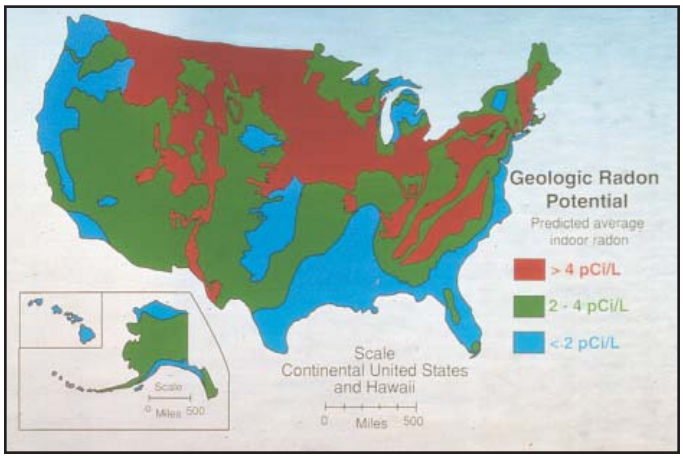
Geologists look back through the rock record to determine where and when floods have historically taken place. Examination of landforms, types of soil and sediment, signs of erosion, and flood-scarring recorded in tree rings, allow the flood history of an area to be pieced together. Geologists combine this data with contemporary knowledge about the area in order to predict the likely-hood of future flooding.

ASBESTOS AND RADON

Two other hazards can be found inside the home; they are asbestos and radon gas. While presently on the decline due to recent public abatement, exposure to certain types of asbestos can result in severe and fatal lung disease. The term “asbestos” has evolved from being used to describe any fibrous mineral, to being reserved exclusively for use in describing a few fibrous minerals considered to be health hazards by federal statutes.[2] Most varieties of asbestos do not pose a major health threat, and those that do, require prolonged contact with the tissue of the lungs.[3] Inhalation and the body’s inability to break down certain types of asbestos fibers results in irritation and the eventual production of cancerous cells.[3] People living in older homes may be most at risk because of the types of materials used in the construction of the building.

Radon is a radioactive gas formed by the decay of the element radium from rocks that have a high uranium content, such as granites, shales, and metamorphic varieties of these rocks.[5] According to the EPA, radon is considered a carcinogen to humans, and its presence in indoor air is estimated to cause between 15,000-20,000 lung cancer deaths each year in the United States.[6] Radon can affect both new and old homes alike, as it is due to the infiltration of the gas through cracks in basements, or the transmittal of radon to the home in contaminated water, which has been in contact with high uranium-content rocks. Radon problems are solvable, and tests are available for its detection.

Today’s geologist is well trained for identifying those forms of asbestos that are considered hazardous to human health. As such, geologists are used to diagnose asbestos problems. Since only certain types of rocks containing high quantities of uranium are presently linked to most radon gas production, geologic maps can be used to identify areas of greatest risk.



Geologic Radon Potential

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