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Western Lowlands liquefaction features (Class A) No. 1029

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Synopsis	The evidence for Quaternary faulting in the Western Lowlands of Missouri and Arkansas consists of late Quaternary liquefaction features that are attributed to prehistoric earthquakes and to seismic-reflection profiles that show offset Quaternary reflectors. These liquefaction features are evidence of strong shaking, but they do not identify the specific fault or faults that caused an earthquake or earthquakes. Because individual Quaternary faults remain unidentified, it is not possible to define and measure specific attributes (azimuth, length, dip, etc.) for the Western Lowlands liquefaction features.
Name comments	The Western Lowlands of Missouri and Arkansas form the part of the northwestern Mississippi embayment, which lies west of the northeast-trending Crowleys Ridge (Saucier and Snead, 1991

	#2021). Several prehistoric liquefaction features west of Crowleys Ridge are here informally grouped under the name Western Lowlands.
County(s) and State(s)	STODDARD COUNTY, MISSOURI NEW MADRID COUNTY, MISSOURI RANDOLPH COUNTY, ARKANSAS
Physiographic province(s)	COASTAL PLAIN
Reliability of location	Poor Compiled at 1:1,700,000 scale. *Comments:* The liquefaction was recognized as the type that is caused by strong ground motion, for example, Obermeier (1996 #2256), and the strong motions are presumed to have been caused by slip on one or more preexisting faults. However, the causative faults have not been identified and the locations and sizes of the liquefaction features identified to date provide poor constraints on the sources of the shaking.
Geologic setting	The northern Mississippi embayment is approximately bisected by the Mississippi River. West of the Holocene meander belt of the river, the embayment is dominated by lowlands of nearly flat, terraced, outwash deposits of late Wisconsinan braided streams (Saucier and Snead, 1991 #2021). The part of the embayment west of the Mississippi River is itself approximately bisected by the uplands of north-northeast-trending Crowleys Ridge. Thus, the ridge divides the outwash deposits, and smaller areas of late Wisconsinan dunes and Holocene floodplains, into the Western Lowlands and Eastern Lowlands (Vaughn, 1994 #3924; Vaughn and others, 1996 #3925). The New Madrid seismic zone is east of Crowleys Ridge, in and east of the Eastern Lowlands and the Mississippi River (for example, Wheeler and Rhea, 1994 #754). Therefore, the seismic zone is generally 30 km or more east of the area summarized here. The New Madrid seismic zone is spatially associated with the Reelfoot rift. The main upper crustal expression of the rift is the Mississippi Valley graben. All of the Western Lowlands paleoseismological sites studied by Vaughn (1994 #3924), Tuttle and others (1998 #3817), and Tuttle (1999 #3921) lie several tens of kilometers northwest of the floor of the graben, and also northwest of the wide, step-faulted margin of the graben (Rhea and Wheeler, 1994 #3919). However, several of the sites lie near

	or on an aeromagnetic lineament that trends northeast (Vaughn, 1991 #3922; Tuttle, 1999 #3921). The lineament is part of the Commerce geophysical lineament, which, after magnetic and gravity modeling, Langenheim and Hildenbrand (1997 #3917) attributed to a mafic dike swarm that they suggested may have formed parallel to and coevally with the Reelfoot rift. If this part of the lineament, the inferred dike swarm, and the rift formed coevally, then likely the mafic magmas intruded fractures that formed or reopened with an extensional component of movement. Thus, the formation of the source of the Commerce geophysical lineament may have involved at least a component of normal faulting. This reasoning indicates that the paleoseismological sites in the Western Lowlands may lie near one of the northwesternmost normal or normal-oblique faults of the rift, even if the sites lie outside the main part of the step-faulted rift margin. Paleoliquefaction sites 1, 2, 6, and 7 of Vaughn (1994 #3924) surround Dudley ridge. Two high-resolution seismic-reflection profiles across the western slope of the ridge are interpreted as showing three faults that extend from Paleozoic and Cretaceous bedrock upward into Quaternary sediments (Shoemaker and others, 1997 #3920; Shoemaker and others, 1998 #3955). Another high-resolution reflection profile across the Commerce geophysical lineament approximately 30 km southwest of Dudley ridge shows about 20 m of dip separation on a reflector within the Quaternary sequence (Stephenson and others, 1999 #3954). Thus, the profile interpretations support the liquefaction evidence of Quaternary faulting. Vaughn (1991 #3922) and Boyd and Schumm (1995 #3916) identified several geomorphic anomalies, including diverted rivers, in the Western Lowlands, and speculated about possible Quaternary tectonism. However, any such tectonism need not occur coseismically, or even involve faulting. Accordingly, this assessment of the Western Lowlands focuses on paleoseismological evidence for prehistoric earthquakes.
Length (km)	km.
Average strike	
Sense of movement	No data *Comments:* The sense of movement and dip are unknown.

