

THE UNIVERSITY OF TEXAS
BUREAU OF ECONOMIC GEOLOGY

MINERAL RESOURCE CIRCULAR
NO. 23

(Typeset from original stencil, September 1980)

Faulting in Northwestern Houston County, Texas

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February, 1943

Senator O'Mahoney has stated recently that the hearings of the subcommittee of the Senate Public Lands Committee "demonstrate beyond a shadow of doubt that an immediate war need is the stimulation of the search for oil."

Geologic exploration must precede and initiate the search for oil. Faulting and geologic structure are responsible for the underground accumulation of gas and oil. From this point of view the circular on faulting in northwestern Houston County is presented to the public.

The presence of some faults in the general vicinity of Anderson, Houston, and Leon counties has been known for some time. As early as 1917 some fault exposures or indications of faulting were described by O. B. Hopkins.¹ The exposures described by him are in the vicinity of Elkhart and Fields Chapel in Anderson County. However, these early observations were of a reconnaissance nature only and merely local and so incomplete that no map of the faulting could be drawn from them. As a consequence the faults of this region were not placed in any of the published geologic maps covering the area. Even the geologic map of the State, published as late as 1937 by the U. S. Geological Survey, does not show any faults in this area. The first published geologic map which shows the faulting in this area is the regional structure map accompanying Liddle's report on the Van oil field.²

The faults described below were mapped in 1941 and 1942. The mapping was done to a scale of 8 inches to the mile (1/7920) on aerial photographic maps of the same type as those used by the Agricultural Adjustment Administration for the measuring of field acreages. The excellence of these photographic maps has made it possible to map the region in great detail and with an accuracy far surpassing previous maps in the Gulf Coastal Plain.

The faults of northwestern Houston County occur as a continuous belt of faults. This belt of faults enters the county at the north end of the Rock Hills and extends past Antrim Church. It is called here the Antrim fault zone.

Antrim Fault Zone

The faults which compose this string of faults enter Houston County from Anderson County at the north end of the Rock Hills. The faults may be traced or conjectured for about 6 miles in Houston County and leave the county approximately 2 miles west of the Grapeland-Palestine highway (U. S. highway No. 287).

The faults of this string are downthrown on the north and upthrown on the south side. They may be recognized by the repetition of the Queen City—Weches—Sparta sequence. Of course, in this sequence the Weches formation is the most easily traced key horizon. Physiographically the fault string is also well expressed. Along its entire mappable length in Houston County it forms a fault line scarp with the south side making the high part of the scarp.

The Queen City formation is the oldest formation exposed along the faults. The formation is variable in composition, but muscovitic and slightly glauconitic sands and sandstones predominate. Brown, muscovitic shales are next in frequency.

Some of the Queen City sandstones, usually more glauconitic ones, are resistant to erosion and form high hills. The Rock Hills owe their prominence to these Queen City rocks.

The Weches formation consists of richly fossiliferous and glauconitic marls chiefly. In the lower part of the formation lime is a conspicuous constituent, and some of the beds are hard, thick, glauconitic and very impure limestones. The middle part of the formation lacks these limestones; instead it contains many layers of red-brown clay-ironstone. The upper portion of the Weches formation consists of brown, silty, nonfossiliferous shales.

The Sparta sand rests on the Weches formation with an erosional disconformity. At the contact of the two formations there is in many places a bed of laminated brown iron ore less than a foot thick. Resting on the iron ore and usually tightly adhering to it is the basal bed of the Sparta sand. This bed is infiltrated with limonite and thus indurated to a slab of hard, brown to maroon-black, ferruginous sandstone.

The Sparta sand is a thick-bedded, loose sand usually without clay or shale beds. This sand forms extensive deep sandy flats upon weathering.

The following paragraphs give a detailed description of the surface geology along and the visible evidence for the faults.

The string enters Houston County from the west, near the north end of the Rock Hills, at a place about 1.29 miles west of Antrim Church or about 1.29 miles north of Rockhill Church. Here the fault is easily recognized from physiographic evidence and the geographic distribution of the Weches outcrops. The outliers and lobes of Weches and Sparta which are situated from 0.18 to 1.13 miles north of Rockhill Church rise to impressive heights. The north end of these outliers and lobes, about 1.09 miles north of Rockhill Church, is particularly impressive, steep, and high. Standing on the Sparta-Weches contact there, one can see for miles to the north over a low region with many whitish sandy fields. This sandy region which one sees below and to the north is the Sparta sand of the downthrown side, whereas the viewer is standing on the upthrown side. Thus erosion has emphasized the fault and produced a fault line scarp on the upthrown side.

