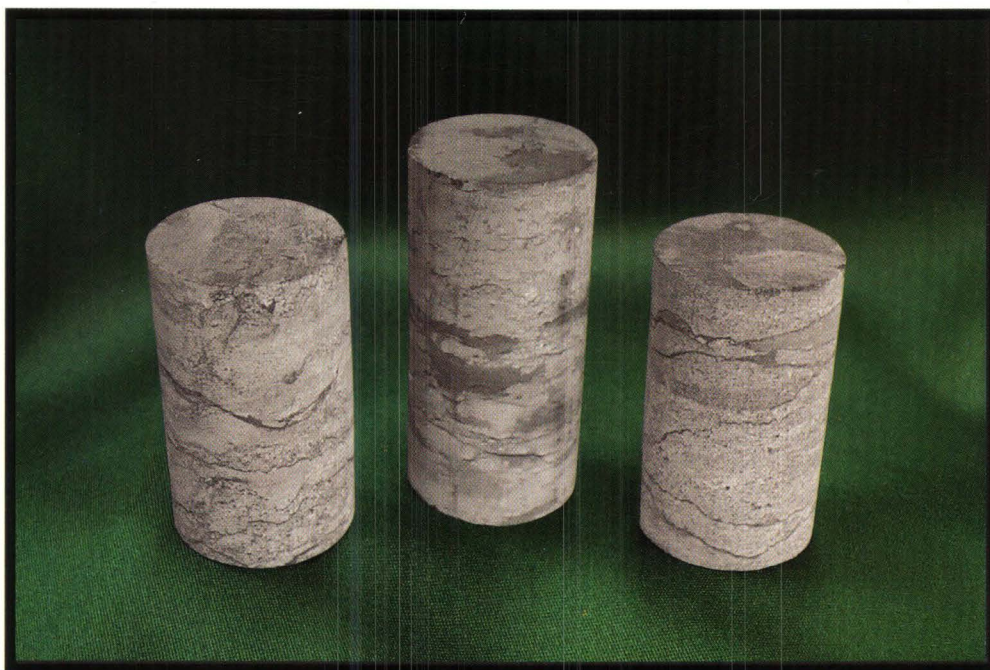


# **Stratigraphy and Vertical Hydraulic Conductivity of the St. Francois Confining Unit in Townships 25–27 N. and Ranges 01–02 W., Southeastern Missouri**

**Water-Resources Investigations Report 01–4270**



Prepared in cooperation with the  
U.S. Department of Agriculture,  
Forest Service,  
U.S. Department of the Interior,  
Bureau of Land Management, and  
Missouri Department of Conservation

U.S. Department of the Interior  
U.S. Geological Survey

**Cover Photograph:** Carbonate rock core samples from the study area in the Doniphan/Eleven Point Ranger District of the Mark Twain National Forest. (photograph by: Rebecca S. Inman).

U.S. Department of the Interior  
U.S. Geological Survey

# **Stratigraphy and Vertical Hydraulic Conductivity of the St. Francois Confining Unit in Townships 25–27 N. and Ranges 01–02 W., Southeastern Missouri**

By Michael J. Kleeschulte<sup>1</sup> and Cheryl M. Seeger<sup>2</sup>

Water-Resources Investigations Report 01–4270

Prepared in cooperation with the  
U.S. Department of Agriculture,  
Forest Service,  
U.S. Department of the Interior,  
Bureau of Land Management, and  
Missouri Department of Conservation

Rolla, Missouri  
2001

---

<sup>1</sup>U.S. Geological Survey

<sup>2</sup>Missouri Department of Natural Resources

**U.S. Department of the Interior**

Gale A. Norton, Secretary

**U.S. Geological Survey**

Charles G. Groat, Director

The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

---

For additional information write to:

**District Chief  
U.S. Geological Survey  
1400 Independence Road  
Mail Stop 100  
Rolla, MO 65401**

Copies of this report can be purchased  
from:

