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Active faults in East Baton Rouge Parish, Louisiana

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Introduction

A fault is a relatively thin boundary–an essentially planar zone or surface in three dimensions–along which rocks rupture to produce two blocks that move relative to one another. East Baton Rouge Parish, which includes the capital seat of Louisiana and an urban area that has undergone substantial development in the past decade, is traversed and impacted by at least two faults (figure 1). These faults are known to be active but apparently do not produce earthquakes. The parish is underlain by coast-parallel terraces formed by deposits of the Mississippi River and smaller coastal-plain streams from the recent geologic past, and these elevated terraces are incised by the bottomlands of the river and streams, in which sediment is still being deposited today. The Prairie Terrace is exposed over most of East Baton Rouge Parish and is broken by the Baton Rouge fault and the Denham Springs-Scotlandville fault, which are collectively referred to as the Baton Rouge fault system.

The individual faults are recognizable at the surface in the parish as escarpments (long slopes that are fairly continuous and comparatively steep, facing in a consistent direction and separating more gently sloping surfaces on either side) having distinctive topographic expression (figures 2, 3). They were first described in the mid-1950s,[1] at which time they were corroborated by subsurface information that had been produced in conjunction with the exploration for oil and gas. Though they do not produce detectable earthquakes, these faults are known to be active because of the cumulative damage done to structures located on and near certain fault segments over periods of years and decades. Examples of such damage include cracked road pavements, foundation slabs, and walls.

Figure 1. Known, active surface faults in East Baton Rouge Parish (adapted from McCulloh 1991, 1996).

[1]Durham and Peeples 1956

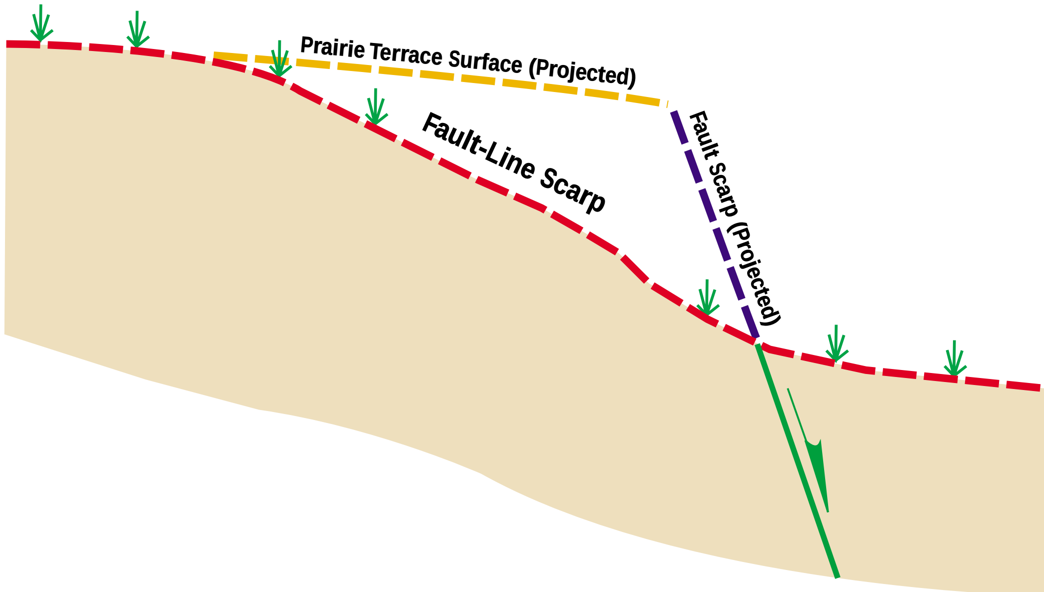


Figure 2. Schematic section across the Baton Rouge fault (adapted from McCulloh 1991). Prairie is the name of the terrace exposed at the surface over most of East Baton Rouge Parish and broken by the faults of the Baton Rouge system. The projected lines show the volume of material removed by erosion.