¹Hopkins, O. B., The Palestine salt dome, Anderson County, Texas: U. S. Geol. Survey Bull. 661, pp. 268-270, 1917.

²Liddle, R. A., The Van oil field, Van Zandt County, Texas: Univ. Texas Bull. 3601, pl. 7, 1936.

In detail the fault may be located by following the Weches outcrops of the Rock Hills. The outcrops can be traced northward up to the fault where they are terminated abruptly, and to the north of them one finds an extensive abandoned field, a Sparta sand flat. Here the fault is very near the edge of the abandoned field. An interesting feature of the Sparta-Weches contact on the south side of the fault is that it descends northward, toward the fault, as if dragged into the fault. This descent is noticeable for about 500 feet.

A gully originates in the west corner of the above mentioned abandoned sandy field. At first this gully is dry and only a red-orange clayey sand containing Weches fragments is exposed in it. This sand is slope wash. But about 470 feet from its head the gully deepens into a narrow but small chasm at the bottom of which are springs issuing from a whitish or white-greenish, clayey water sand. This is weathered Sparta sand and it underlies the slope wash material. Farther down the gully, about 600 feet from its head, the Weches-Sparta contact is seen in the gully. The basalmost Sparta is an indurated, brown, ferruginous, slabby sandstone. The Sparta-Weches contact can be traced from this gully to the west along the hillside sloping to the gully. The contact is marked as usual by the slabby basal Sparta sandstone, laminated iron ore, water seeps, and a soil change. This Weches is on the downthrown side of the fault.

The fault plane itself is not visible here. But at two places about 150 feet south of the channel of the gully are large blocks of laminated Weches iron ore. This ore seems out of place as it lies much higher than the downthrown and much lower than the upthrown Weches. It may possibly be a sliver wedged in the fault. At any rate the relationships are such that the fault must pass near these iron ore blocks.

Among the high hills, from which the headwaters of Sand Branch, McElroy Horse Branch, and School House Branch issue, the fault is well defined, because the Weches formation abuts against and is cut off by the fault. The top of the Weches is easily traced up to the fault in several instances. For instance, on the hill nose between the two headwaters forks of Sand Branch, the top of the Weches and the basal, slabby, ferruginous bed of the Sparta sand can be traced with the aid of loose slabs and blocks up to the fault. In other words, the fault is indicated, because the top of the Weches cannot be traced around that hill nose from one headwaters branch to the other.

Here is also an exposure of the fault plane itself (see fig. 1).³ This exposure is in the south ditch of the county road, about 100 feet west of the western headwaters fork of Sand Branch or about 450 feet from the corner of the county road. A spring issues from the bank about 5 feet south of the fault plane itself, the creek branch near by has a swampy bottom, and the road between the fault exposure and the creek branch channel is a quagmire. The water of the spring and part of the water in the quagmire and swamp is groundwater perched in alluvium or slope wash above the impervious Weches marl of the upthrown side of the fault; it is a fault line spring. Accordingly, the road cut on the other side, the north side of the road at that place is dry even in the wet season because it is wholly on the downthrown side of the fault and in previous Sparta sand. The strike of the fault plane is S. 84° E. with reference to magnetic north and the dip is 70° to the north.

Fig. 1.—Exposure of Antrim fault in south ditch of county road near west fork of Sand Branch.

Explanation:	Thickness Feet
1. Gray humus-carrying sand soil	0.5
2. Transition between soil and weathered slope wash, buff in color	0.2
3. Rusty and dirty yellow, clayey sand (weathered slope wash)	1.0
4. Orange-red, vertical, clayey sand remnants surrounded by leached, light gray or light rust-yellow streaks of the same material (weathered slope wash)	2.5
5. Tough, plastic, light bluish-gray, leached clay surrounding pieces of thoroughly oxidized and weathered Weches glauconite marl, which are mostly soft and rust-yellow and rarely hard and rust-orange. Most of the pieces are elongate and parallel with the iron ore. This is the upthrown side of the fault.	
6. Hard, rust-brown, laminated Weches iron ore standing on edge	0.2
7. Fault plane.	
8. Hard, rust-brown sandstone; this is Sparta sand indurated by iron hydroxide deposition along the fault plane	0.1
9. Soft, gray and deep orange-red mottled sand (weathered Sparta sand of downthrown side of fault)	0.5
10. Soft, dull orange and gray mottled sand (weathered Sparta sand).	

