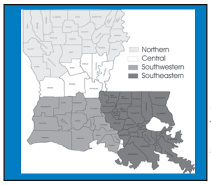
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Louisiana Geological Survey

NewsInsights

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Surface Faulting Within the New Iberia, Louisiana Region

Paul V. Heinrich

In the continuing re-examination and remapping of the surface geology of Southwestern Louisiana, i.e. Snead et al. (2002), a significant discrepancy was noted between modern and historic geologic mapping of Iberia Parish. The first geologic study of Iberia Parish, Howe and Moresi (1931), mapped two distinct Pleistocene geomorphic surfaces, the Hammond and Pensacola terraces, within Iberia Parish as illustrated in their Plate 1. Although the differences between these terraces were not discussed in detail, they stated that the Pensacola Terrace consists of a surface that clearly lies 3 m (10 ft) below the level of the Hammond Terrace. However, all subsequent geologic and geomorphic maps that included Iberia Parish, i.e., Bernard and LeBlanc (1965), Doering (1956), Fisk and McFarlan (1955), Saucier and Snead (1989), Snead and McCulloh (1984), and Winker (1991), recognized only one Pleistocene surface instead of the two recognized by Howe and Moresi (1931). In addition, some of these maps, i.e., Bernard and LeBlanc (1965) and Fisk and McFarlan (1955), showed the relict channels and meander belt of a Pleistocene Mississippi River meander belt, the Lafayette meander belt, crossing the boundary between the two terraces mapped by Howe and Moresi (1931) within Iberia Parish.

Given these contradictions, it would be easy to dismiss this boundary as a nonexistent feature resulting from inadequate topographic and other data and overinterpretation on the part of Howe and Moresi (1931). However, recent geologic mapping in other parts of Louisiana has shown that even lacking the benefit of modern topographic data, various types of aerial imagery and remote sensing data, and GIS capabilities currently available to modern geologists and physical geographers, the early geologists, such as Henry V. Howe, were able to recognize significant, but extremely subtle, geomorphic and geologic features by careful observations during fieldwork. Thus, a detailed examination was made of the geology of the New Iberia region to determine the significance of the discrepancy between how Howe and Moresi (1931) and later geologists mapped the surface geology of Iberia Parish.

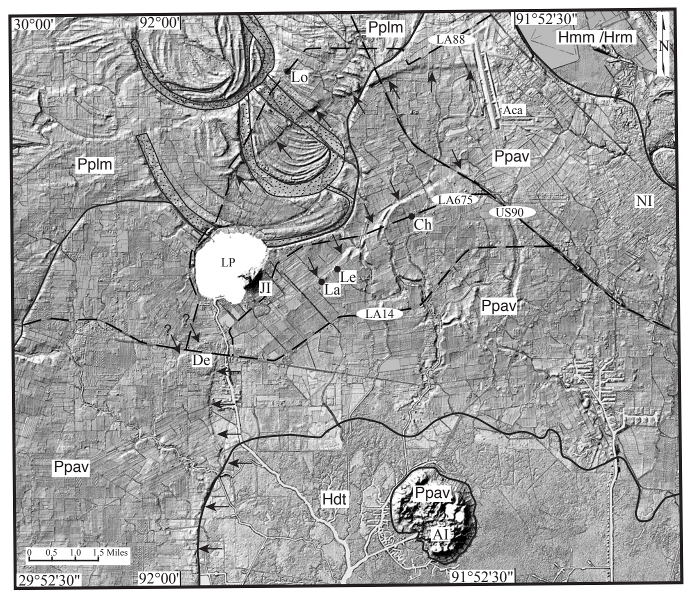

Figure 1. Sketch map of the geology of the New Iberia, Louisiana area on a digital elevation model base created from LIDAR Data. LIDAR Data from "Atlas: The Louisiana Statewide GIS" web page at http://atlas.lsu.edu/ and compiled using MacDEM, Version1.00.

The Louisiana Geological Survey NewsInsights

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LGS Mission Statement

The goals of the Geological Survey are to perform geological investigations that benefit the state of Louisiana by:

(1) encouraging the economic development of the natural resources of the state (energy, mineral, water, and environmental);

(2) providing unbiased geologic information on natural and environmental hazards; and

(3) ensuring the effective transfer of geological information.

The Louisiana Geological Survey was created by Act 131 of the Louisiana Legislature in 1934 to investigate the geology and resources of the State. LGS is presently a research unit affiliated with the Louisiana State University and reports through the Executive Director of the Center for Energy Studies to the Vice Chancellor for Research and Graduate Studies.

For this study, a variety of data was consulted. During this study, both 7.5' and 15' USGS topographic mapping were examined in detail. In addition to USGS topographic maps,1:2,000 black and white Edgar Tobin Aerial Survey aerial photography flown between 1939 and 1942; 1:20,000 black and white Agricultural Stabilization and Conservation Service aerial photography flown at various times between 1939 and 1962; USGS digital orthophoto quarter quadrangles; and digital elevation models (DEMs) made from LIDAR (LIght Detection And Ranging) data were examined. Finally, subsurface data and structural maps from a variety of sources were collected and analyzed.

As a result of studying topographic mapping and aerial images, three significant scarps were noted in the region of New Iberia, Louisiana. First, it was found that the boundary between the Hammond and Pensacola terraces of Howe and Moresi (1931) was largely based upon a down-to-gulf, east-west scarp, called the Parc Perdu scarp, which cuts across northern Iberia Parish as mapped by Snead et al. (2002). Second, the LIDAR DEM shows another scarp, the Leleux scarp, facing inland and lying south of the Parc Perdu scarp. Together, these scarps create a well-defined graben that extends southwest from the Acadiana Regional Airport to Jefferson Island. Finally, a third well-defined scarp, the Delcambre scarp, was found extending south of Jefferson Island (Figure 1).

Two other linear features were noted in the New Iberia, Louisiana area. The LIDAR DEM shows a distinct northeast-southwest trending linear scarp that lies northwest and west of Delcambre, Louisiana (Figure 1). Also, the same data show a poorly defined line, which cannot be seen in Figure 1, along which an abrupt change in elevation occurs, within the Lafayette meander belt that parallels and lies just north of the Parc Perdu scarp. The significance and origin of these features remain undetermined.

The Parc Perdu scarp consists of an arcuate northeast-to-southwest-trending scarp that extends from the northern end of the Acadiana Regional Airport, north of New Iberia, Louisiana to the southeast edge of Sec. 8, T.11S., R.6E. south of Jefferson Island (Figure 1) (Snead et al. 2002). It crosses US Highway 90 at a point 1.4 km (0.87 mile) south of its junction with Louisiana Highway 88. This gulfward-facing scarp is best developed within irregular Secs. 36, 37, 38, and 39, T.12S., R.5E. where it displaces relict channels and ridge-and-swale topography of the Lafayette meander belt. Within irregular Sec. 38, T.12S., R.5E. and 1.9 km (1.2 miles) south of Lozes, Louisiana, this scarp displaces a relict Lafayette meander belt channel occupied by Bayou Parc Perdu, for which this scarp is named. Within irregular Sec.39 and the southeast corner of Sec. 8, T.12S., R.5E., the Parc Perdu scarp bends south towards Lake Peigneur and disappears before reaching it.

The height of the Parc Perdu scarp varies greatly along its length. The small segment of this scarp lying east of the Acadiana Regional Airport is only about 1.5 m (5 ft) high. West of the Acadiana Regional Airport and past where it crosses US Highway 90, the Parc Perdu scarp is about 3 m (10 ft) to as much as 3.6 m (12 ft) high. Further to the southwest, where it crosses the Lafayette meander belt, its height decreases to about 2 to 2.4 m (7 to 8 ft). Where this scarp bends southward toward Lake Peigneur, its height decreases to 1.5 m (5 ft) and less.

As mapped by Snead et al. (2002), the Parc Perdu scarp is interpreted to be a fault-line scarp, and this investigation showed clearly that it is in fact a fault-line scarp. Its tectonic origin is clearly demonstrated by constructional landforms, i.e. relict ridge-and-swale topography and channels of the Lafayette meander belt, that are cut and offset by it. In addition, limited analysis of subsurface data clearly indicates that this scarp is associated with a major down-to-gulf east-west fault connecting the Iberia and Jefferson Island salt domes. This scarp clearly is not part of a depositional boundary between Pleistocene coast-parallel terraces as interpreted by Howe and Moresi (1931), but rather is a fault-line scarp.

The Leleux scarp starts within the S1/2 of SE1/4 of Sec. 7, T.12S., R.6E., about 0.6 km (0.4 mile) northeast of where it crosses US Highway 90 about 0.25 km (0.4 mile) southeast of Segura BR Canal. The low scarp continues to the southwest where it passes northwest of Charlotte, Louisiana. Further southwest, it crosses Louisiana highway 675 about 1.4 km (0.87 mile) southwest of Charlotte. Within irregular Sec. 57, T.12S., R5E., the scarp parallels and lies just north of the former path of now-removed Missouri Pacific Railroad track, which is shown on the 1963 Delcambe 7.5' topographic map, and the former hamlets of Leleux and LaSalle, Louisiana. The Leleux scarp is highest within the segment crossing US Highway 90 where it is around 1.8 m (6 ft) high. Further to the southwest, it is only 1 to 1.2 m (3 to 4 ft) high before disappearing southwest of LaSalle. The Leleux and Parc Perdu scarps form a well-defined graben extending from the Acadiana Regional Airport to Jefferson Island.