Figure 3. Photograph of the fault-line scarp of the Baton Rouge fault (in the far distance) where it traverses Highland Road not far north of LSU. The fault here coincides with a terrace boundary, the one marking the Pleistocene-Holocene contact: the Prairie terrace (Pleistocene) on the upthrown side is juxtaposed against deposits of the current Mississippi River flood plain (Holocene) on the downthrown side.

The two known faults in East Baton Rouge Parish represent the recently reactivated surface expressions of deep-seated faults (figure 4) of a type known as growth faults, formed originally in much older strata. A growth fault is a fault that is or was active during deposition of some of the strata it displaces, such that the thickness of such strata on the downthrown side expands or "grows," in some cases very dramatically. This results in increasing fault displacement with depth over much of the interval affected by the fault. Such faults are typically associated with centers of voluminous sedimentation. Reactivation in the recent geologic past has produced characteristic patterns of displacement with depth (figure 5) and accounts for the distinctive surface expression of the faults. After an initial period of growth faulting in conjunction with rapid sediment deposition, the faults were inactive (quiescent) for tens of millions of years, and only reactivated in the recent geologic past. This reactivation propagated the faults upward to the surface, in much the same way as an uncorrected flaw in a road bed will soon become expressed in a new overlay of asphalt pavement–but in the case of the reactivated faults, the propagation was through thousands of feet of sediment. As a result, an enormous thickness of strata shows essentially the same amount of displacement between the interval of old, deep strata recording the initial period of activity and that recording the recent reactivation. This relationship was documented by Hanor (1982) for a western extension of the Denham Springs-Scotlandville fault beneath the Mississippi River flood plain; Durham and Peeples (1956), though they did not graphically depict the depth distribution of fault displacement, made clear that the same relationship holds for the Baton Rouge fault. Heinrich (2000) found the same pattern of displacement for the De Quincy fault in southwestern Louisiana, though his data did not extend deeply enough to reach the initial interval of growth faulting.

Faults other than the Baton Rouge and Denham Springs-Scotlandville faults have been postulated in East Baton Rouge Parish but remain speculative. Some of these could be faults that have become inactive, and some could be active faults with very small displacements, associated with but subsidiary to the known faults. The Baton Rouge fault and the Denham Springs-Scotlandville fault not only constitute an important aspect of the geology of the area, but knowledge about them is essential to developing strategies for fault-hazard risk assessment and damage reduction. Detailed mapping of the faults at the surface provides a framework useful for formulating and evaluating such strategies in the location of structures on and near the escarpments, which are termed fault-line scarps.