To the east of this fault exposure on the ridge between McElroy Horse Branch and School House Branch the fault is so clearly indicated by soils and rock fragments that it is clearly visible on the aerial photographs. The dark, red or brown, stony soil of the Weches formation on the upthrown side abuts sharply against the light, whitish, loose and sandy soil of the Sparta sand on the downthrown side of the fault. The reason for the fact that here the soil distinctions are so much better than in other places is that the Sparta sand of the downthrown side forms a hill which is higher than the Weches on the other side of the fault. Thus the Weches fragments cannot wash down over the Sparta and the soil boundaries remain sharp.

What seems to be a fault exposure is in School House Branch. The fault exposure is 0.2 mile airline distance upstream, that is, southwest, from the county road bridge at Antrim Church and about 0.14 mile northeast of the Williams graveyard.

Here is an exposure of hard, rust-brown sandstone forming a knarled rib of 1 foot width, 10 feet length, and 0.6 foot height crossing the creek channel obliquely. In the left bank which is 10 feet high are several large blocks of this hard sandstone embedded in orange-red, massive sandy clay (reworked Queen City sand). See figure 2. These blocks are abundant only to one side of the hard rib. Upstream from the hard rib the reworked Queen City looks different than downstream; it is more rust-yellow than orange and is more smoky and clayey.

The strike of the rib is N. 78° E.; the dip is 71° to the north.

³The illustrations and map mentioned in text are available for inspection at the Bureau of Economic Geology, The University of Texas, Austin. They will be published in a forthcoming bulletin on the mineral resources, University of Texas Publication No. 4301.

From School House Branch nearly to Elkhart Creek the fault cannot be defined closely by surface features, because here the Sparta sand on one side abuts against the Queen City sand on the other. These two sand formations produce here so similar soils that the fault becomes lost. Outcrops are not present in the immediate vicinity.

The fault is again well defined on the west side of Elkhart Creek near the mouth of McElroy Horse Branch. Here the Weches formation can be traced right against sandy soils on the slopes leading down to the creek bottoms. The fault must be between the Weches outcrops and the sandy soils.

Similar conditions prevail on the east or left bank of Elkhart Creek. Here the Weches formation and even the limestone of the lower Weches can be traced clearly down the creek to a place about 0.27 mile upstream from the county road bridge. At that place the Weches ends abruptly and only sands are visible south of that place. However, the Weches is well indicated higher up on the hill slope to the east. Thus the fault can be placed as a line connecting the south end of the Weches on the Elkhart Creek bank with the north end of the Weches on the hill slope. Farther east this fault is not traceable because to both sides of it there is the lower Sparta sand. It is also probable that this fault plays out to the east.

About 0.2 mile south of this fault is a second parallel fault. This fault can be mapped because the Weches of the downthrown side is seen to end abruptly against the Queen City formation of the upthrown side. Near its west end at the upper edge of the creek valley slope at the margin of the woods is a short ridge of hard, ferruginous, veined sandstone standing on edge and striking S. 77° E. to the north of this ridge is the Weches formation.

From this ridge to the valley of Matthews Spring Branch the fault is defined by Weches soil and fragments on the north and Queen City soil, fragments, and outcrops to the south.

In the valley of Matthews Spring Branch are two excellent exposures of the fault. The western one of the two exposures is in a steeply descending ravine which is the first left tributary of Matthews Spring Branch that enters the branch downstream from the fault exposure in the channel of Matthews Spring Branch itself. The ravine has its beginning in the north corner of an abandoned field among a group of young pines just east of a window of old pines. The deeply incised part of the ravine begins only about 75 feet from the channel of Matthews Spring Branch, and a red oak tree straddles there the head of the ravine. The ravine is obviously very young and has been caused by the disturbing of natural drainage through the plowing of the field at its head. The ravine makes a waterfall over the incline footwall of the fault (see fig. 3).

The second fault exposure is in the channel of Matthews Spring Branch itself. The exposure is located about 0.22 mile north of Matthews Cemetery or 0.35 mile east-southeast of the confluence of this branch with Kennedy Creek (see fig. 5).

At the fault exposure the branch changes direction; up-creek from the fault the general direction of the branch is northwest; down-creek it is west for about 200 feet. This change in the direction is due to the change of rocks at the fault and the deflecting power of the resistant Weches rocks on the downthrown side of the fault on the right bank of the creek.