The nature of the Leleux scarp is problematic. The Leleux scarp offsets a relict,Pleistocene distributary, which extends southward from the Lafayette meander belt and now is partially occupied by Bayou Petite Anse. The scarp also consists of two segmented arcs similar to other known fault-line scarps. However, an xamination of the available subsurface data found a lack of any evidence of a deep-seated fault that might be associated with this scarp. If the Leleux scarp is a fault-line scarp, it must represent the surface expression of an antithetic fault associated with the Parc Perdu fault-line scarp to the north.

The Delcambre scarp is a north-to-south trending, eastward-facing scarp, which consists of at least two arcuate segments (Figure 1). The northern segment extends from Delcambre, Louisiana southward to Bayou Tigre. The southern segment extends gulfward from Bayou Tigre where it disappears along with the surface of the Pleistocene Avoyelles alloformation beneath the marshes of the Holocene Mississippi delta plain. The height of this scarp ranges from 1.2 to 1.8 m (4 to 6 ft) in elevation.

The Delcambre scarp is considered to be a fault-line scarp. It has the well-defined arcuate segmentation seen in other faults within the Louisiana coastal plain. Also, it is associated with a prominent fault in the subsurface that extends southward from the Jefferson Island salt dome. Although conclusive evidence of its being a fault-line scarp is lacking, its character and the downdip presence at an appropriate location and depth of a major north-to-south striking fault indicates this scarp is likely tectonic in origin.

The fault-line scarps and other linear features, which were found in the process of reevaluating historic geologic mapping of the New Iberia areas, demonstrate that Late Pleistocene faulting within the coastal plain of Southwest Louisiana is not limited to the Tepetate fault zone as previously described by Hanor (1982), Heinrich (1997, 2000), and Miller and Heinrich (2003). The ongoing compilation of geologic maps for the White Lake and Port Arthur 100,000 quadrangles and a preliminary analysis of LIDAR data covering the Lake Charles 100,000-scale quadrangle also has found numerous fault-line and possible fault-line scarps lying south of the Tepetate fault zone not previously detected by an examination of topographic mapping, soils mapping, and aerial imagery.

The presence of such fault-line scarps, south of the Tepetate fault zone, indicates that the potential for the damage to infrastructure within Southwest Louisiana by fault movement is greater than previously thought. Except possibly for the 1983 Lake Charles earthquake, there is no direct evidence of earthquake activity associated with faults within southwest Louisiana. Thus, the primary hazard posed by these faults is movement resulting from either natural processes or reactivation by groundwater pumping. Such movement could cause cumulative damage to buildings built on or near them or to roads, pipelines, or runways built across them. For example, in case of the New Iberia region, the proposed right-of-way of Interstate Highway 49 crosses both the Parc Perdu and Leleux fault-line scarps and a linear feature possibly related to fault activity.

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Characterization/Transmissivities of Louisiana Aquifers Explored

Douglas Carlson

Introduction

This article is a second of a series of articles which will appear in the Louisiana Geological Survey's newsletter considering the properties of aquifers within Louisiana. Aquifers are units of rock or sediment which provide an economically useful amount of water for consumers (Fetter, 2001). The determination of Louisiana aquifers' properties is part of a larger goal of the Louisiana Geological Survey (LGS) to develop a series of groundwater models of major aquifer systems throughout Louisiana, first of which is the Chicot Aquifer. The Chicot Aquifer groundwater model and future models will provide policy makers a tool for better understanding of how these various aquifers respond to possible future scenarios of groundwater demand.

However, before the construction of the conceptual and mathematical model of an aquifer is started there is need to gather and analyze existing information available for the aquifer and determine the physical properties of the aquifer. The results of aquifer properties analysis provides a reasonable range of parameter values to create the model framework and/or test when calibrating a groundwater model.

Transmissivity

Transmissivity is the property of an aquifer that is the volume of water that will flow through a unit area of an aquifer when the gradient is one (Fetter, 2001). In general, transmissivity indicates what the possible discharge volume of a well is when it is pumped, that is as transmissivity increases so will well productivity increase. Transmissivity is dependent on mainly on the hydraulic conductivity of an aquifer, however transmissivity is also dependent on the saturated thickness of the aquifer (Fetter, 2001).The units that express transmissivity are those of area/time, often feet squared per day abbreviated ft^2/day, or volume/time/length, often gallons per day per foot abbreviated gal/day/ft.

Natural geologic materials have a wide range of transmissivities. This is a result of the wide range of values for the components that comprise transmissivity, hydraulic conductivity and saturated thickness. The range of hydraulic conductivity is about 12 orders of magnitude for geologic materials (Weight and Sonderegger, 2001). Hydraulic conductivity is an indicator of how easy is it for water to pass through rock or soil. Saturated thickness probably ranges over about three orders of magnitude, from thin sand lenses of a few feet thick often used as sources of water for single household wells to major sandstone or sand aquifers that are about 1000 feet thick, for example the Chicot Aquifer that has freshwater saturated thicknesses in portions over 1000 feet (Carlson et al., 2003).

Transmissivity value for any aquifer will vary significantly throughout an aquifer depending on the point selected within the aquifer (Fetter, 2001). This variation is a result of both the thickness of an aquifer and hydraulic conductivity of the aquifer variation from point to point. In general, because the aquifers of Louisiana are sands, the distribution of hydraulic conductivity values will be log normally distributed, for example Sparta Aquifer (Figure 1) (Carlson, 2004), which is the typical distribution for sands (Weight and Sonderegger, 2001). What this means is the number of observed hydraulic conductivity values will form a standard normal curve "bell-shaped curve" of the frequency of observations (dependent variable on the Y axis) plotted against

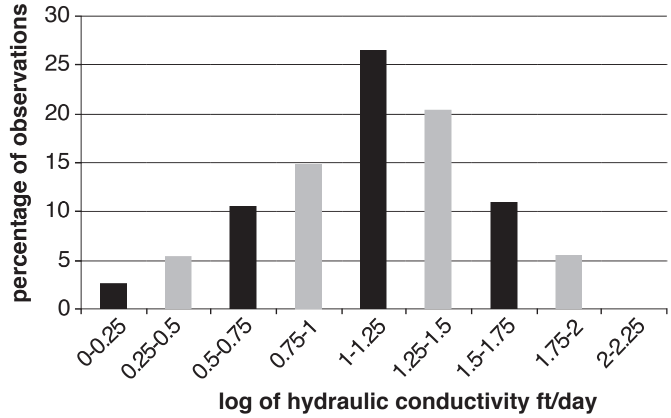


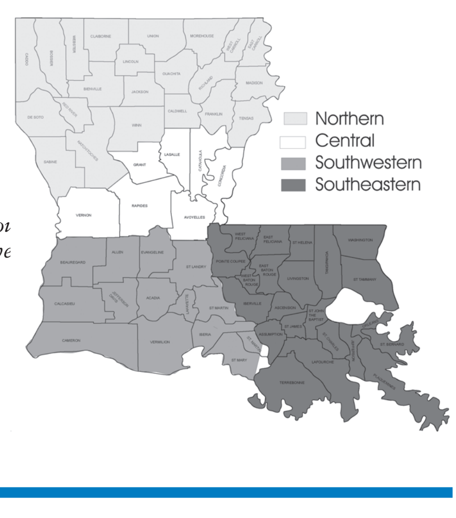
Figure 1. The Sparta Aquifer of northern Louisiana is typical of sand aquifers in that the distribution of hydraulic conductivity values of this unit is log normally distributed.

values of hydraulic conductivity (independent variable on the X axis) when hydraulic conductivity values are divided into equal steps on a log scale. For a normally distributed data set approximately two thirds of observations will fall within one standard deviation of the mean (Kirk, 1990). In addition, generally hydraulic conductivity values among aquifers will vary more than thicknesses. So, with this in mind the values that appear in Figure 4, 6, 9 and 12 are geometric mean values.

Transmissivity Values for Louisiana Aquifers

This study of aquifer transmissivity values of Louisiana aquifers is probably the largest to date. This study includes transmissivity results from about 3300 specific capacity tests. Specific capacity tests are simple pumping tests that include a measure of water level at the start and end of test, how long the pump is running ant the pumping rate. Specific capacity tests are often performed after a well is drilled to determine if the well, as drilled and completed, will produce an adequate amount of water to meet the needs of its owner. The transmissivity values determined for this study of Louisiana aquifers were derived by using the Bradbury and Rothschild (1985) technique for analyzing specific capacity tests. This study's source of specific capacity test data is the U.S. Geological Survey (2003). Results will be considered for four regions within Louisiana: northern, central, southwestern and southeastern (Figure 2).

Figure 2. This figure displays which parishes fall within each of the fou regions used to divide the aquifers of Louisiana: northern, central, southwestern and southeastern.



