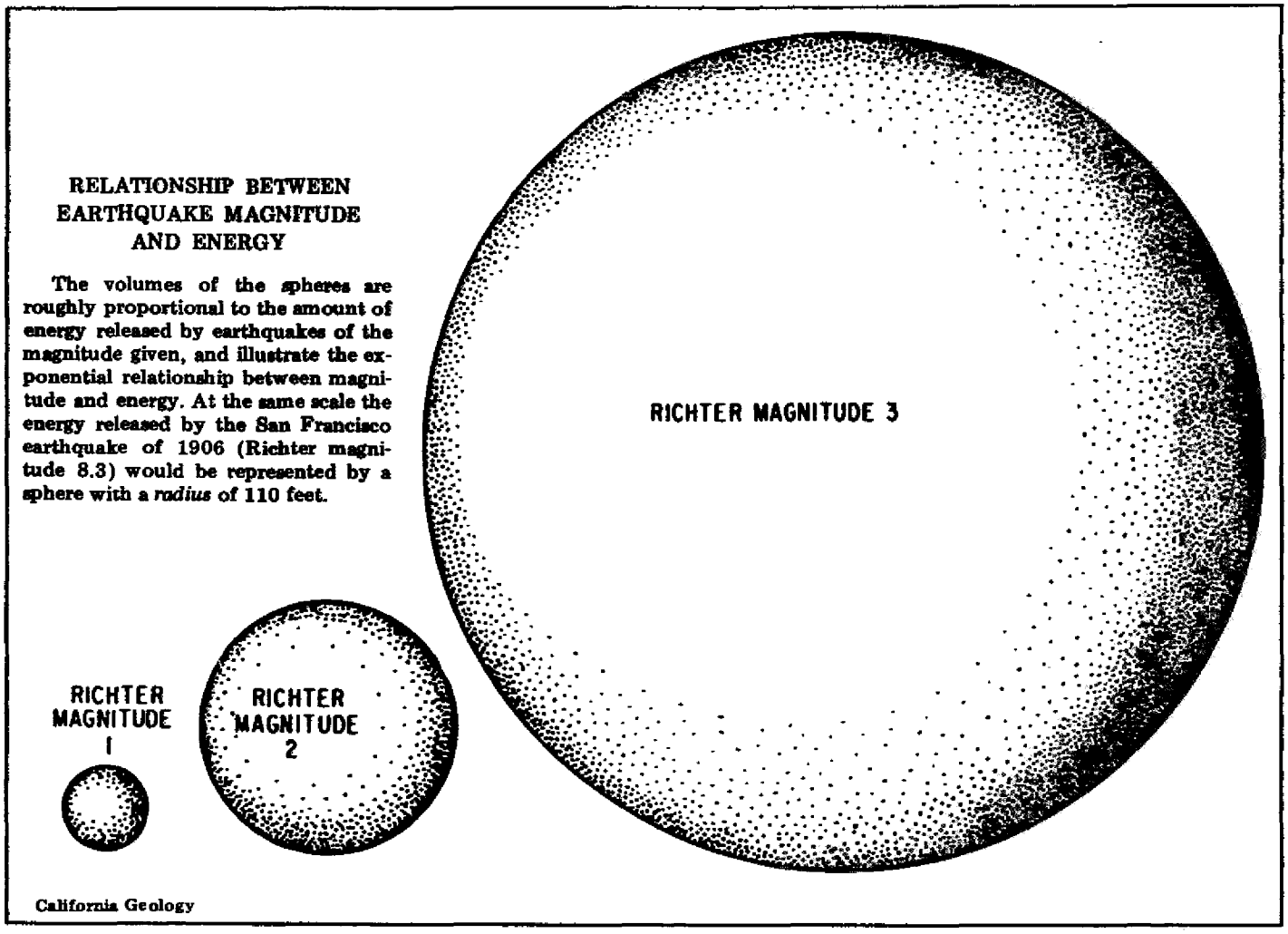
Earthquake Magnitude and Intensity

Vibrations produced by earthquakes are detected, recorded and measured by instruments called *seismographs*. The zig-zag trace recorded by a seismograph —called a "seismogram" — reflects the varying amplitude of the vibrations by responding to the motion of the ground beneath the instrument. From the data expressed in seismograms, the time, epicenter, and focal depth of an earthquake can be determined, and estimates can be made of the amount of energy that was released.

