THE NATURE OF THE EARTHQUAKE THREAT IN ST. LOUIS

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Earthquake hazard in the St. Louis area arises from two causes: nearby earthquakes that produce short-duration, high-frequency ground motion and more distant earthquakes that produce relatively long-duration, low-frequency ground motion.

Figure 1 shows my version of the earthquake source zones of the central United States together with my estimates of the surface-wave magnitude of the earthquake with a 1,000-year recurrence time. The source zones closest to the St. Louis area are the St. Francois Mountain uplift to the southwest and the Illinois Basin to the east. The more distant zones are the Wabash Valley fault zone to the southeast and the New Madrid fault zone to the south. On average, St. Louis is 150 to 200 km form the Wabash Valley Zone and 175 to 350 km from the New Madrid Zone.

All four sources zones have produced earthquakes that caused damage in St. Louis. An M_S = 4.4 earthquake in April 1917, which occurred in the St. Francois uplift region about 60 km south of St. Louis, caused modified Mercalli intensity (MMI) V-VI effects in the city. This resulted in bricks being shaken from chimneys, broken windows, cracked plaster, and horses thrown to the pavement.

Two damaging Illinois Basin earthquakes occurred near Centralia, Illinois, about 100 km east of St. Louis. The June 1838 event was of M_S = 5.8 and the October 1857 event of M_S = 5.3. Contemporary newspaper accounts and some current earthquake catalogs mistakenly put their epicenters at St. Louis because of the amount of damage that occurred in the city. The former event caused a number of chimneys to be thrown down in St. Louis, corresponding to a MMI of VII. The latter produced only fallen plaster and cracks in walls and chimneys in the St. Louis metropolitan area, corresponding to a MMI of VI.

A M_S = 5.2 earthquake originated in the Wabash Valley region about 150 km from St. Louis in November 1968. In St. Louis the MMI was only V (cracked plaster, objects thrown off shelves, etc.) but in the eastern part of the metropolitan area the MMI was at least VI (cracks in walls and chimneys and people thrown to ground).

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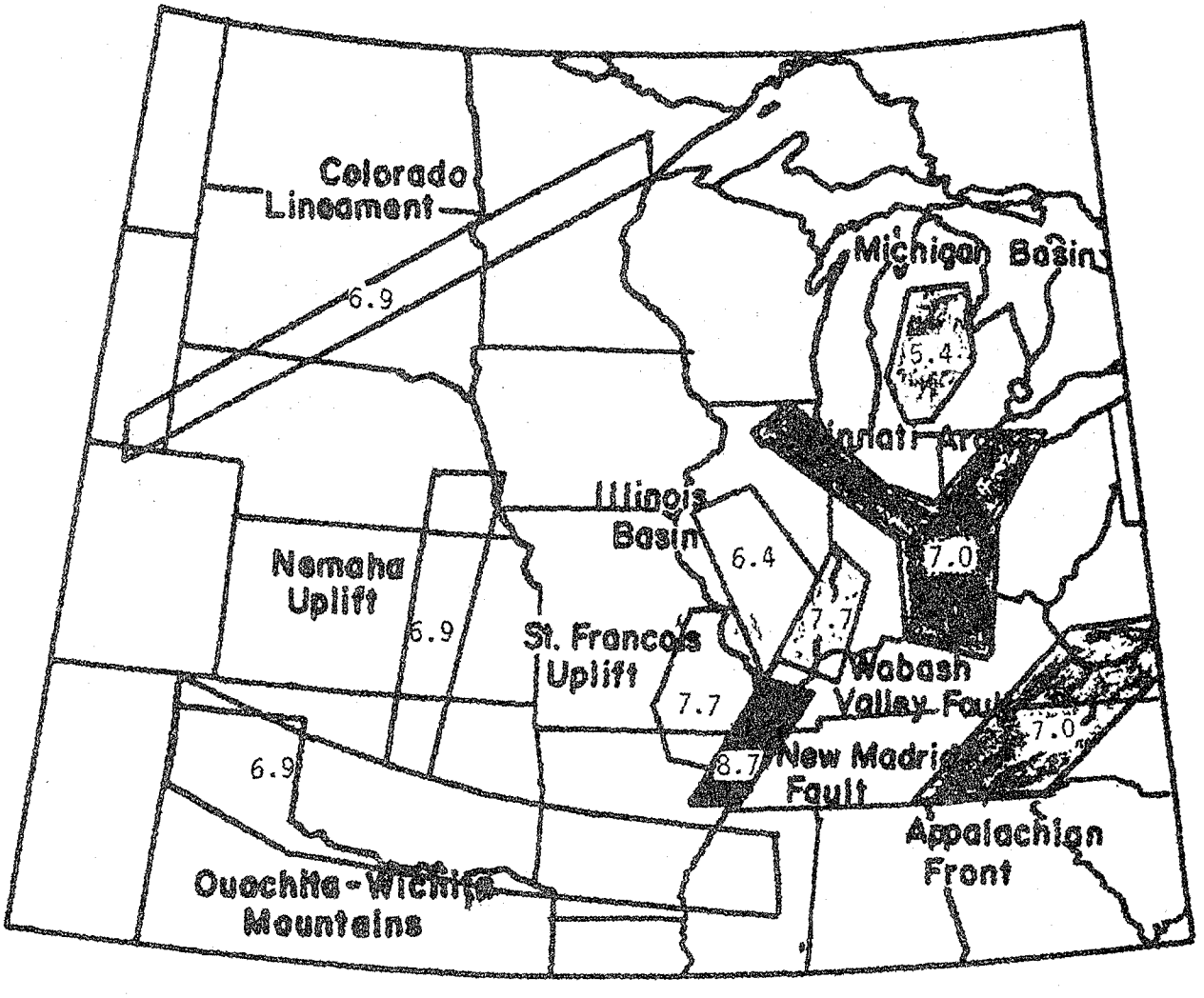