The nature of the channel also changes at the fault. Down-creek from the fault the channel of the branch is wider, free or nearly free of large boulders, and is floored by flat Weches rock exposures; up-creek from the fault it is narrower, full of large boulders of a post-Eocene ferruginous conglomerate, and the rock floors of brown, muscovitic laminated sandy shale of the Queen City formation are not extensive nor flat (compare fig. 4). The Queen City stays inclined for 40 feet from the fault. At that place there is a second fault in the Queen City (compare fig. 6).

On the hill about 1100 feet east of Matthews Spring Branch the fault is defined by the abrupt termination of Weches soil against Sparta soil. On the east slope of that hill there are many fragments of hard, ferruginous, veined sandstone indicating the presence of the fault. From here on eastward to the vicinity of the now abandoned New Hope schoolhouse the fault is not recognizable, because the Queen City sand abuts against the Sparta sand and the soils of these two formations are very similar. However, from New Hope schoolhouse to Bridges Mill Branch, a distance of a little more than half a mile, the fault is again defined by the Weches abutting against the Sparta formation.

The fault can be located definitely in the northwestward flowing, spring fed branch 0.09 mile south of New Hope schoolhouse. In the bottom of the entrenched channel of this branch, about 30 feet south of the fence line, which crosses the channel and separates the woods from the sandy field above, there is an exposure of a weathered glauconite marl ledge of the Weches against which weathered bluish-gray water sand of the Sparta rests. The fault passes between these two formations, but the exposure lacks depth and the rocks are weathered so that it is not possible to obtain the strike and dip of the fault plane.

The fault can be located also in the northwestward flowing, spring-fed branch which passes about 100 feet north of the New Hope schoolhouse. The location is in the channel about 50 feet north of the north corner of that sandy field. Here, horizontal and weathered Weches ledges are exposed upstream. Downstream they give way to gummy, bluish-gray, leached clay enclosing Weches blocks. This clay is identical to the clay found at the fault exposure on the county road (see fig. 1). This place is exactly in line with the veined sandstone block ridge described in the next paragraph.

In the woods to the east of the last mentioned tributary a straight line of the veined, ferruginous sandstone indicates the fault trace clearly. At the west end of the block line the blocks stand on edge for about 10 feet and are apparently *in situ*. These blocks are aligned in N. 63° E. (magnetic) direction. The whole line of blocks is about 500 feet long. The blocks are toppled over and scattered over a width of about 10 to 20 feet. Some of the blocks are up to 3 feet long. The line of blocks occurs at a pronounced break in slope. The slope above (on the south) is less steep than the slope below (on the north). The gentle slope above is composed of red-brown sandy clay soil with very many fragments of weathered Weches and ends at the Weches-Sparta contact; the steeper slope below is developed on red-brown clayey sand soil with some Weches fragments. The fragments and the iron stain have evidently descended from above.

To the east of this block line is a gully which descends from a sandy field and flows in the woods near their east edge about 0.16 mile west of the bed of Bridges Mill Branch. Here, the fault can be defined by Weches and Sparta outcrops, although the fault plane itself is not visible. In this gully exposures are very poor; but there is an exposure of weathered, orange-red and white mottled Sparta sand with good traces of the original bedding. This exposure indicates the uppermost Sparta on the downthrown side of the fault. Upstream from this exposure the channel of the gully is full of Weches debris.

In the valley of Bridges Mill Branch (also known as Fall Branch) the fault is recognized readily. The Weches forms the sides of this narrow valley for about 0.64 mile; to the north it is cut off abruptly and Sparta sand replaces it.

On the right or east side the northernmost clear Weches exposures are in a short, spring-fed tributary of Bridges Mill Branch. On the south side of this tributary the steep hill down which several wagon roads descend has excellent exposures of the Weches limestone bench. On the north side of the tributary the Weches is more weathered but nevertheless clearly showing. As one rounds the hill slope to the north of this tributary the Weches boulders and fragments in sandy and clayey soil are abruptly replaced by gray sand soil of the Sparta. Several small gullies are developed in this sand just north of the fault trace. The fault plane itself is not visible. The eastern side slopes of the valley of Bridges Mill Branch are different north and south of the fault. To the north of the fault in the Sparta sand they are sandy, longer, gentler and cut by several shallow and short gullies washing down from a sandy field on top. To the south they are clayey or rocky, shorter, steeper, and higher. This is a topographic expression of the fault. On the left or west side of Bridges Mill Branch the fault is clearer than on the right side. Here the Weches and in particular its limestone bench can be traced right up to the fault trace. The northern end of the limestone is strongly weathered and the limestone appears as a hard, rust-brown, porous clay-ironstone whose blocks strewn the hill slope. The soil is red-brown and clayey at that place. However, as one proceeds northward along the hill slope the blocks of weathered Weches and its clay soil disappear suddenly and the hill slope becomes longer and gentler and only light dun, loose sand soil is visible. Among the northernmost weathered Weches blocks one finds also very hard, dark rust-brown knarled, ferruginous sandstone. This sandstone has many narrow veins which stand out as ribs on the weathered surface. The blocks are up to 3 feet in diameter. This sandstone is Sparta sand from the downthrown side sheared by the tectonic stresses and indurated by waters circulating along the fault plane.