**U.S. Geological Survey  
Branch of Information Services  
Box 25286  
Denver, CO 80225-0286**



# CONTENTS

|                                                              |    |
|--------------------------------------------------------------|----|
| Abstract.....                                                | 1  |
| Introduction .....                                           | 2  |
| Purpose and Scope.....                                       | 4  |
| Previous Investigations .....                                | 4  |
| Exploration Borehole Data .....                              | 6  |
| Geohydrologic Units.....                                     | 7  |
| Acknowledgment .....                                         | 8  |
| Stratigraphy .....                                           | 8  |
| Individual Geologic Units.....                               | 8  |
| Precambrian Rocks .....                                      | 8  |
| Lamotte Sandstone .....                                      | 11 |
| Lamotte Sandstone-Bonneterre Formation Transition Zone ..... | 11 |
| Bonneterre Formation .....                                   | 13 |
| Davis Formation .....                                        | 17 |
| Derby-Doerun Dolomite.....                                   | 19 |
| St. Francois Confining Unit.....                             | 19 |
| Vertical Hydraulic Conductivity .....                        | 21 |
| Methodology.....                                             | 24 |
| Evaluation of Results .....                                  | 25 |
| Summary.....                                                 | 30 |
| References Cited.....                                        | 32 |

# CONTENTS

|                                                              |    |
|--------------------------------------------------------------|----|
| Abstract.....                                                | 1  |
| Introduction .....                                           | 2  |
| Purpose and Scope.....                                       | 4  |
| Previous Investigations .....                                | 4  |
| Exploration Borehole Data .....                              | 6  |
| Geohydrologic Units.....                                     | 7  |
| Acknowledgment.....                                          | 8  |
| Stratigraphy .....                                           | 8  |
| Individual Geologic Units.....                               | 8  |
| Precambrian Rocks .....                                      | 8  |
| Lamotte Sandstone .....                                      | 11 |
| Lamotte Sandstone-Bonneterre Formation Transition Zone ..... | 11 |
| Bonneterre Formation.....                                    | 13 |
| Davis Formation .....                                        | 17 |
| Derby-Doerun Dolomite.....                                   | 19 |
| St. Francois Confining Unit.....                             | 19 |
| Vertical Hydraulic Conductivity .....                        | 21 |
| Methodology.....                                             | 24 |
| Evaluation of Results .....                                  | 25 |
| Summary.....                                                 | 30 |
| References Cited.....                                        | 32 |

## FIGURES

|                                                                                                                                                                     |    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 1. Map showing location of study area, Viburnum Trend, Precambrian rock outcrops in the St. Francois Mountains, and the prospecting area.....                       | 3  |
| 2. Generalized geohydrologic section from western Howell County to eastern Carter County across the prospecting area.....                                           | 5  |
| 3. Well-numbering system.....                                                                                                                                       | 7  |
| 4.-10. Maps showing:                                                                                                                                                |    |
| 4. Location of exploration boreholes .....                                                                                                                          | 9  |
| 5. Structure of the top of the Lamotte Sandstone.....                                                                                                               | 12 |
| 6. Structure of the top of the Bonneterre Formation .....                                                                                                           | 16 |
| 7. Structure of the top of the Davis Formation.....                                                                                                                 | 18 |
| 8. Structure of the top of the Derby-Doerun Dolomite .....                                                                                                          | 20 |
| 9. Thickness of the St. Francois confining unit.....                                                                                                                | 22 |
| 10. Net shale thickness of the combined St. Francois confining unit and the upper Bonneterre Formation .....                                                        | 23 |
| 11. Boxplots showing the vertical hydraulic conductivity and porosity of formations and rock types in the study area.....                                           | 27 |
| 12. Boxplots showing the vertical hydraulic conductivity of the St. Francois confining unit, formations, and rock types in the study area and prospecting area..... | 28 |

## TABLES

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| 1. Core log analysis data.....                                                     | 36 |
| 2. Porosity, vertical permeability, and vertical hydraulic conductivity data ..... | 60 |
| 3. Summary statistics for vertical hydraulic conductivity analysis.....            | 26 |

**Sea level:** In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude, as used in this report, refers to distance above or below sea level.

# Stratigraphy and Vertical Hydraulic Conductivity of the St. Francois Confining Unit in Townships 25–27 N. and Ranges 01–02 W., Southeastern Missouri

By Michael J. Kleeschulte<sup>1</sup> and Cheryl M. Seeger<sup>2</sup>

## Abstract

The St. Francois confining unit (Derby-Doerun Dolomite and Davis Formation) lies beneath the Ozark aquifer (Jefferson City Dolomite to the Potosi Dolomite) and impedes the circulation of water between the overlying Ozark aquifer and the underlying St. Francois aquifer (Bonneterre Formation and Lamotte Sandstone). The Bonneterre Formation is the potential host formation for lead-zinc deposits in the area. There is concern that mine dewatering in the Bonneterre Formation could lower water levels in the Ozark aquifer. To address this concern, the vertical hydraulic conductivity of the St. Francois confining unit in six townships (T. 25–27 N. and R. 01–02 W.) of Oregon, Carter, and Ripley Counties of southeastern Missouri was evaluated by describing the stratigraphy and measuring the vertical hydraulic conductivity of core samples.