Northern Louisiana

There are five major aquifers: Cockfield, Mississippi River Alluvial, Sparta, Upland Terrace and Carrizo-Wilcox and two local aquifers: Ouachita River Alluvial and Red River Alluvial in northern Louisiana. Four of the major aquifer's location can be seen in Figure 3. Four of these aquifers are Quaternary in age (Lovelace and Lovelace, 1995): Mississippi River Alluvial, Ouachita River Alluvial, Red River Alluvial and Upland Terrace. These are also the aquifers that have the larger values of transmissivity (Figure 4) than the older (Lovelace and Lovelace, 1995) and finer grained aquifers (Renken, 1998): Cockfield, Sparta and Wilcox-Carrizo, which lack the coarse sands and gravels of the younger aquifers. The Cockfield and Sparta Aquifers are Eocene units and the Carrizo-Wilcox is an Eocene-Paleocene unit (Lovelace and Lovelace, 1995). The Mississippi Alluvial Aquifer has by far the largest transmissivity, about 3 to 4 times that of Red River Alluvial and Upland Terrace (Figure 4). This difference is partly a result of the fact the Mississippi River Alluvial Aquifer has a hydraulic conductivity twice that of Red River Alluvial and Upland Terrace Aquifers (Carlson, 2004). However, the greater thickness of Mississippi River Alluvial sands is also a major contributing factor in this difference of transmissivity.

Central Louisiana

There are six aquifers in this region: Catahoula, Cockfield, Evangeline, Jasper (Williamson Creek and Carnahan Bayou), Mississippi River Alluvial, and Upland Terrace. Three of these are aquifer's location are shown in Figure 5. The Mississippi River Alluvial and Upland Terrace have by far the largest transmissivity values of these six (Figure 6). The typical transmissivity for these two aquifers is about six to sixteen times larger than for the other aquifers. This difference is even larger than the hydraulic conductivity difference calculated (Carlson, 2004). This is a result of the fact that apparently the Mississippi River Alluvial and Upland Terrace sands are thicker than sands of the Catahoula, Cockfield, Evangeline and Jasper Aquifers. Upland Terrace and Mississippi River Alluvial are both Quaternary age. The Evangeline Aquifer is Pliocene-Miocene in age, Jasper Aquifer is Miocene in age, Catahoula Aquifer is Miocene-Oligocene in age, and Cockfield Aquifer is Eocene in age (Lovelace and Lovelace, 1995). Often the Jasper Aquifer is divided into three units: Williamson Creek and Carnahan Bayou Aquifers and the Dough Hills clay (aquitard) in between (Lovelace and Lovelace, 1995). In general, the aquifers of this region have larger transmissivities than those in northern Louisiana (Figures 4 and 6).

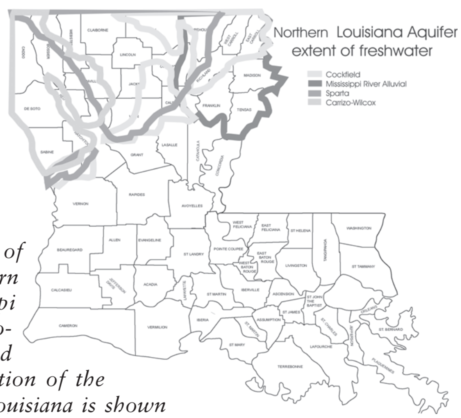


Figure 3. The extent of four aquifers in northern Louisiana: Mississippi River Alluvial, Carrizo-Wilcox, Cockfield and Sparta. Only the portion of the aquifer in northern Louisiana is shown in this figure.

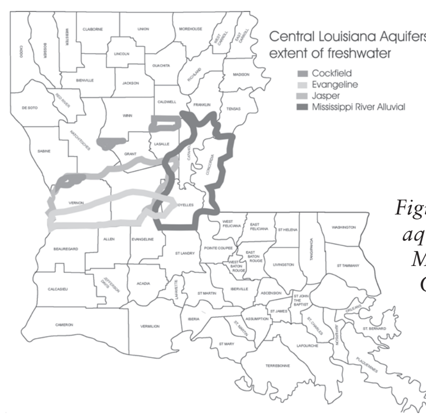


Figure 5. The extent of four aquifers in central Louisiana: Mississippi River Alluvial, Cockfield, Williamson Creek and Carnahan Bayou. Only the portion of teh aquifer in central Louisiana is shown in this figure.

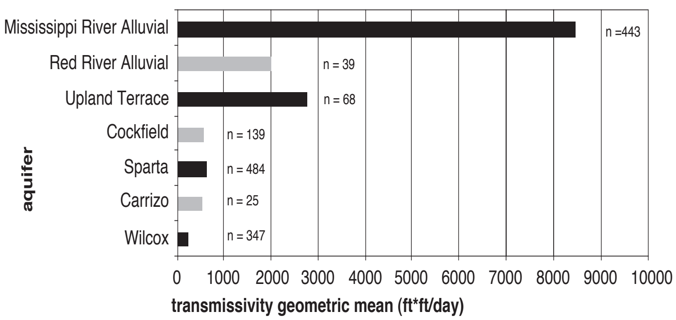


Figure 4. Transmissivity values of select major aquifers in northern Louisiana. Only transmissivity values calculated within northern Louisiana are included above for each of the aquifers. These seven aquifer sands have about 98% of 1576 transmissivity values for this region's data set, minor aquifers account for the rest. Transmissivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique. The n = xx is at the end of each bar is the number of transmissivity values determined for an aquifer for this figure and similar ones that follow.

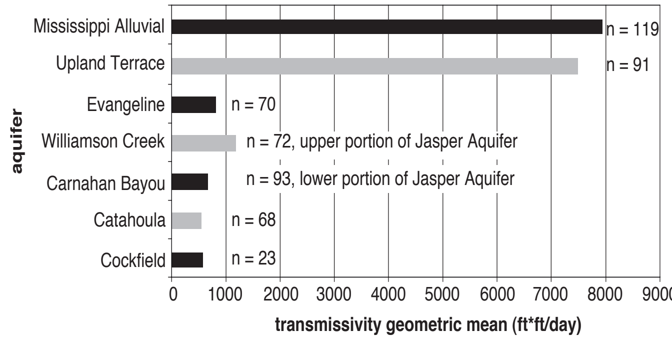


Figure 6. Transmissivity values of select major aquifers in central Louisiana. Only transmissivity values calculated within central Louisiana are included above for each of the aquifers. These seven aquifer sands have about 98% of 546 transmissivity values for this region's data set, minor aquifers account for the rest of the transmissivity values Transmissivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

Southwestern Louisiana

Southwest Louisiana is dominated by a single aquifer, the Chicot Aquifer. The Evangeline Aquifer is a secondary source of water (Figure 7). The Chicot Aquifer is a thick Quaternary aquifer composed of sands and gravels and interbedded silts and clays (Lovelace, 1998). It is a variable aquifer in terms of the number of clay layers and how continuous clay layers are. In Calcasieu and Cameron Parishes the Chicot Aquifer has been divided into three sands "200 foot sand", "500 foot sand", and "700 foot sand" (Sargent and McGee, 1998) (Figure 8). In Allen, Beauregard, Evangeline and St. Landry Parishes the Chicot Aquifer is usually considered a single undifferentiated unit (U.S. Geological Survey, 2003), and in Acadia, Iberia, Jefferson Davis, Lafayette, St. Martin, and Vermilion the Chicot is divided into the upper and lower Chicot (Lovelace and Lovelace, 1995). Even the lowest transmissivity value of the Chicot Aquifer for the '700 foot sand" and lower Chicot is still higher than all but the Upland Terrace and Mississippi River Alluvial Aquifers (Figures 4, 6 and 9). The Evangeline Aquifer is a source of water for Allen, Beauregard, Evangeline and St.Landry Parishes, however, in general, to the south of these four parishes the Evangeline water is too saline to be a source of water for human consumption (Jones and others, 1954). Lastly, the Evangeline Aquifer's typical transmissivity is about 600 ft^2/day compared to the Chicot Aquifer's transmissivity of 6,300 ft^2/day to 16,200 ft^2/day (Figure 9).

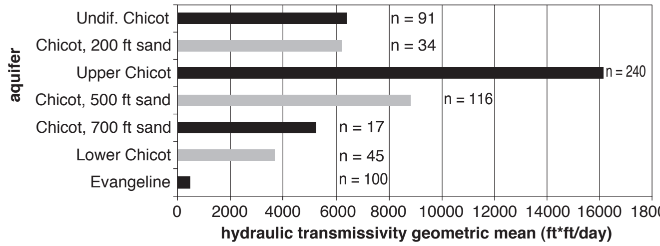


Figure 9. Transmissivity values of major aquifers in southwestern Louisiana. This region's 707 transmissivity values have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

Age	Aquifer System	Baton Rouge area	St. Tammany Tangipahoa and Washington Parishes	New Orleans area and lower Mississippi River Parishes
Pleistocene	Chicot Equivalent	400 ft sand 600 ft sand	Upper Pontchatoula	Gramercy Norco Gonzales-New Orleans 1200 ft sand
Pliocene	Evangeline Equivalent	800 ft sand 1000 ft sand 1200 ft sand 1500 ft sand 1700 ft sand	Lower Pontchatoula Big Branch Kentwood Abita Covington Slidell	
Miocene	Jasper Equivalent	2000 ft sand 2400 ft sand 2800 ft sand	Tchefuncta Hammond Amite Ramsey Franklinton	

Figure 10. Above is the hydrostratigraphy of aquifers of southeastern Louisiana as defined by Lovelace and Lovelace (1995). This figure is a modification of figure 1 in Lovelace and Lovelace (1995).