	Information on prehistoric earthquakes is known only from the locations and estimated age of liquefaction features. No surface ruptures are known from the earthquakes.
Dip	No data *Comments:* The causative fault or faults remain unidentified and uncharacterized.
Paleoseismology studies	The main reports on liquefaction features in the Western Lowlands are those of Vaughn (1994 #3924), Tuttle and others (1998 #3817), and Tuttle (1999 #3921). Vaughn (1994 #3924) summarized results from 12 sites. Four of the sites are east of Crowleys Ridge in the Eastern Lowlands and will not be considered further here. Of the eight sites in the Western Lowlands, all contained liquefaction features attributed to prehistoric earthquakes. However, dateable materials were recovered only at sites 1 (Dudley Main Ditch, site DM-1 of Wheeler and Rhea, 1994 #754; site V1 of Tuttle, 1999 #3921), 2 (Mingo Ditch, site MD-1 of Wheeler and Rhea, 1994 #754; site V2 of Tuttle, 1999 #3921), 3 (Wilhelmina Cutoff of the St. Francis River, site SF-2 of Wheeler and Rhea, 1994 #754; site V3 of Tuttle, 1999 #3921), and 6 (Dudley Main Ditch). These four sites yielded evidence of at least four prehistoric events (individual earthquakes or sequences of earthquakes). Vaughn (1994 #3924) suggested that a small surficial sand blow at site 3 may have formed during the 1811–12 New Madrid earthquakes. The sites are within 27 km of each other (Vaughn, 1994 #3924, fig. 2). The first two events are best represented by crosscutting dikes at site 1. A dike of event 1 fed a crater and a sand blow. Three dikes of event 2 cut the older dike, crater, and sand blow. Both events are bracketed by dates of 22,750 radiocarbon yr B.P., from wood 35 cm below the event 1 sand blow, and of 3,570 yr B.P., from wood at the base of a paleochannel that post-dates both events. Elsewhere at site 1, a late Wisconsinan channel deposit contained a bone dated at 12,570 yr B.P. The channel deposit is cut by a dike, which is itself cut by a younger dike. The younger dike is truncated by a second, late Holocene channel deposit with wood at its base that yielded a date of 590 yr B.P. Therefore, the two dikes represent two liquefaction episodes between 12,570 yr B.P. and 590 yr B.P. These episodes might or might not correspond to events 1 and 2. At site 6, deformed beds beneath a sand blow

contain wood and bone; the bone gave a date of 17,990±150 yr B.P. Vaughn (1994 #3924) assumed that the sand blow was coeval with event 1. Thus, events 1 and 2 are younger than 22,750 yr B.P. Note that, depending on the validity of the correlations elsewhere in site 1 and to site 6, both events may be younger than 17,990 yr B.P. Alternatively, the dikes elsewhere in site 1 might have formed in unrecognized events between events 2 and 3. Regardless, events 1 and 2 occurred before 3,570 yr B.P.

Dikes and buried sand blows at site 2 were attributed to event 2. A carbonaceous silt 58–62 cm below a sand blow was dated at 13,430±170 yr B.P. Early Archaic archeological artifacts are on the terrace surface that overlies the sand blow, indicating that the event predated 9,000–10,000 yr B.P. (Vaughn, 1994 #3924).

Events 3 and 4 are known only from site 3 (Vaughn, 1994 #3924). Two surficial sand blows about 100 m apart bury dated soils, and Vaughn (1994 #3924) suggested that the ages of the soils approximate the ages of the events. Organic material in the soil horizon immediately beneath the larger sand blow was dated as 1660±70 and 1110±65 yr. B.P., which give calibrated ages of AD 240–560 and 770–1020, respectively (Vaughn and others, 1993 #3923; Vaughn, 1994 #3924). Thus, event 3 was estimated to have occurred during AD 240–1020. Similarly, organic material from the soil horizon immediately beneath the smaller sand blow was dated as AD 1440–1540 (calibrated), which is the estimated age of event 4.