The Davis Formation is an intrashelf basin facies consisting of a series of shales interbedded with shaley limestones, shale-free limestones, and local dolostones, and ranges from 24 to 320 ft (feet) thick, but typically the thickness is 100 to 200 ft. Shale-dominant sequences can be tens of feet thick, and contain as much as 90 percent shale. Carbonate-dominant zones may be 70 ft thick or greater. The top of the Davis Formation (based on 56 data points) ranges from 620 to 2,022 ft deep

and ranges in altitude from 40 ft below sea level in the northern part of the study area to 1,182 ft below sea level in the southern part of the study area.

The Derby-Doerun Dolomite represents a pair of superimposed carbonate ramp cycles. Where present, the basal shaley sequence represents a transition with the Davis Formation. The formation (based on 50 data points) ranges from 50 to 386 ft thick, but typically is 120 to 180 ft thick in the study area. The top of the Derby-Doerun Dolomite ranges from 495 to 2,020 ft deep (based on 53 data points), and ranges in altitude from 85 ft above sea level to 947 ft below sea level.

The St. Francois confining unit is thickest in the central and southern parts of the study area. The thickness, as determined by 51 core logs that completely penetrate the unit, ranges from less than 200 ft in the northwestern and east-central parts of the study area to 411 ft in the central part, but typically ranges from 270 to 340 ft. The net shale thickness of the confining unit (based on 29 data points) ranges from 1.7 ft in the east-central part of the study area to 89 ft in the southwest part. These net shale thickness values include the cumulative shale thickness of rock from the top of the Derby-Doerun Dolomite to the base of the False Davis.

Vertical hydraulic conductivities of 35 rock core samples from the St. Francois confining unit in the study area range from  $7.6 \times 10^{-15}$  to  $2.1 \times 10^{-10}$  ft/s (foot per second). The logarithmic transformed vertical hydraulic conductivities of the Derby-Doerun Dolomite and Davis Formation are

<sup>1</sup>U.S. Geological Survey

<sup>2</sup>Missouri Department of Natural Resources

similar ( $p$ -value = 0.073) using the statistical two-sample  $t$ -test; however, this  $p$ -value approaches the level of significance value of 0.05. The vertical hydraulic conductivity of the Derby-Doerun Dolomite is larger and less variable than the Davis Formation. When grouped by rock type, the vertical hydraulic conductivity of samples that contain carbonate, shale, or both carbonate and shale, are similar.

A comparison on the ranked data using the Mann-Whitney test shows the confining unit in the study area is statistically different ( $p$ -value = 0.020) from the confining unit in the prospecting area (west and adjacent to the study area). The median value of the vertical hydraulic conductivity data from the study area ( $6.7 \times 10^{-13}$  ft/s) is three times larger than the median vertical hydraulic conductivity value for the prospecting area ( $2.2 \times 10^{-13}$  ft/s). The interquartile range shows that the variability of the study area data spans one order of magnitude ( $2.0 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s) and that the corresponding data from the prospecting area spans nearly two orders of magnitude ( $3.2 \times 10^{-14}$  to  $1.1 \times 10^{-12}$  ft/s).

The ranked vertical hydraulic conductivities of the Derby-Doerun Dolomite in the two areas are statistically similar ( $p$ -value = 0.514). The median vertical hydraulic conductivity of the study area data ( $1.2 \times 10^{-12}$  ft/s) is about three times greater than the median value of the prospecting area data ( $4.4 \times 10^{-13}$  ft/s). The variability of the data, as shown by the interquartile range, is less in the study area ( $5.5 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s; spanning less than one order of magnitude) as compared to the prospecting area ( $3.2 \times 10^{-14}$  to  $6.3 \times 10^{-10}$  ft/s; spanning over four orders of magnitude).

The ranked vertical hydraulic conductivities of the Davis Formation in the two areas show these data sets are statistically similar ( $p$ -value = 0.076). The median vertical hydraulic conductivity value of study area samples ( $4.5 \times 10^{-13}$  ft/s) is three times greater than the median value of the prospecting area data ( $1.6 \times 10^{-13}$  ft/s). The interquartile range of the study area data spans one order of magnitude ( $1.2 \times 10^{-13}$  to  $1.4 \times 10^{-12}$  ft/s) and the

corresponding data from the prospecting area spans nearly 1.5 orders of magnitude ( $3.2 \times 10^{-14}$  to  $7.4 \times 10^{-13}$  ft/s).