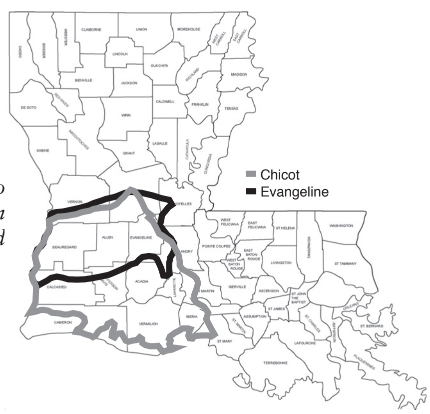


Figure 7. The extent of two aquifers in southwestern Louisiana: Chicot and Evangeline. Only the portion of the aquifer in southwest Louisiana is shown in this figure.

Age	Lake Charles Area (western Chicot)	Rice growing area (eastern Chicot)
Pleistocene	200 foot sand	Upper sand unit
	500 foot sand	Lower sand unit
	700 foot sand	
Pliocene Miocene	Evangeline	

Figure 8. Above is the hydrostratigraphy of aquifers of southwestern Louisiana as defined by Lovelace and Lovelace (1995). This figure is a modification of figure 1 in Lovelace and Lovelace (1995).

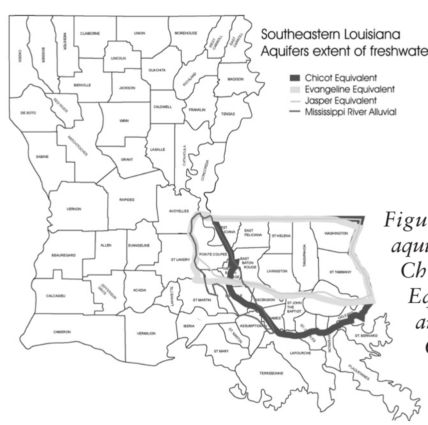


Figure 11.The extent of four aquifers in southeastern Louisiana: Chicot Equivalent, Evangeline Equivalent, Jasper Equivalent and Mississippi River Alluvial. Only the portion of the aquifer in southeast Louisiana is shown in this figure.

Southeastern Louisiana

Lastly the southeastern portion of Louisiana has the most complex set of aquifers. Fetter (2001) notes that there are 10 different aquifers noted for the Baton Rouge part of this region, while Lovelace and Lovelace (1995) in their figure 1 note 29 aquifers in the entire southeastern Louisiana area. All of these units are Miocene to Quaternary in age (Lovelace and Lovelace, 1995). However, a large number of these aquifers can be classed by their ages into a fairly systematic system of aquifers (Figure 10): Chicot, Evangeline and Jasper Equivalents. Their location in Louisiana is displayed in Figure 11.

The Chicot Equivalent Aquifer of southeastern Louisiana has a lower transmissivity than the Chicot Aquifer of southwestern Louisiana, while the reverse is true about the comparison of Evangeline Equivalent Aquifer's transmissivity to Evangeline Aquifer's transmissivity (Figures 9 and 12). This is probably a result of each aquifer's position relative to the position of the dominate axes of sediment deposition during the Miocene, Pliocene and Pleistocene (Galloway, et al., 2000). The source of material for the southeastern aquifers is the Appalachians to the northeast (Rosen, 1969), while the source of material for the southwestern aquifers is the Mississippi River's watershed (Taylor and others, 1995).

This study has included 543 values of specific capacity data for 24 different named aquifer units as defined by (Lovelace and Lovelace, 1995). However, the vast majority of these results can be included within Chicot Equivalent (135 values), Evangeline Equivalent (126 values), and Jasper Equivalent (163 values) as defined by Lovelace and Lovelace (1995). All three of these major aquifer groups have sands with similar transmissivities. The geometric mean of transmissivity for sands is 2450 ft^2/day for Chicot Equivalent, 2090 ft^2/day for Evangeline Equivalent, and 2510 ft^2/day for Jasper Equivalent.

Acknowledgments

I would like to thank Charlie Demas and Wendy Lovelace among others at the Baton Rouge office of the U.S. Geological Survey for their gracious help and access to their vast set of records. Without this information many of the data sets analyzed and presented in this report would be either impossible or far more difficult to access.

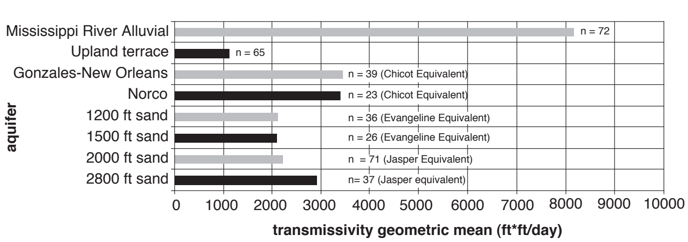


Figure 12. Transmissivity values of select major aquifers in southeastern Louisiana. Only transmissivity values calculated within central Louisiana are included above for each of the aquifers. These eight aquifer sands have about 67% of the 543 transmissivity values for this region's data set. The remaining 33% of transmissivity values are for other secondary aquifers. Transmissivities have been determined from analysis of U.S. Geological Survey (2003) specific capacity data by using the Bradbury and Rothschild (1985) technique.

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Is the Hot Wells Area of Louisiana Anomalous?

Douglas Carlson and Richard P. McCulloh

Introduction

During 1913 a crew drilling for oil about 14 miles northwest of Alexandria, Louisiana was disappointed to have hot salty water gushing out of their well (Jaycees, n.d.) (Figure 1). However, one of the workmen who washed and soaked his hands in the water soon discovered that his case of eczema was cured. This was the beginning of the Hot Wells as a spa. Between 1913 and 1934 Hot Wells was a privately owned sanitarium, hotel and baths. In 1934 an accident occurred which blocked the flow of the well, which in turn largely ended private operation of this facility. In 1937 the Central Louisiana State Hospital acquired the title to the Hot Wells property (Hotwellsresort, 2004). Later in 1949 the state of Louisiana constructed the McNutt Hill building as a health spa for $350,000 (Jaycees, n.d.). This building replaced the previously far smaller structures that were present in 1946. At that time it was believed that the waters were helpful to those suffering from skin troubles, arthritis and rheumatism. Some individuals claimed the waters cured dandruff and athlete's foot, while others have claimed the water helped those with polio (Anonymous, 1955). In 1953 the state transferred operations to the Rapides Parish Jaycees after the state operated Hot Wells Spa from 1949 to 1953. In 1961 Hot Wells operations were transferred back to the state of Louisiana. From 1961 to 1995 a variety of state agencies operated the Hot Wells facility: Department of Commerce and Industry (1961-1964), Tourist Commission (1964-1976), Office of State Parks (1976-1982), Department of Health and Human Resources (1982-1988), and Louisiana National Guard (1988-1995). However, during the last 13 years of operation the facility was neglected and deteriorated given that a minimum of repair and maintenance was done. Finally in 1995 the Hot Wells facility was transferred from the state of Louisiana to the Rapides Parish Police Jury, which in turn has been seeking private investment and redevelopment of the facility (Hotwellsresort, 2004).

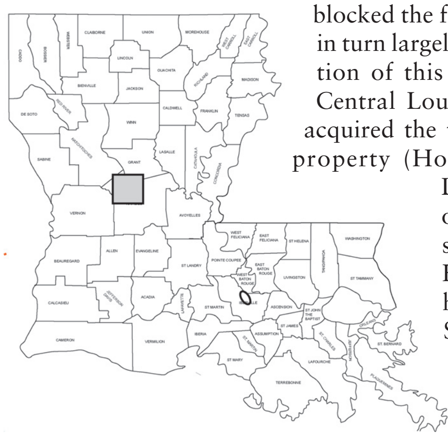

Figure 1. Hot wells study area is within gray box located in northwestern Rapides Parish.

One interesting element of the facility's history would appear to be the relatively late switch from shallow to deep production of the waters supplying the spa. The authors have not seen this mentioned in any publicly available accounts of the spa's hronology, but the junior author recalls a telephone conversation ca. 1982 with one of the resort staff who indicated that at that time the spa waters were being produced from a well greater than 10,000 ft. deep. This seemed momentarily to 'solve' the riddle of what (if anything) had made the hot well(s) at Hot Wells hot: it was the depth regime—i.e., the production of geothermal brine from a depth typical of oil and gas wells, which is several thousand feet deeper than the deepest of standard water wells. On reflection, however, it was clear that the legend surrounding the original reputed anomaly remained unexplained, because the deepest wells of the early 20th century in that area were no deeper than a few thousands of feet. The LGS geological bulletin on the geology of Rapides and Avoyelles Parishes (Fisk, 1940) contains data for 53 wildcat wells in Rapides Parish, of which three are in the same township as Hot Wells (T. 4 N., R. 3 W.) and another 11 are in the adjacent townships to the north, west, and northwest. The depth range for 13 of these 14 wells (no total depth is listed for one) is 608-3,202 ft. Of the three wells in the same township as Hot Wells, one listed in Section 119, with a total depth of 3,048 ft., is geographically nearest to the facility, which lies in adjacent Section 118 in the northwest portion of the township.

