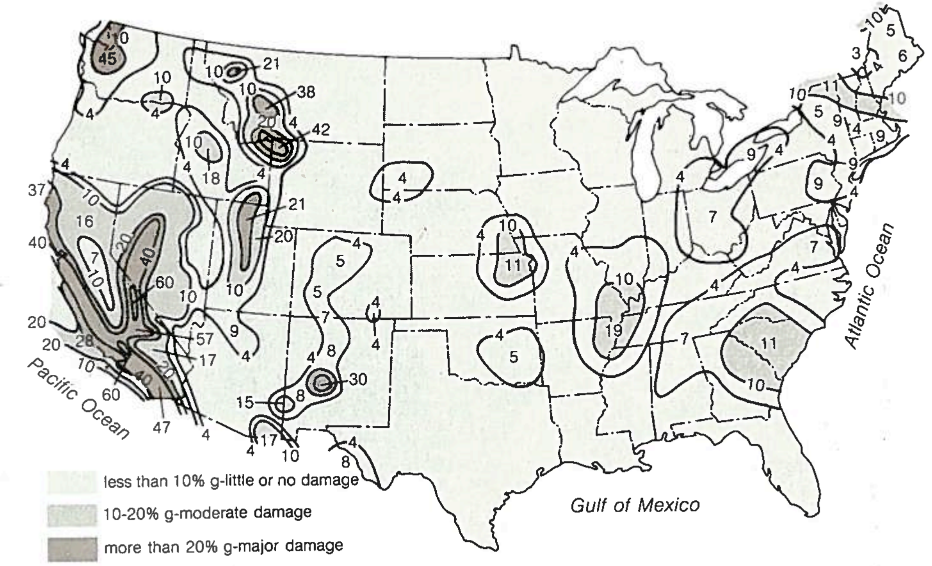

Figure 17-25
Map shows expected level of earthquake-shaking hazards. Levels of ground shaking for different regions are shown by contour lines that express in percentage of the force of gravity the maximum amount of shaking likely to occur at least once in a 50-year period. Damage begins to occur at about 10 percent g. An acceleration of 0.1 percent g or more is perceptible to people. [Modified from U.S. Geological Survey Chart.]

Table 17-2
Some of the world's worst earthquakes (in lives lost).

Year	*Place*	*Deaths (est.)*	*Year*	*Place*	*Deaths (est.)*
856	Corinth, Greece	45,000	1908	Messina, Italy	160,000
1038	Shansi, China	23,000	1915	Avezzano, Italy	30,000
1057	Chihli, China	25,000	1920	Kansu, China	180,000
1170	Sicily	15,000	1923	Tokyo, Japan	99,000
1268	Silicia, Asia Minor	60,000	1930	Apennine Mountains, Italy	1,500
1290	Chihli, China	100,000	1932	Kansu, China	70,000
1293	Kamakura, Japan	30,000	1935	Quetta, Baluchistan	60,000
1456	Naples, Italy	60,000	1939	Chile	30,000
1531	Lisbon, Portugal	30,000	1939	Erzincan, Turkey	40,000
1556	Shen-shu, China	830,000	1948	Fukui, Japan	5,000
1667	Shemaka, Caucasia	80,000	1949	Ecuador	6,000
1693	Catania, Italy	60,000	1949	Khait, U.S.S.R.	12,000
1693	Naples, Italy	93,000	1950	Assam, India	1,500
1731	Peking, China	100,000	1953	Northwestern Turkey	1,200
1737	Calcutta, India	300,000	1954	Northern Algeria	1,600
1755	Northern Persia	40,000	1956	Kabul, Afghanistan	2,000
1755	Lisbon, Portugal	30,000–60,000	1957	Northern Iran	2,500
1783	Calabria, Italy	50,000	1957	Western Iran	1,400
1797	Quito, Ecuador	41,000	1957	Outer Mongolia	1,200
1819	Cutch, India	1,500	1960	Southern Chile	5,700
1822	Aleppo, Asia Minor	22,000	1960	Agadir, Morocco	12,000
1828	Echigo (Honshu), Japan	30,000	1962	Northwestern Iran	12,000
1847	Zenkoji, Japan	34,000	1963	Skopje, Yugoslavia	1,000
1868	Peru and Ecuador	25,000	1968	Dasht-e Bayaz, Iran	11,600
1875	Venezuela and Columbia	16,000	1970	Peru	20,000
1896	Sanriku, Japan	27,000	1972	Managua, Nicaragua	10,000
1897	Assam, India	1,500	1976	Italy	900
1898	Japan	22,000	1976	Guatemala	23,000
1906	Valparaiso, Chile	1,500	1976	T'ang-shan, China	700,000
1906	San Francisco	500	1976	Philippines	3,100
1907	Kingston, Jamaica	1,400	1976	New Guinea	9,000

Figure 17-26
Housing tracts constructed within the San Andreas fault zone, San Francisco peninsula. The white line indicates the approximate fault trace, along which ground ruptured and slipped about 2 m during the earthquake of 1906. [Photo by R. E. Wallace, U.S. Geological Survey.]

the opening and extension of tiny cracks. This increase in volume, called *dilatancy,* begins when the stress reaches half the value needed to break the rock. When rocks become dilatant, other measurable physical changes occur—for example, in their electrical resistance, and the propagation speed of seismic waves (Fig. 17-27). The idea is to detect these physical changes in a region of the Earth's crust that has become dilatant just before an earthquake and issue a warning. For a great earthquake some of these changes (seismic velocity, uplift) can begin to occur 10 to 15 years before the shock, so that long-term preparations can be initiated (Fig. 17-28). Such changes as a reduction in the number of small tremors, followed by a rapid increase, can occur days or hours before the shock and can serve notice that it is time to evacuate weak structures, close down nuclear power plants and gas lines, and take other last-minute precautions.

If earthquake prediction has just become respectable, earthquake control continues to boggle the imagination. Yet some chance discoveries have opened this intriguing possibility. In 1966, a dramatic correlation was found between the rate of high-pressure injection of waste fluids into a deep well and the frequency of earthquakes in the vicinity of Denver, Colorado (Fig. 17-29). Apparently the earthquakes were triggered by reduction of frictional resistance to faulting. The pressure exerted by the injected