The Mann-Whitney test shows the ranked vertical hydraulic conductivities of each rock type from the study area are statistically similar to the same rock type in the prospecting area [carbonates ( $p$ -value = 0.225), shales ( $p$ -value = 0.668), and carbonates and shales ( $p$ -value = 0.227)]. However, in each of the three cases the study area samples have larger median values and less variability than the prospecting area samples.

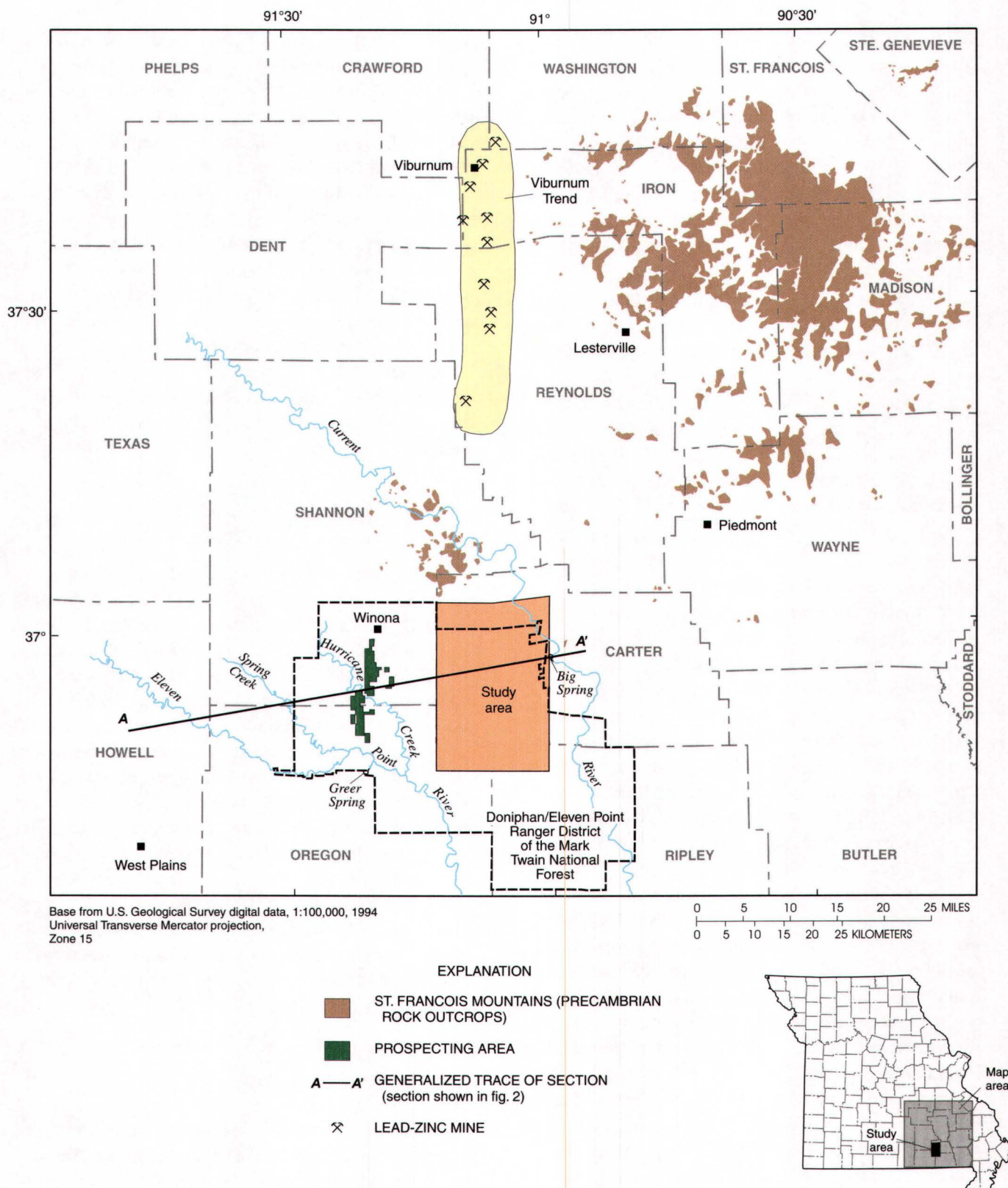
Because the vertical hydraulic conductivity of the various rock types of the confining unit in the study area are statistically similar, the entire carbonate-shale thickness is the primary factor determining the effectiveness of the confining unit. The range of effective vertical hydraulic conductivity of the St. Francois confining unit in the study area using appropriate minimum and maximum thickness, net shale thickness, and vertical hydraulic conductivities is  $3 \times 10^{-13}$  to  $2 \times 10^{-12}$  ft/s. The vertical hydraulic conductivity of the confining unit is small, and the confining unit effectively impedes the ground-water flow between the Ozark aquifer and the St. Francois aquifer, unless preferred-path secondary permeability has developed along faults and fractures that extend through the confining unit.