The question to be addressed here is: is the Hot Wells area of Louisiana special in terms of geothermal conditions or salinity of the water? McCulloh (1991) informally considered this issue. He noted that two U.S. Geological Survey geologists (now retired), James E. Rogers and George Cardwell, familiar with the geology of the Rapides area gave a split opinion regarding apparently anomalous character of the geothermal gradient as indicated by three USGS water wells in the Hot Wells area. This study is a more comprehensive consideration of this question.

Previous Studies

Three major studies of groundwater have been completed in the last 60 years (Maher, 1940; Newcome and Sloss, 1966; and Smoot and Fendick, 1998) for all or parts of Rapides Parish. However, they have either ignored Hot Wells (Maher, 1940; and Smoot and Fendick, 1998) or have only briefly described these wells (Newcome and Sloss, 1966). Newcome and Sloss (1966) noted the Hot Wells water has a salinity that is 60,000 parts per million of dissolved solids a value that is about twice that of sea water, and has a temperature of 115°F for well water drawn from wells that are about 3000 feet deep. The wells used for mineral waters in the Hot Wells area extend almost 2000 feet below the bottom of freshwater (Newcome, and Sloss, 1966). These authors do not address the question, are the temperature and salinity of the waters pumped from the Hot Wells typical for that depth?

There have been many geothermal studies of Louisiana in the past 35 years. The focus of these studies is usually in southern Louisiana (Jam et al., 1969; Bebout et al., 1982; Abbott et al., 1985; Suggate, 1998; Jones et al., 2003; and Nelson, 2003) or areas in the Gulf of Mexico offshore of Louisiana (Cathles and Nunns, 1991; and Jones et al., 2003). Often the studies focus on the geothermal conditions around salt domes (Kumar, 1977; Ball, 1982; and Leger, 1988). There has been a more limited number of studies that include examination of geothermal conditions in northern Louisiana (Smith and Dees, 1982a; and Heydari et al., 1997) or over a wider area of Alabama, Florida, Georgia, Louisiana, and Mississippi (Smith, et al., 1981; and Smith, and Dees, 1982b). However, it appears that none of these studies focused on the geothermal conditions of central Louisiana, which includes the Hot Wells area.

It appears that McCulloh (1991) is the only previous study of geothermal gradients in the Hot Wells area. In the summer of 1991 the junior author was permitted to borrow a file of materials on the Hot Wells area by George Cardwell (now retired) of the U.S. Geological Survey's Water Resources Division district office in Baton Rouge. The file contained a number of well logs, for three of which it was possible to calculate geothermal gradients. Notes made for these wells, and their calculated geothermal gradients, were as follows: R-617: 1.58°F/100 ft; R-618: 1.81°F/100 ft; and R-810: 1.38°F/100 ft. Geothermal gradient calculations assumed a mean annual surface temperature of 66 of. All of these wells are located in the same section as the Hot Wells spa. When queried about these results at the time, Cardwell and another U.S. Geological Survey hydrologist, James E. Rogers (of the former Water Resources Division office in Alexandria, Louisiana, also now retired) rendered split opinions as to whether the results reflected a significant thermal anomaly.

Results

Temperature

The source of temperature values with depth is the bottom hole temperature (BHT) values noted in the header, top page, of geophysical logs of wells drilled in the study area. For this study temperature data were gathered from the U.S Geological Survey's collection of water well electric logs and the Louisiana Department of Natural Resources collection of oil and gas well electric logs. The study area includes nine townships in northwest Rapides Parish and southwest Grant Parish (Figure 1). The range of temperatures recorded is 80°F to 350°F for a variety of observation points that lie at depths ranging from 505 feet to 18,413 feet below the earth's surface (Figure 2).

It appears from the results of this study that the Hot Wells area is not significantly different than the 9 township region that surrounds it and composes the study area (Figure 2). The regression results are reasonable in that the resulting surface temperature is 66.2°F, which is close to the yearly mean temperature of 66.3°F in this area as indicated by the Boyce, Louisiana yearly average temperature (Louisiana Office of State Climatology, 2004). Boyce is a U.S. weather bureau station located within the study area and lies about four miles north of the Hot Wells site. The Hot Wells site appears not to yield an anomalous temperature that stands out on the temperature gradient plot (Figure 2). However, maybe there is a more subtle anomaly that will appear if one plots the residuals for each well on a map of the study area. When wells have multiple temperature values at different depths the average is used for the anomaly map (Figure 3). This will result in 33 observation points noting temperature anomalies that appear in figure 3.

It is apparent when considering temperature anomalies as defined by the residual between observed and calculated temperature using the regression line developed from figure 3 results that the Hot Wells area is not outstanding. It is a small possible residual that appears roughly in the center of the figure. However, there are three other anomalies with similar values located in the east, right side of Figure 3. Additionally, there is a major anomaly in the northwest portion of the study area, top left corner of Figure 3, through it is defined by only two points. So it appears that if the Hot Wells area is warmer than usual it is only slightly warmer, it is not a large temperature anomaly.

Salinity

For this study about 45 electrical logs were examined to determine the concentration of dissolved solids from the observed resistivity. The set includes 26 water wells and 19 oil and gas wells. Usually the water wells did not reach the base of freshwater, while almost all of the oil and gas wells, 18 of 19, reach the base of both freshwater and brackish water. The calculation of dissolved solids is a three step process. First, read and record the observed resistivity value for the tool that measures resistivity farthest into sediment, which is usually a 64-inch normal electrical log. Second, determine the resistivity of water within the pores by applying Archie's law (Archie, 1942) and a typical porosity for sediments in this area, 35%, which was determined from examination of porosity logs in nearby parishes. Three, convert the water resistivity into a concentration of dissolved solids value using Hem's (1989)equation and a constant typical for sulfate poor waters and unit conversion factors. Values of

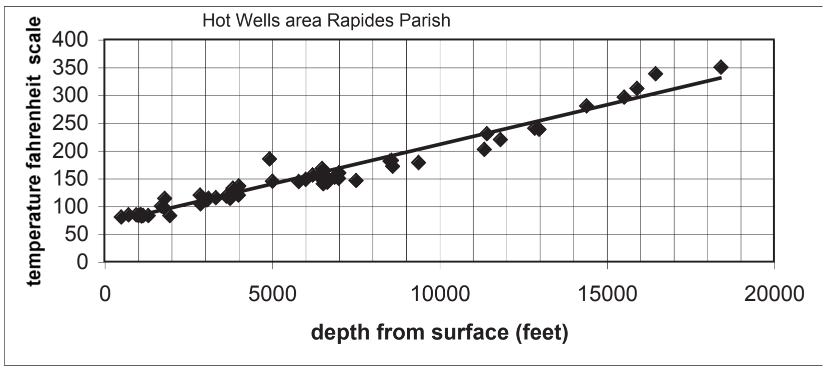

Figure 2. The 54 temperature results observed from 38 wells in the Hot Wells study area fall generally in a straight line. The increase of temperature with depth is 1.42°F/100 ft. The temperature at the surface is 66°F. The regression coefficient is 0.957 which means over 95% of temperature variation can be explained by a linear regression function displayed by the straight line.

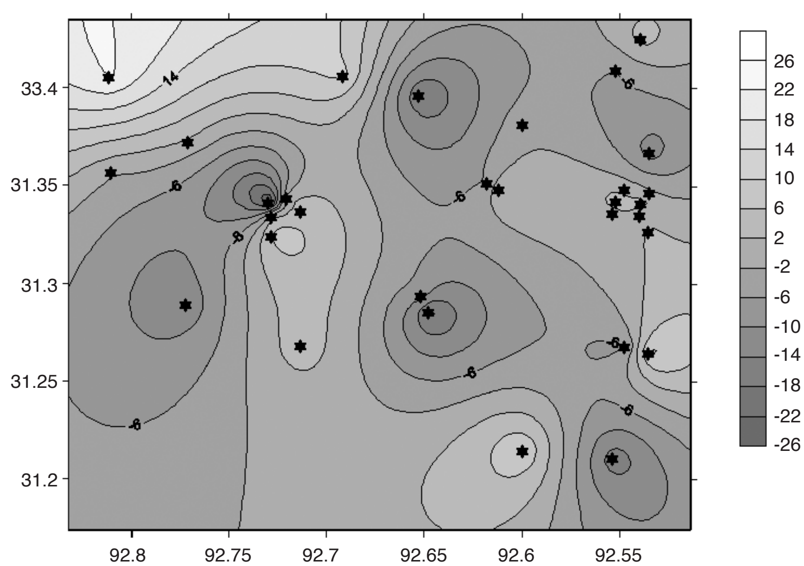

Figure 3. Temperature anomalies relative to general temperature gradient as determined from regression of temperature data that is in Figure 2. Hot Wells area is located at x = -92.73 and y = 31.33 as shown by a cluster of five observation points displayed by stars

dissolved solids were determined every ten feet within sands that lie above the base of brackish water and at selected points below the base of brackish water. Freshwater by definition has total dissolved solids (TDS) concentration under 1,000 parts per million (ppm). Brackish water by definition has a TDS between 1,000 ppm and 10,000 ppm (Driscoll, 1986). For this study the top of brackishwater-base of freshwater is considered to be the top of the first sand fully saturated with brackish waters. Likewise the top of saline water-base of brackish water is considered to be the top of the first sand fully saturated with saline water. Saline water by definition is water with a TDS between 10,000 ppm and 100,000 ppm.