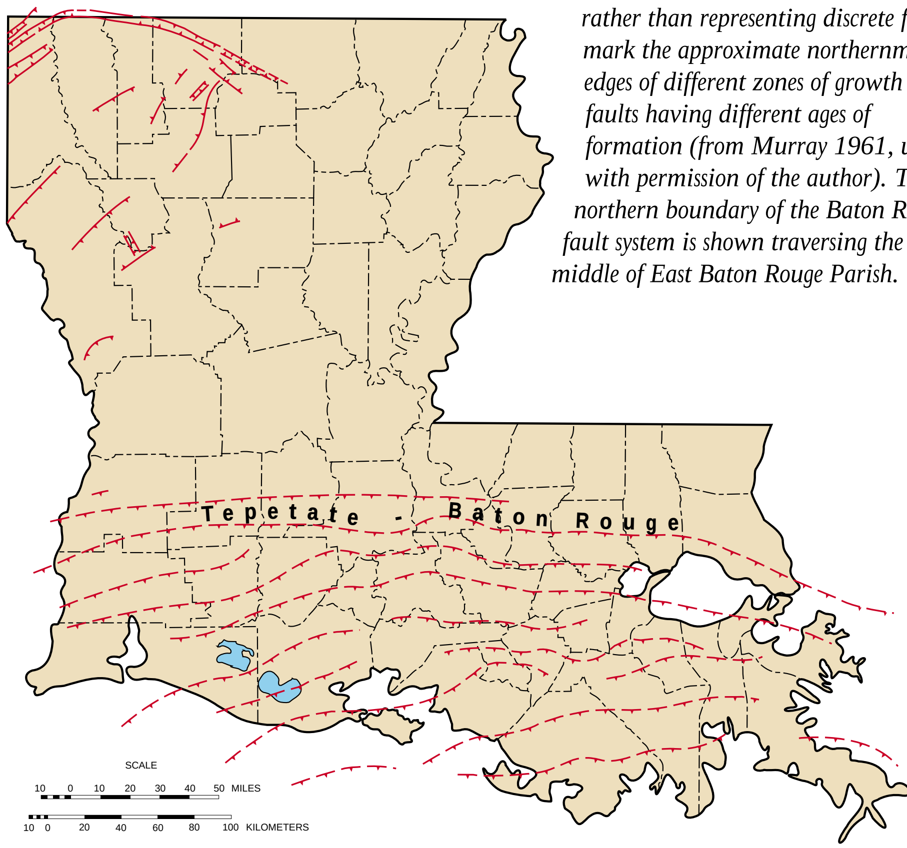


Figure 4. Generalized subsurface faults in Louisiana (teeth indicate downthrown sides). North Louisiana faults are from Gulf Coast Association of Geological Societies and American Association of Petroleum Geologists (1972, used with permission). The dashed lines in south Louisiana, rather than representing discrete faults, mark the approximate northernmost edges of different zones of growth faults having different ages of formation (from Murray 1961, used with permission of the author). The northern boundary of the Baton Rouge fault system is shown traversing the middle of East Baton Rouge Parish.

Recent Investigations of Baton Rouge Area Faults

Excellent detailed mapping of the surface faults in East Baton Rouge Parish was done on lot-and-block maps at a scale of 1 inch=400 feet for the city-parish Department of Public Works in the early 1980s.[2] Later mapping done at 1:24,000 (1 inch=2000 feet) in the early 1990s was an attempt to revise the preexisting mapping at the scale of standard 7.5-minute quadrangles, based on a systematic use of consistent recognition criteria and without emphasis on structural damage as the primary criterion. This rendering of the faults made use of characteristic topographic patterns observed for the fault-line scarps and was incorporated in geologic mapping of East Baton Rouge Parish also done in the early 1990s.[3]

The current rate of movement along the Baton Rouge fault was estimated to be several centimeters (a few inches) per decade in the report accompanying the maps made in the early 1980s of the faults in East Baton Rouge Parish. The authors noted that the present rate of near-surface movement has been accelerated by ground-water pumpage and possibly also by the alteration of surface drainage in the Baton Rouge area within the last century. Drainage changes could have induced different amounts of consolidation of near-surface material on opposite sides of the fault. The downthrown side, which naturally tends to be wetter, would have experienced greater consolidation and volume