FIGURE 1 Earthquake source zones of the central United States.

The largest earthquake shaking in the St. Louis area since the city's founding in 1764 was caused by earthquakes of the New Madrid fault zone. Earthquakes in December 1811 and January and February of 1812 (M_S values ranging from 8.0 to 8.7) caused chimneys to be thrown down in St. Louis and 2-foot thick stone building foundations to be badly cracked. There were reports of sand catering and soil liquefaction in Cahokia, Illinois, just across river from St. Louis. The four largest earthquakes caused MMIs of VII to IX in St. Louis area. The October 1895 earthquake (M_S about 6.5) occurred near the northern end of the New Madrid fault and caused MMI VI effects at St. Louis. A few chimneys and old building walls were thrown down, suspended objects were thrown from walls, and groceries and other objects were thrown off shelves.

Future earthquake damage in St. Louis can be expected to be more severe than the damage produced by the past earthquakes. In the nineteenth century the population density was low and there were no high-rise structures. There were only 2,000 people living in the metropolitan area in 1811 as opposed to 2,400,000 today. Previously there were no pipelines, bridges, dams, or manufacturing plants with toxic substances to be affected. Futhermore, there was no great dependence on electricity, telephones, highways, and airports, and the economic impact of the disruption of such facilities must be considered.

It is not now possible to make short-term predictions of earthquakes in the Mississippi Valley; however, our knowledge of the earthquake history and the source physics of the New Madrid region permit some generalizations. During the next 50 years MMI VII motion can reasonably be expected in the St. Louis area from earthquake in the St. Francois uplift, the Illinois Basin, or the Wabash Valley region. The shaking will be of relatively short duration (30 seconds or less) and can be expected to cause widespread damage to the walls and chimneys of low-rise structures.

According to my calculations, the maximum earthquake that the New Madrid fault is capable of generating in the near future is one of M_S = 7.6. Figure 2 shows the MMI curves for such an earthquake if it were to occur on the central part of fault. The motion at St. Louis again would be of about MMI of VII, but it would be of relatively low frequency (about 5 to 0.1 Hz), of possibly 2 or more minutes duration, and sinusoidal in character. It would not cause structural damage to well designed, high-rise structures, but it would cause large-amplitude displacements at the upper levels and much nonstructural damage (e.g., fallen ceiling panels and light fixtures, moved and overturned furniture, and fallen debris within and outside the buildings). Widespread chimney damage to low-rise structures also should be expected. Sensitive equipment, including computer facilities, could be put out of operation or damaged. The probability of such an M_S = 7.6 earthquake occurring on the New Madrid fault is about 25 percent in the next 50 years according to Professor Arch Johnston of Memphis State University. However, he finds the probability of occurrence during the next 50 years of the size of the 1895 event to be about 90 percent. The extent of damage of this smaller earthquake in the St. Louis area will depend upon whether it occurs

near the northern end of the fault as it did in February 1812 and 1895, near the southern end of the fault as in December 1811 and 1843, or in the central portion as in January 1812.