The severity of an earthquake can be expressed in several ways. The *magnitude* of an earthquake, as expressed by the *Richter magnitude scale*, is a measure of the amplitude of the seismic waves. The amplitude is measured on seismograph recordings. When the earth quakes, the amplitude of the wave recorded on the seismograph is measured and is then corrected mathematically to what the amplitude would have been if it had been recorded at a distance of 100 kilometres from the epicenter. The Richter magnitude derived from these corrected seismograph recordings indicates the amount of energy released as if it had been recorded at this standard 100-kilometre distance from the



epicenter of the quake. The intensity as expressed by the *Modified Mercalli intensity scale*, is a partly subjective measure which depends on the effects of a quake such as damage at a particular location.

Richter Magnitude Scale

The Richter magnitude scale, named after Dr. Charles F. Richter, Professor Emeritus of the California Institute of Technology, measures the energy of an earthquake at its source, and is the scale most commonly used, but often misunderstood. On this scale, the earthquake's magnitude is expressed in whole numbers and decimals. However, Richter magnitudes can be confusing and misleading unless the mathematical basis for the scale is understood.

It is important to recognize that magnitude varies logarithmically with the wave amplitude of the quake recorded by the seismograph. Each whole number step of magnitude on the scale represents an increase of *10 times* in the measured wave amplitude of an earthquake, and an increase of *31 times* in the amount of energy released by the quake. Thus, the amplitude of an 8.3 magnitude earthquake is not twice as large as a shock of magnitude 4.3, but 10,000 times as large. Correspondingly, a magnitude 8.3 earthquake releases almost one million times more energy than one of magnitude 4.3.

A quake of magnitude 2 on the Richter scale is the smallest quake normally felt by humans. Earthquakes with a Richter magnitude of 7 or more are commonly considered to be major. The Richter magnitude scale has no fixed maximum or minimum; observations have placed the largest recorded earthquakes in the world at about 8.9, and the smallest at about -3. Earthquakes with magnitudes smaller than 2 are called "microearthquakes." Richter magnitudes are not used to estimate damage. An earthquake in a densely-populated area, which results in many deaths and considerable damage, may have the same magnitude as an earthquake that occurs in a barren, remote area, that may do nothing more than frighten the wildlife.

■ Earthquake Intensity

Modified Mercalli Intensity Scale of 1931

The first scale to reflect earthquake intensities was developed by de Rossi of Italy, and Forel of Switzerland, in the 1880's. This scale, with values from I to X, was used for about two decades. A need for a more refined scale increased with the advancement of the science of seismology, and in 1902, the Italian seismologist, Mercalli, devised a new scale on a I to XII range. The Mercalli Scale was modified in 1931 by American seismologists Wood and Neumann to take into account modern structural features:

I. Not felt except by a very few under especially favourable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day, felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