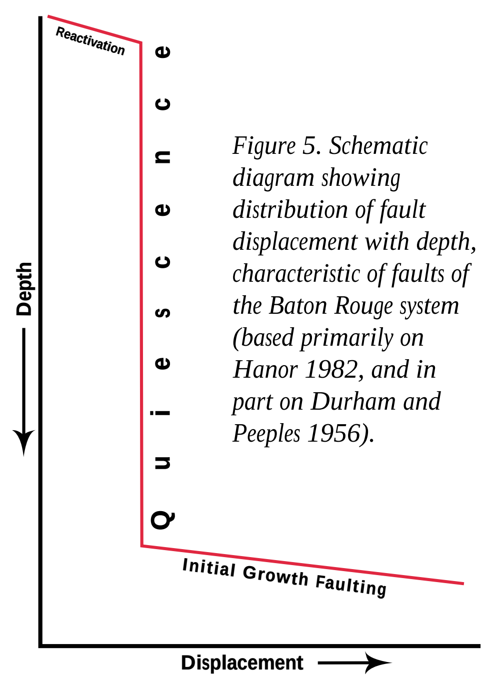


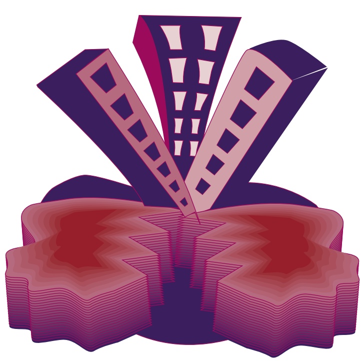
Figure 5. Schematic diagram showing distribution of fault displacement with depth, characteristic of faults of the Baton Rouge system (based primarily on Hanor 1982, and in part on Durham and Peeples 1956).

[2] Roland and others 1981
[3] McCulloh 1991

decrease as a result of such changes. This would have accelerated the apparent relative movement observable at the surface. The authors of the report estimated that the preexisting (pre-European settlement) rate of movement was about 2.5 centimeters (1 in.) every 400 years.

It appears that at present certain fault segments may be active and others relatively quiescent, although this is an anecdotal suggestion rather than a rigorously demonstrated finding. There are places along the trace of the Baton Rouge fault where homes 50+ years old, according to their present owners, have never had structural problems; and there are other places where homes less than 25 years old have reportedly had such problems almost from the time their construction was finished. Thus far no law requiring disclosure of faults or fault-related damage on properties, analogous to the disclosure law applicable to flood zones and flooding, has been put into effect.

Fault damage includes cracked road pavements, foundation slabs, and walls.



Possibilities for Future Research

Research on these faults in the future will likely include the search for and experimentation with potential instrumental alternatives to investigation by trenching. The only way to actually check the correctness of a map interpretation of a surface fault trace (if the trace on the ground is not exposed to view) is to dig a trench that exposes the fault plane in the material beneath the soil zone. The degree of development in East Baton Rouge Parish effectively precludes this, because the entire width of the fault-line scarp must be trenched to insure that the trench does in fact intersect the fault somewhere along its reach. Noninvasive instrumental techniques that would permit identification and accurate detailed mapping of surface faults would alleviate this problem; these might include shallow seismic profiling, shallow resistivity surveys, and gravity surveys. Ground-penetrating radar (GPR) may be disqualified in East Baton Rouge Parish because the stratum underlying the terrace surface consists largely of clay, which could make it an unsuitable medium for the GPR technique.

If a technique or suite of techniques can be developed that is an effective substitute for trenching, this will permit not only the accurate and detailed mapping of the known active faults along which movement produces structural damage in places in the highly developed Baton Rouge area, but also the evaluation of escarpments that may or may not be associated with faults. In other parts of south Louisiana, it can be difficult to distinguish among escarpments that represent faults, those that represent boundaries between terraces of different ages, and those that represent some combination of the two. Where the two coincide, the position of the escarpment separating the two terrace surfaces appears to have been controlled by the preexisting fault (cf. figure 3). Because these examples are in yet undeveloped areas, there has been no imperative to determine which explanation applies in individual cases. Preliminary indications are that many–if not all–of these escarpments are in fact active surface faults, analogous to those of the Baton Rouge system, but that this has not come to light previously because the areas are undeveloped. In southwestern Louisiana especially, numerous low escarpments have been documented[4] that resemble the fault-line scarps in East Baton Rouge Parish, and one has been definitely shown to be a fault with the same distinctive pattern of displacement with depth characteristic of recent reactivation.[5] If future development encroaches on such areas, determining the exact nature of the escarpments will become more urgent, and south Louisiana will likely have, in addition to Baton Rouge, other increasingly urbanized areas subject to potential structural damage associated with faulting.

[4] Heinrich 1997, 2000

[5] Heinrich 2000

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Damage to structures built on and near faults of the Baton Rouge system in East Baton Rouge Parish (from photographs taken in conjunction with the investigation of Roland and others 1981, on file at the Louisiana Geological Survey).

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