In general the base of both freshwater and brackish water will dip towards the south (Figures 4 and 5). Fresh water's base is only at about 500 feet in the northern edge of the Hot Wells area and it dips southwards to about 2000 ft. The Hot Wells site, which is approximately in the center of the region, appears to have a somewhat unusual position for the base of freshwater. Hot Wells is located where the base of freshwater is only 900 ft below the surface; in fact right at the wells it is only about 700 ft below surface (Figure 4). It appears the Hot Wells resort is over a localized peak of brackish water. However, for the base of brackish water the Hot Wells site appears to lie over a broader peak than in the case of the base of freshwater. The peak of brackish water base lies slightly west (to left) of the peak of fresh water's base (Figures 4 and 5).

Comparisons

The temperature gradient present in the townships that surround Hot Wells, 1.42°F/100 ft, is a very typical gradient for many areas in Louisiana. The Hot Wells gradient is lower than values typically observed around salt domes, 1.6°F/100 ft to 1.76°F/100 ft (Ball, 1982; and Leger, 1988). In general, thermal gradients in southern Louisiana are lower, 1.21°F/100 ft to 1.35°F/100 ft (Jam et al., 1965; Leger, 1988; Suggate, 1998) than the Hot Wells gradient. Hot Wells gradient is higher than gradients above 10,000 ft throughout southern Louisiana, 0.8°F/100 ft to 1.18°F/100 ft (Jones, 1975; Kumar, 1977), but generally lower than gradients below 10,000 ft throughout southern Louisiana, 1.35°F/100 ft to 5.00°F/100 ft (Jones, 1975; Kumar, 1977; Bebout et al., 1982; and Nelson, 2003). The thermal gradients observed throughout northern Louisiana tend to be larger than the Hot Well gradient. For example Smith et al. (1981) observed a gradient of 1.37°F/100 ft to 2.20°F/100 ft, and Smith and Dees (1982a) observed a gradient of 1.92°F/100 ft to 2.41°F/100 ft, in northern Louisiana. Lastly the largest range seen is in Smith and Dees' (1982b) observations of 0.72°F/100 ft to 2.42°F/100 ft, with an average of 1.44°F/100 ft.

These results appear to indicate that Hot Wells results are very typical. However there is very little consideration of results in central Louisiana or the state as a whole. For this study thermal gradient was determined for both Grant and Rapides Parishes by analyzing temperature results for 154 wells and 198 wells respectively. The Hot Wells gradient is in between the

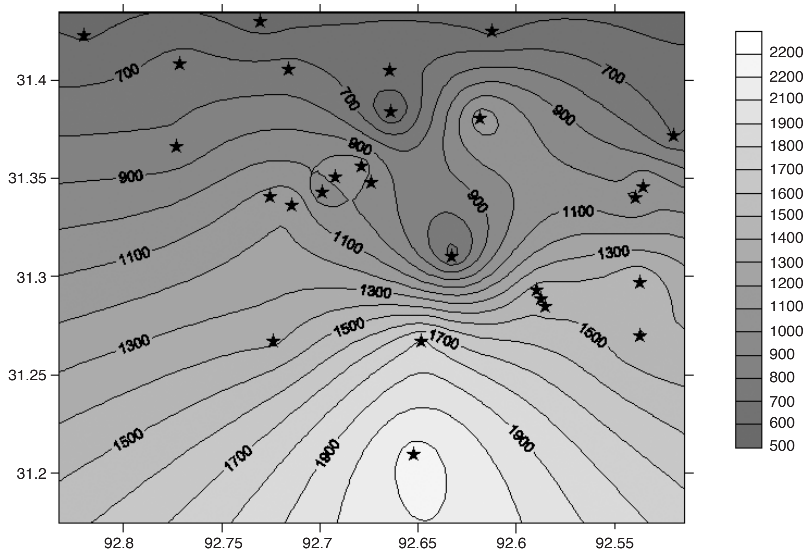

Figure 4. The depth of the base of freshwater from the earth's surface for the Hot Wells area ranges from about 500 ft to 2000 ft. This is the depth to the top of the first sand fully saturated with water that has a dissolved solids concentration over 1,000 ppm. The stars on the figure are the 30 wells drilled deep enough in

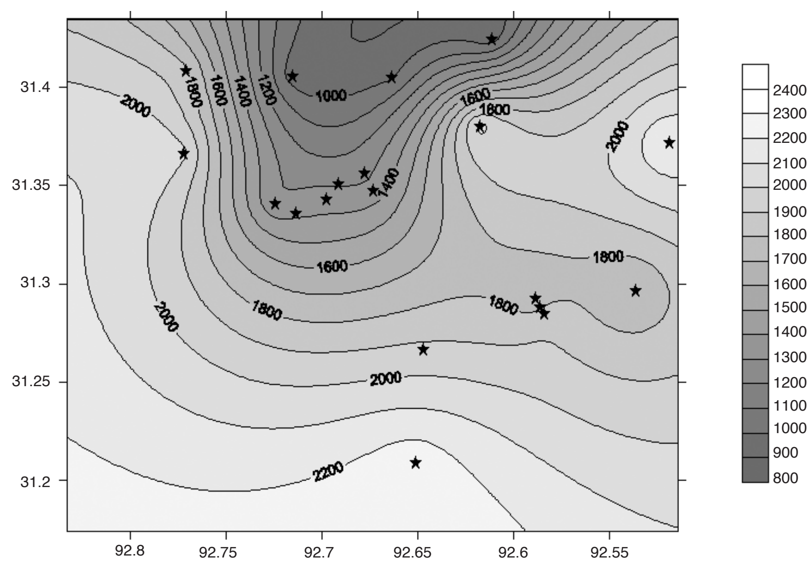

Figure 5. The depth of the base of brackish water from the earth's surface for the Hot Wells area ranges from about 800 ft to 2200 ft. This is the depth to the top of the first sand fully saturated with water that has a dissolved solids concentration over 10,000 ppm. The stars on the figure are the 21 wells drilled deep enough in the Hot Wells study area to reach the base of brackish water.

two parish results, where the gradient for Grant Parish is 1.64°F/100 ft and the gradient for Rapides Parish is 1.28°F/100 ft. It seems noteworthy now that the calculated gradient for well R-618 is well above the value calculated more recently by the senior author for the nine-township Hot Wells study area (1.42°F/100 ft reported in Figure 2), and that the gradient for well R-617 is somewhat higher, whereas the gradient for well R-810 lies relatively near this recently calculated value. The average gradient determined for McCulloh's (1991) three wells is 1.59°F/100 ft. This is reasonable given that these three wells fall within an anomalously warm area just to the right of the cluster of 5 wells at x = -92.73 and y = 31.33, Figure 3. Lastly, it appears that Hot Wells gradient, 1.42°F/100 ft, is larger than the average of gradients for all parishes, 1.28°F/100 ft, by about 11%. After analyzing typically about 180 wells in each parish, the state-wide parish results for the 64 parishes indicate that 18 parishes have a higher gradient and 46 have a lower gradient than the Hot Wells area (Figure 6). In general, the state results appear to parallelprevious results in that the parish gradients tend to be larger in northern and southeastern Louisiana and lower in southwesternLouisiana and in particular in the coastal parishes (Figure 6).

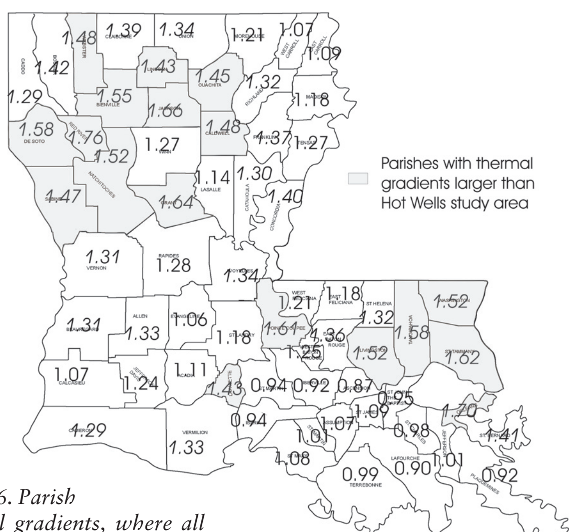

Figure 6. Parish thermal gradients, where all values are degrees Fahrenheit per 100 feet downwards. Parishes that have thermal gradients larger than the state average are in italics, while parishes with thermal gradients smaller than the state average are in block text.