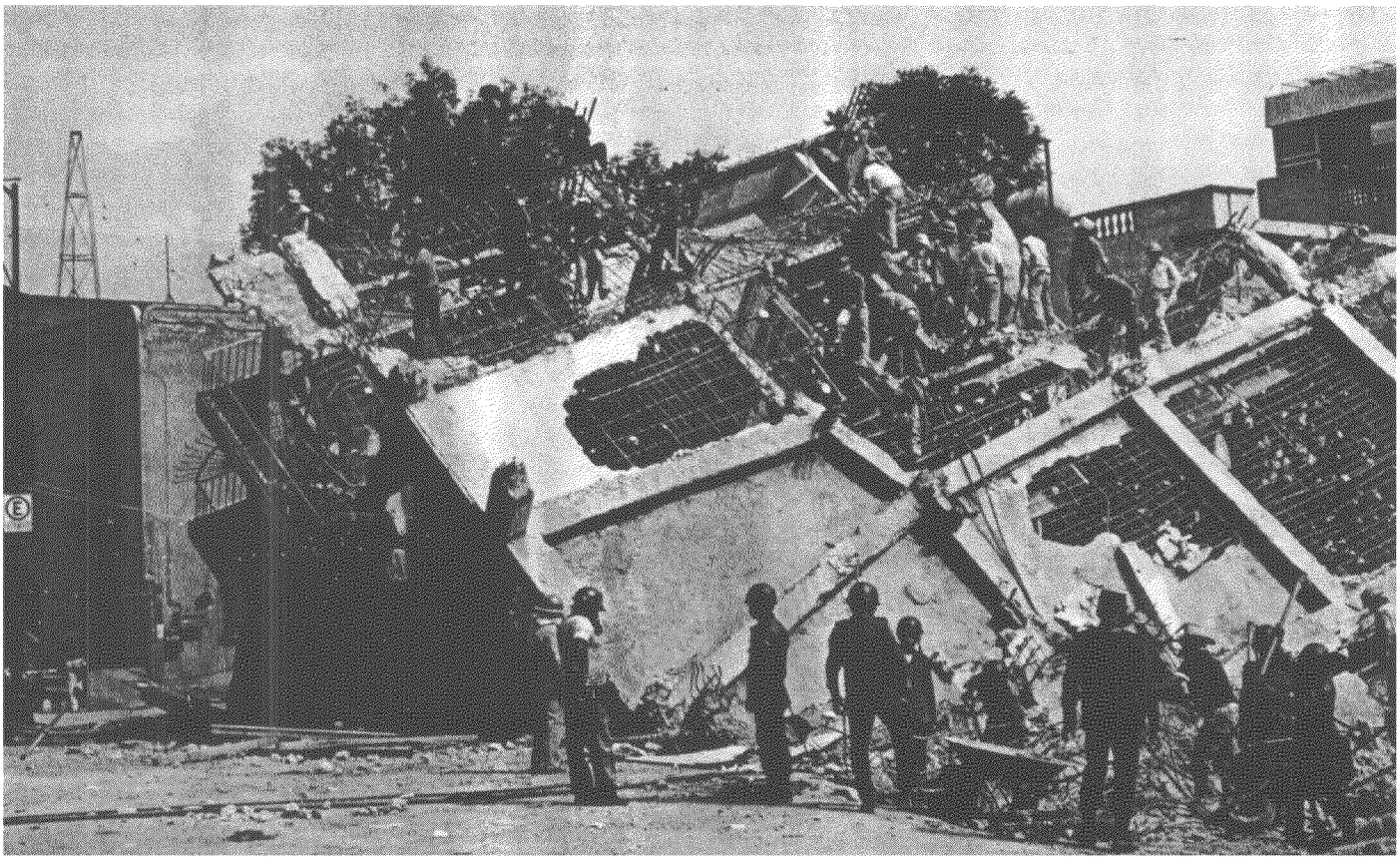
VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures; Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service.



An earthquake of magnitude 8 on the Richter Scale, shook Mexico City, on 19 September 1985 causing much loss of life and extensive property damage.

UNDRO/B. Larner

Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.

The Modified Mercalli intensity scale measures the intensity of an earthquake's effects in a given locality, and is perhaps much more meaningful to the layman because it is based on actual observations of earthquake effects at specific places. It should be noted that because the data used for assigning intensities can be obtained only from direct firsthand reports, considerable time —weeks or months— is sometimes needed before an intensity map can be assembled for a particular earthquake. On the Modified Mercalli intensity scale, values range from I to XII. The most commonly used adaptation covers the range of intensity from the conditions of "I — not felt except by very few, favorable situated," to "XII — damage total, lines of sight disturbed, objects thrown into the air." While an earthquake has only one magnitude, it can have many intensities, which decrease with distance from the epicenter.

Comparison of Magnitude and Intensity

It is difficult to compare magnitude and intensity because intensity is linked with the particular ground and structural conditions of a given area, as well as distance from the earthquake epicenter, while magnitude is a measure of the energy released at the focus of the earthquake.

Richter Magnitude		Expected Modified Mercalli Maximum Intensity (at epicenter)
2	I - II	Usually detected only by instruments.
3	III	Felt indoors.
4	V	Felt by most people; slight damage.
5	VI - VII	Felt by all; many frightened and run outdoors; damage minor to moderate.
6	VII - VIII	Everybody runs outdoors; damage moderate to major.
7	IX - X	Major damage.
8	X - XII	Total and major damages.

After Charles F. Richter, 1958, *Elementary Seismology.*

Based on material from the September 1984 issue of California Geology, State of California, The Resources Agency, Department of Conservation, California Division of Mines and Geology. ■