Tuttle and others (1998 #3817), and Tuttle (1999 #3921) sought to define the ages and size distribution of liquefaction features in and near the New Madrid seismic zone, including the Western Lowlands. She summarized results from 116 liquefaction and archeological sites, of which 25 are in the Western Lowlands. Of these 25 sites, 15 contained prehistoric liquefaction features attributed to earthquakes. Most of the features are sand dikes. Only three sandblows were found and two of these were dated at Current River 8 and at Current River 2 of Tuttle (1999 #3921). Current River 8 is at or near site 4 of Vaughn (1994 #3924), and Current River 2 is newly discovered.

At the Current River 2 site, a sand blow buried a cypress knee. Later, a tree root, now burned, penetrated a paleosol above the sand blow. Calibrated dates on the cypress knee and the burned root constrained the sand blow to have formed during AD 1310–1450 (Tuttle, 1999 #3921).

	The Current River 8 site records two to four liquefaction episodes (Tuttle, 1999 #3921). Sand dikes and a sand blow (episode I) were intruded by later sand sills (episode II). Other sills were intruded (episode III) into sediment that had been deposited on top of the sand blow. The sills of episode III were themselves cut by younger dikes (episode IV). No structural or stratigraphic evidence precludes episodes II–IV from having formed during the same earthquake or earthquake sequence. The only age control is from wood found 15 cm below the episode I sand blow. The wood yielded a calibrated date of 3490–3470 BC and 3380–3090 BC. Thus, episodes I–IV postdate 3490 BC. (Tuttle, 1999 #3921). Tuttle (1999 #3921) combined her results with those of several other paleoliquefaction studies, including that of Vaughn (1994 #3924), to deduce the occurrence of very large to great earthquakes or earthquake sequences in the New Madrid seismic zone in AD 900±100 yr, AD 1530±130 yr, and, of course, 1811–12. Additional liquefaction events occurred before AD 900, but their ages and geographic distributions remain poorly constrained. Because no sand blows were found in the area that could be attributed to the 1811–12 New Madrid earthquakes, Tuttle (1999 #3921) suggested that the sand blow at Current River 2, which formed in AD 1380±70 yr, may be too large to have been caused by an earthquake in the New Madrid seismic zone 80 km or more distant. Instead, Tuttle (1999 #3921) suggested that the sand blow may be related to a separate source in the Western Lowlands. Earlier, Vaughn (1994 #3924) had attributed his event 2 to a possible source in a different part of the Western Lowlands. The two to four liquefaction episodes at Current River 8 (site V4 of Vaughn, 1994 #3924) are known only to postdate 3490 BC. One or more of liquefaction episodes II–IV at Current River 8 might have been coeval with the single episode at Current River 2 (Tuttle, 1999 #3921). Events 3 and 4 at site 3 of Vaughn (1994 3924; site V3 of Tuttle, 1999 #3921) are attributed to the AD 900±100 yr and AD 1530±130 yr earthquakes or earthquake sequences in the New Madrid seismic zone (Tuttle, 1999 #3921, figure 47). The zone is only approximately 50 km away from site 3, at which Vaughn (1994 #3924) suggested that a smaller surficial sand blow may be attributed to the 1811–12 New Madrid earthquakes.
Geomorphic expression	The liquefaction features generally lack geomorphic expression because they are largely exposed in the walls of excavations and

	cut banks of streams . Some sand blows are exposed at ground level (Vaughn, 1994 #3924; Tuttle, 1999 #3921).
Age of faulted surficial deposits	late Wisconsinan (Saucier and Snead, 1991 #2021).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Probably AD 1380±70 yr (Tuttle, 1999 #3921).
Recurrence interval	 *Comments:* No recurrence interval is reported. Vaughn (1994 #3924) attributed his event 2 to a possible source in the Western Lowlands between 22,750 yr BP and 3,570 yr BP. Tuttle (1999 #3921) also attributed a liquefaction event at AD 1380±70 yr to a Western Lowlands source. However, the two events were recognized at sites approximately 70 km apart, and are poorly characterized as to the geographic distributions of coeval liquefaction features. Accordingly, neither potential source is known to have had more than one well-dated earthquake, so no recurrence interval can be calculated.
Slip-rate category	Insufficient data *Comments:* There are no data from which to estmate a slip rate. No causal fault, surface rupture, or dated fault offset is known. There is no evidence that the strong motion that affected any two sites originated on the same fault.
Date and Compiler(s)	2000 Russell L. Wheeler, U.S. Geological Survey, Emeritus
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