In terms of salinity the results determined for this study are similar to those of previous studies. Like the previous studies this study has the base of freshwater surface generally dipping southwards from a depth of about 500 ft to 1800 ft from the northern to the southern edge of the study area (Figure 4). Both Smith and Fendick (1998) and Newcome and Sloss (1966) have the base of freshwater dipping southward from a depth of 500 ft to 1500 ft from the northern to the southern edge of the study area. However, perhaps because these previous studies have fewer observation points than this study, 15 versus 45, they tend to miss the slight ridge within the base of freshwater in the Hot Wells area. Winslow et al. (1968) observed that the base of brackish water is dipping generally southward from depths of 700 ft in the north to 2000 ft in the south across the study area, which is similar to this study's results of 1000 ft to 2200 ft depth from north to south (Figure 5). With this study's larger data set it is possible to reveal the slight ridge in the base of brackish water in the Hot Wells area.This ridge was also missed by Winslow et al. (1968), because of their thinner data set, comprising only five observation points in the study area versus the 20 observations points used in this study.

Conclusions

The Hot Wells area as indicated by past studies is neither anomalous in terms of temperature or salinity. However, this could be a function of the fact that past studies tended to examine all of Rapides Parish or even larger areas. By comparison this study, which focused on a smaller, nine-township area around the Hot Wells area with a greater density of data than previous works, appears to reveal a subtle temperature and salinity anomaly.

Acknowledgements

The senior author would like to thank the Louisiana Department of Natural Resources for access to their vast collection of oil and gas logs available at their log library and in the SONRIS system. In addition, he would like to thank the U.S. Geological Survey, Baton Rouge Office, for access to their vast collection of water well logs, which were used as an important data set of temperature at relatively shallow depths, under 3000 ft. Without these data sets this study would not have been possible. The junior author thanks George Cardwell and James E. Rogers for interesting discussion of the possible validity of a Hot Wells anomaly in the early 1990s.

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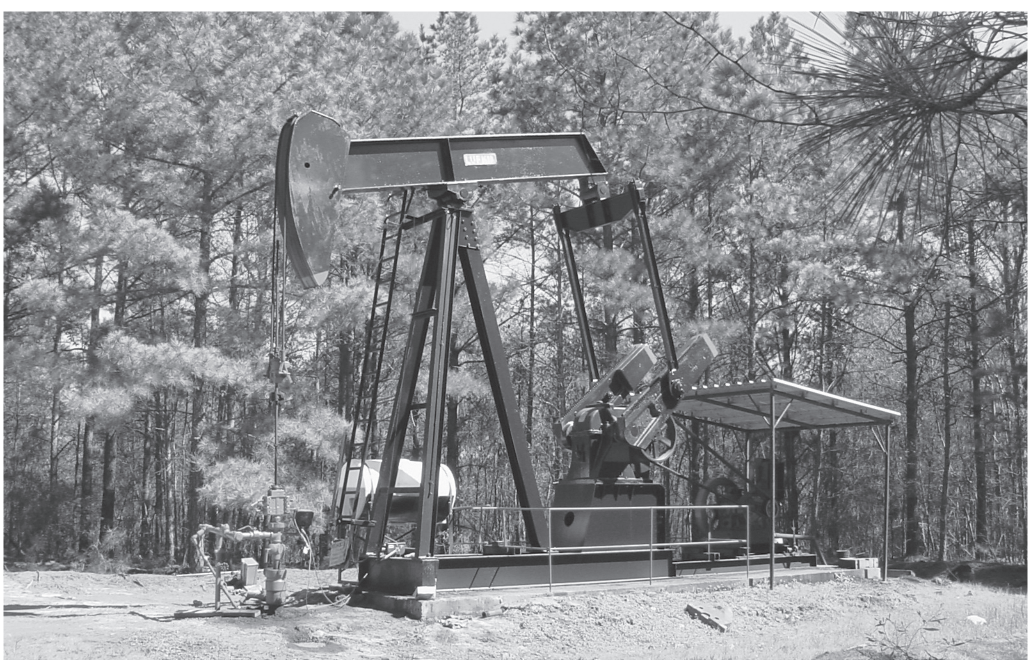


Oil well in the Rawson Creek Oil Field, which lies north of Harrisonburg, Louisiana in Catahoula Parish. It currently produces oil from the Wilcox Group.

Conferences & Awards

Gulf Coast Association of Geological Societies 54th Annual Convention, San Antonio, Texas, October 10-12, 2004

LGS Faculty and Staff who attended this meeting were Chacko John, Clayton Breland, Ron Zimmerman, Douglas Carlson and Riley Milner. LGS had an exhibit booth at this meeting displaying LGS publications and providing information on ongoing LGS research projects. Riley Milner was at the booth and was assisted by Chacko John. Conference attendee interest in LGS activities was evidenced by a steady flow of visitors to the exhibit booth throughout the convention. Papers presented by LGS Staff are listed elsewhere in this newsletter.

During the opening session the GCAGS Distinguished Service Award was presented to Chacko John by the GCAGS President Stewart Chuber. He also presented the third place Grover E. Murray Best Published Paper Award to Don Goddard (Center for Energy Studies) and Ron Zimmerman (LGS) for their paper titled ***"Shallow Miocene and Oligocene Gas Potential: Southeastern Louisiana's Florida Parishes"***. The first place GCGS/GCSSEMP Gorden I. Atwater best poster award was presented to Paul Heinrich for his poster titled ***"Origin of a circular Depression and Associated Fractured and Shocked Quartz, St. Helena Parish, Louisiana"***. These papere were presented at the 2003 GCAGS Convention in Baton Rouge and published in the Transactions volume for that year.

LGS Advisory Board Meeting

The Annual LGS Advisory Board Meeting was held on November 17, 2004 in the LGS Conference Room. Chacko John presented a brief overview of all LGS activities and was followed by presentations of ongoing LGS research projects by the Faculty and Staff. The Board members were very complimentary of the LGS programs and remarked that they would try and arrange a meeting with the governor to present potential benefits of LGS research to the economic development of the state and impress upon her the need for additional financial support for the Survey in order to be able to undertake such beneficialresearch projects.

LGS Service Awards

Fifteen year service awards were presented to LGS Research Associates Patrick O'Neill (left) and Lisa Pond (middle). A ten year service award was presented to Research Associate Riley Milner (right).

CWPPRA Awards

Dr. Bill Good received the "Coastal America Partnership Award" in recognition of his efforts to protect and restore Louisiana's Coastal Resources at the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) meeting held onAugust 18, 2004.

Personnel News

LGS welcomes the following new staff members:

Dr. Thomas Van Biersel joined LGS as Assistant Professor of Research in hydrogeology on October 01, 2004. Previously he worked at Southern Connecticut State University as Assistant Professor of Earth Sciences. His Ph.D is from the University of Wisconsin-Milwaukee.

Dr. Billy J. Good earned his doctorate in Marine Sciences from Louisiana State University. He joined LGS on July 01, 2004 as Coastal Research Manager. Prior to coming to LGS, Dr. Good served as Administrator of the Coastal Restoration Division, Louisiana Department of Natural Resources.

Dr. Roger J. Barnaby comes to LGS with over fourteen years experience in the petroleum industry and research institution, specializing in various aspects of petroleum and sedimentary geology. He joined LGS as Assistant Professor-Research starting December 01, 2004. Dr. Barnaby obtained his doctorate degree from the Virginia Polytechnic Institute.

Dr. Ronald Zimmerman retired from LGS at the end of August 2004 after having served at the Basin Research Institute and LGS for a total of thirteen years. He was presented with a plaque at a general staff meeting on August 24, 2004 by LGS Director Chacko J. John and a lunch reception in his honor was held on August 25, at Vincent's Restaurant. LGS thanks Ron for his distinguished and dedicated service. Though he is now retired, Ron continues to assist LGS with the research projects he was involved in at the time of his retirement.

Papers Published

Breland, F.C., Jr., 2004, ***Coalbed methane potential in Louisiana, in Warwick, P.D., ed., Selected presentations on coal-bed gas in the eastern United States,*** U.S. Geological Survey Open File Report 2004-1273, p. 27-35.

Breland, F. C., Jr., 2004, ***An introduction to coal seam natural gas (CSNG), aka, coalbed methane (CBM) in Coalbed methane resources in the Southeast,*** Petroleum Technology Transfer Council Short Course, Lafayette, LA, June 8, 2004,.

Breland, F.C., Jr. and Warwick, P.D., 2004, ***Coalbed methane (CBM) activity in Louisiana, in Short Course #3, Coalbed methane in the Gulf Coast,*** Gulf Coast Association of Geological Societies/ Gulf Coast Section SEPM, 54th Annual Convention, San Antonio, TX.

Carlson D., 2004, ***Underlying Aquifers Effect on Recharge Rates in Louisiana: Geological Society of America,*** Abstracts with Programs v. 36, no. 5, p. 131 [abstract].