The topographic expression of the fault on the left side of Bridges Mill Branch is quite interesting. As explained above, the Weches slope is rock-strewn, clayey, shorter and steeper. The Sparta slope on the downthrown side is sandy, longer, and gentler. However, on this side the fault is also well expressed on the top of the hill just above the valley slope. The hill spur which parallels and flanks the valley originates from the Sparta-Weches cuesta on the south side of the fault. Its slope is steep near the Sparta-Weches contact, but on descending it flattens gradually and completely so that it is level as it crosses the fault. However, to the north of the fault the hill spur rises again about 1 or 2 feet and forms a small, flat-topped hill of Sparta sand. On this hill spur there is also a distinct change of vegetation. On the Weches side the grass is lower and less dense. The grass does not cover all of the ground and leaves many bare red-brown clay soil patches unoccupied; on the Sparta side it is taller and denser.

These distinctions in topography and vegetation extend along the fault westward to the edge of the old clearing. Also veined sandstone blocks are scattered along a line over this clearing. To the south of this clearing the front of the Sparta-Weches cuesta on the upthrown side of the fault is peculiarly modified; it is parallel with the fault and straight for about 0.2 mile as if chopped off by the fault. Here the cuesta is functioning as a fault-line scarp. The cuesta has obviously been developed by erosion subsequent to the faulting.

The easternmost place at which the fault can be placed exactly is in a small, northwestward flowing, right tributary of Bridges Mill Branch. This tributary develops from several springs located in a small young pine forest. The springs owe their origin apparently to ground water perched in the Sparta sand above the impervious Weches beds. The channel of the tributary is at first very shallow and runs in Sparta sand soil; then it descends in a 3-foot waterfall over weathered clayey material consisting in part of Weches clay and glauconite; below this waterfall at the lower end of the pine forest there are good Weches exposures in the channel, and the water descends in small waterfalls over some of the harder Weches ledges. The Weches exposures occupy merely a small area; along the tributary the length of the exposures is about 85 feet. Downstream from the last Weches ledge the tributary channel exposes orange and gray mottled sandy clay with pebbles and boulders of weathered Weches, apparently an ancient channel fill. This part of the channel is steep and narrow. The channel fill exposures extend for about 45 feet only. Below, the exposures in the channel consist of weathered, slightly clayey, light rust-orange and light gray mottled Sparta sand with its original bedding showing in some exposures. Here the channel of the tributary widens and the last Sparta exposure is on the left or southwest side of the tributary channel at the head of the widened channel. Below this last Sparta exposure the channel is wide (20 feet) and its banks are nearly everywhere overgrown so that exposures are scarce.

Here then the Sparta sand crops out above the Weches in normal position and below the Weches in abnormal position. The exposures obviously necessitate the placing of a fault between the Weches exposures and the Sparta exposures below. Thus the fault is located within the small stretch of channel between these exposures. The fault has topographic expression insofar as the cross section of the channel is narrow and the gradient steep (waterfalls) in the Weches on the upthrown side and the cross section is wide and the gradient gentler in the Sparta below the fault.

Eastward from this little tributary the fault is not securely traceable, because the same formation, the lower Sparta sand, crops out to both sides of the fault. The creek valleys which cross the eastern extension of the fault were investigated, but they lack exposures in crucial places. Therefore, the east end of the fault becomes rather indefinite. However, there are several indications of the fault in this region.

The various branches of Kennedy Creek, which drain northward, have cut deeply into the upland in many places. Yet the side walls of these valleys are all sandy, and Weches outcrops are not present. This seems to indicate that these branches have not cut deep enough to expose the Weches under the Sparta sand. Thus there is a considerable thickness of Sparta sand present in the region where these branches are, and this in turn indicates the downthrown side, where naturally the Sparta would be deeper than on the upthrown side.

On the county road (old Grapeland-Palestine road) about 0.3 mile from the county line there are some exposures of well-bedded sands with shale partings. The dip of these beds is 25 degrees to the northwest. This dip may be in the vicinity of the concealed fault.