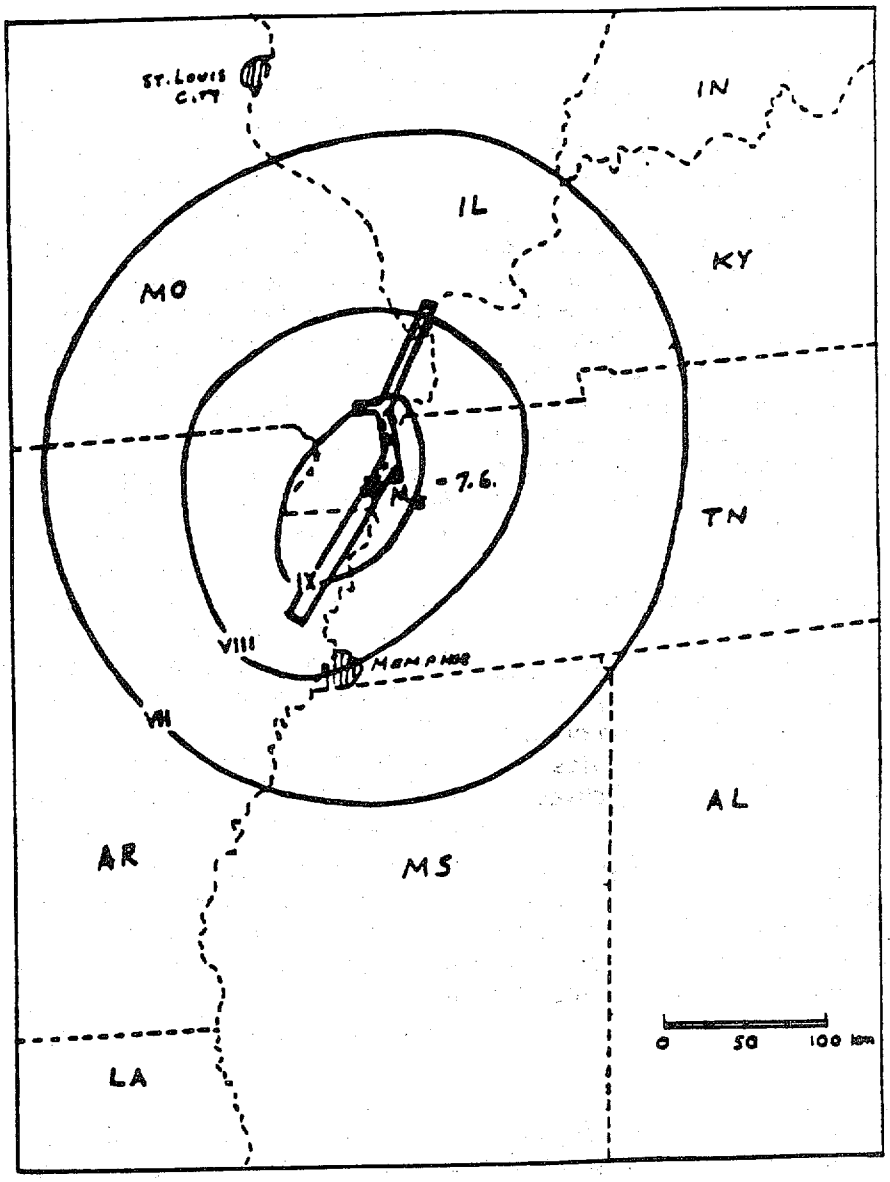

FIGURE 2 MMI curves for earthquakes generated in the New Madrid fault.