Carlson D., and R. Milner, 2004, ***Hydrologic differences arising from source material differences between south-western Louisiana aquifers and their age equivalents insoutheastern Louisiana: Gulf Coast Association of Geological Societies Transactions,*** v. 54, p. 101-111.

John, C.J., B.L. Jones, B.J. Harder, R.J. Bourgeois and M.B. Miller, 2004, ***New Field Discoveries in Chandeleur Sound, Offshore Louisiana: Gulf Coast Association of Geological Societies Transactions,*** v. 54, p. 267-278.

Miller, Byron, C. J. John, B.J. Harder, and R.J. Bourgeois, 2004, ***The University Oil and Gas Field: Hydrocarbons, Reservoirs, and Future Potential;*** American Association of Petroleum Geologists Annual Convention Abstracts Volume, v. 13, p. A97.

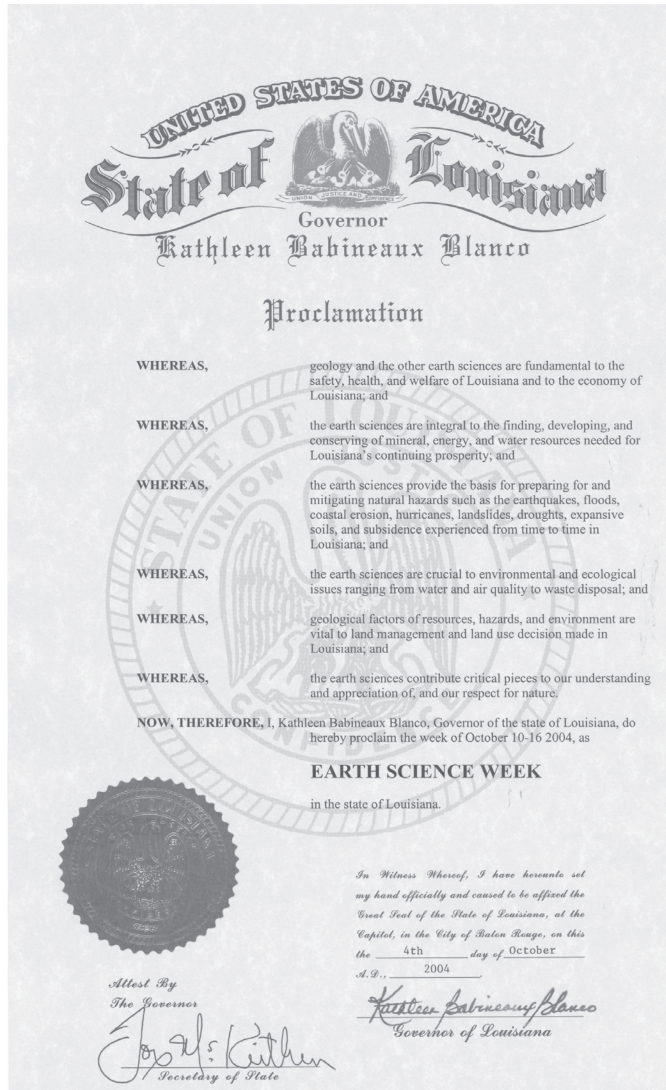
Warwick, P.D., Breland, F.C., Jr., Ratchford, M.E., Ingram, S.L. Sr., and Pashin, J.C., 2004, ***Coal gas resource potential of Cretaceous and Paleogene coals of the eastern Gulf of Mexico Coastal Plain:*** Geological Society of America Northeast/Southeast Section Meeting, Abstracts with Programs, v. 36, no. 2, p. 53.

Warwick, P.D.; Breland, F.C., Jr., Karlsen, A.W., and Hackley, P.C., 2004, ***Regional correlation and character of coal-bearing zones, Wilcox Group, north-central Louisiana-implications for coalbed gas exploration*** [abs.]: American Association of Petroleum Geologists Annual Convention Abstracts Volume, p. A145.

Warwick, P.D., Breland, F.C., Jr., Clark, A.C., and Willett, J.C., 2004, ***Preliminary Results from Coal-Bed Methane Drilling in Ouachita Parish, Louisiana:*** U.S. Geological Survey Open-File Report 2004-1239, 4 p.

Warwick, P.D, Breland, F.C., Jr., Ratchford, M.E. and Hackley, P.C., 2004, ***Gas resource potential of Cretaceous and Paleogene coals of the Gulf of Mexico Coastal Plain (including a review of the activity in the Appalachian and Warrior basins), in Warwick, P.D., ed., Selected presentations on coal-bed gas in the eastern United States,*** U.S. Geological Survey Open File Report 2004-1273, p. 1-25.

Warwick, P.D., Breland, F.C., Jr., and Hixon, R.L., 2004, ***Preliminary results from a coal-bed methane test well in Ouachita Parish, Louisiana:*** Geological Society of America Abstracts with Programs, v. 36, no. 5.



UNITED STATES OF AMERICA

State of Louisiana

Governor

Kathleen Babineaux Blanco

Proclamation

WHEREAS, geology and the other earth sciences are fundamental to the safety, health, and welfare of Louisiana and to the economy of Louisiana; and

WHEREAS, the earth sciences are integral to the finding, developing, and conserving of mineral, energy, and water resources needed for Louisiana's continuing prosperity; and

WHEREAS, the earth sciences provide the basis for preparing for and mitigating natural hazards such as the earthquakes, floods, coastal erosion, hurricanes, landslides, droughts, expansive soils, and subsidence experienced from time to time in Louisiana; and

WHEREAS, the earth sciences are crucial to environmental and ecological issues ranging from water and air quality to waste disposal; and

WHEREAS, geological factors of resources, hazards, and environment are vital to land management and land use decision made in Louisiana; and

WHEREAS, the earth sciences contribute critical pieces to our understanding and appreciation of, and our respect for nature.

NOW, THEREFORE, I, Kathleen Babineaux Blanco, Governor of the state of Louisiana, do hereby proclaim the week of October 10-16 2004, as

EARTH SCIENCE WEEK

in the state of Louisiana.

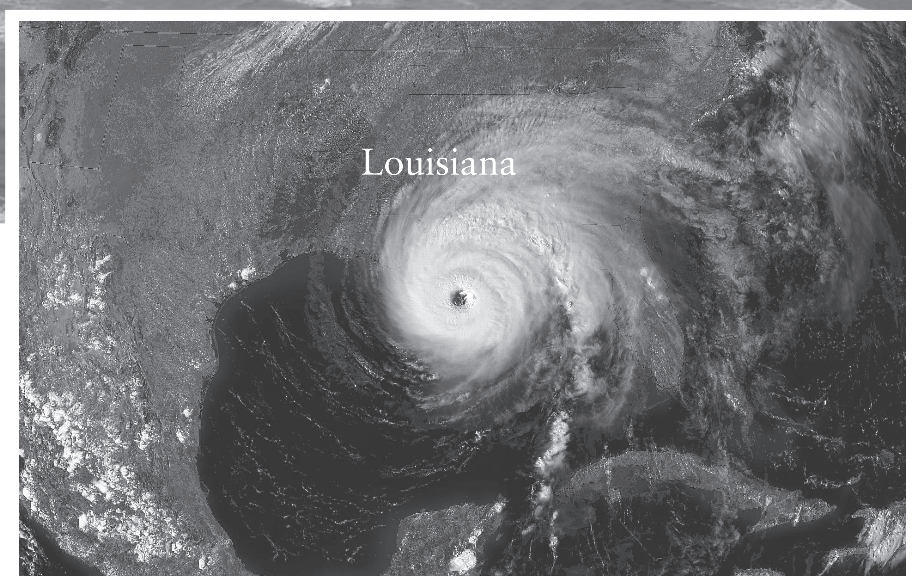
In Witness Whereof, I have hereunto set my hand officially and caused to be affixed the Great Seal of the State of Louisiana, at the Capitol, in the City of Baton Rouge, on this the 4th day of October A.D., 2004.

Attest By The Governor

Secretary of State

Governor of Louisiana

Proclamation issued by Governor Kathleen Blanco for Earth Science Week, October 10-16, 2004, at the request of LGS.



Hurricane Ivan

September 14, 2004

Chandeleur Light House photos taken by Karen Westphal. Satellite image courtesy of NOAA.

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LGS to Host DMT Workshop

The next Digital Mapping Techniques Workshop will be hosted by LGS from April 24-27, 2005.

The Digital Mapping Techniques workshops are an internationally-recognized venue for promoting standards, common practices, and innovative techniques for geologic mapping, map production, and information management. The Association of American State Geologists and the U.S. Geological Survey have conducted eight annual "DMT" workshops, with each drawing an invited group of about 100 technical experts from about 40 geologic mapping agencies and private companies from all over the country.

These meetings serve as a forum for discussion and information-sharing. They have significantly helped the U.S. and Canadian geoscience community converge on more standardized approaches for digital mapping, GIS analysis, and information management, and thus agencies have adopted new, more efficient techniques for digital map preparation, analysis, and production.

Sponsorships are invited. For workshop details and sponsorship opportunities, please contact Robert Paulsell (email: rpaulsell@lsu.edu, phone number 225/578-8655). For further information, please see the DMT website: http://ngmdb.usgs.gov/Info/dmt/.

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