## INTRODUCTION

The Bonneterre Formation of the St. Francois aquifer is the potential host formation for lead-zinc deposits in southeastern Missouri (Wharton, 1975). Lead and zinc exploration in the Doniphan/Eleven Point Ranger District (historically referred to as the Fristoe Unit) of the Mark Twain National Forest in southeastern Missouri has been ongoing since the 1960s. In the late 1970s and early 1980s, the search intensified and several hundred exploration holes were drilled. The exploration has become focused on a small area north of the Eleven Point River (hereinafter referred to as the prospecting area; fig. 1).

The prospecting area lies within a larger region of well-developed karst terrain with an extensive network of solution-enlarged fractures ranging from small





**Figure 1.** Location of study area, Viburnum Trend, Precambrian rock outcrops in the St. Francois Mountains, and the prospecting area.

channels to large conduits. The two largest springs in Missouri are in this area—Big Spring, which has an annual mean discharge of 447 ft<sup>3</sup>/s (cubic feet per second) and Greer Spring, which has an annual mean discharge of 344 ft<sup>3</sup>/s (Hauck and Nagel, 2001). Discharge from these springs helps sustain flow in two nationally designated streams; Big Spring flows into the Current River (Ozark National Scenic Riverways), and Greer Spring flows into the Eleven Point River (Eleven Point National Scenic River).

A generalized geohydrologic section from western Howell County to eastern Carter County is shown on figure 2. This preliminary section was drawn by projecting geologic data from nearby exploration boreholes at right angles to the trace of the section (R.W. Harrison, U.S. Geological Survey, written commun., 2000). Names of geologic units used in this report follow the nomenclature used by the Missouri Department of Natural Resources, Division of Geology and Land Survey (DGLS).

Predominantly carbonate rock sequences of the Lower Ordovician and Upper Cambrian Series (Jefferson City Dolomite to the base of the Lamotte Sandstone) overlie igneous granites and rhyolites of the Precambrian basement rock in the study area. The formations from the Jefferson City Dolomite to the Eminence Dolomite are predominant at land surface; these rocks, together with the Potosi Dolomite, form the Ozark aquifer, which is a primary source of water for domestic and public-water supplies and major springs (Imes and Emmett, 1994) in southern Missouri. The St. Francois confining unit lies beneath the Ozark aquifer and consists of carbonates and shales of the Derby-Doerun Dolomite and the Davis Formation. This confining unit impedes the circulation of water between the overlying Ozark aquifer and the underlying St. Francois aquifer, which primarily consists of carbonates of the Bonneterre Formation and the Lamotte Sandstone. Little is known about the hydrology of the St. Francois aquifer because the shallower Ozark aquifer is a reliable source of ground water for the area. The Precambrian basement rock has an irregular surface characterized by numerous knobs (high areas) that can protrude hundreds of feet above the surrounding basement rock and penetrate into or through overlying formations. Locally, this can cause overlying formations to be thin or absent.

Lead-zinc mining in this environmentally sensitive karst area may have possible impacts on the water resources of the area. The potential mines in the Bonneterre Formation would be at depths greater than

1,300 ft (feet) and would have to be dewatered before lead-zinc minerals can be extracted. Environmental concerns include, but are not limited to, the fact that mine dewatering could lower water levels in the surficial Ozark aquifer. In 2000, the U.S. Geological Survey (USGS) and DGLS began a study to describe the stratigraphy and vertical hydraulic conductivity of the St. Francois confining unit in an area just east of the prospecting area. This information is relevant to the effectiveness of the St. Francois confining unit to impede flow of water between the (overlying) Ozark aquifer and the (underlying) St. Francois aquifer. This study was performed in cooperation with the U.S. Department of Agriculture, Forest Service (Forest Service), the U.S. Department of the Interior, Bureau of Land Management (BLM), and the Missouri Department of Conservation.

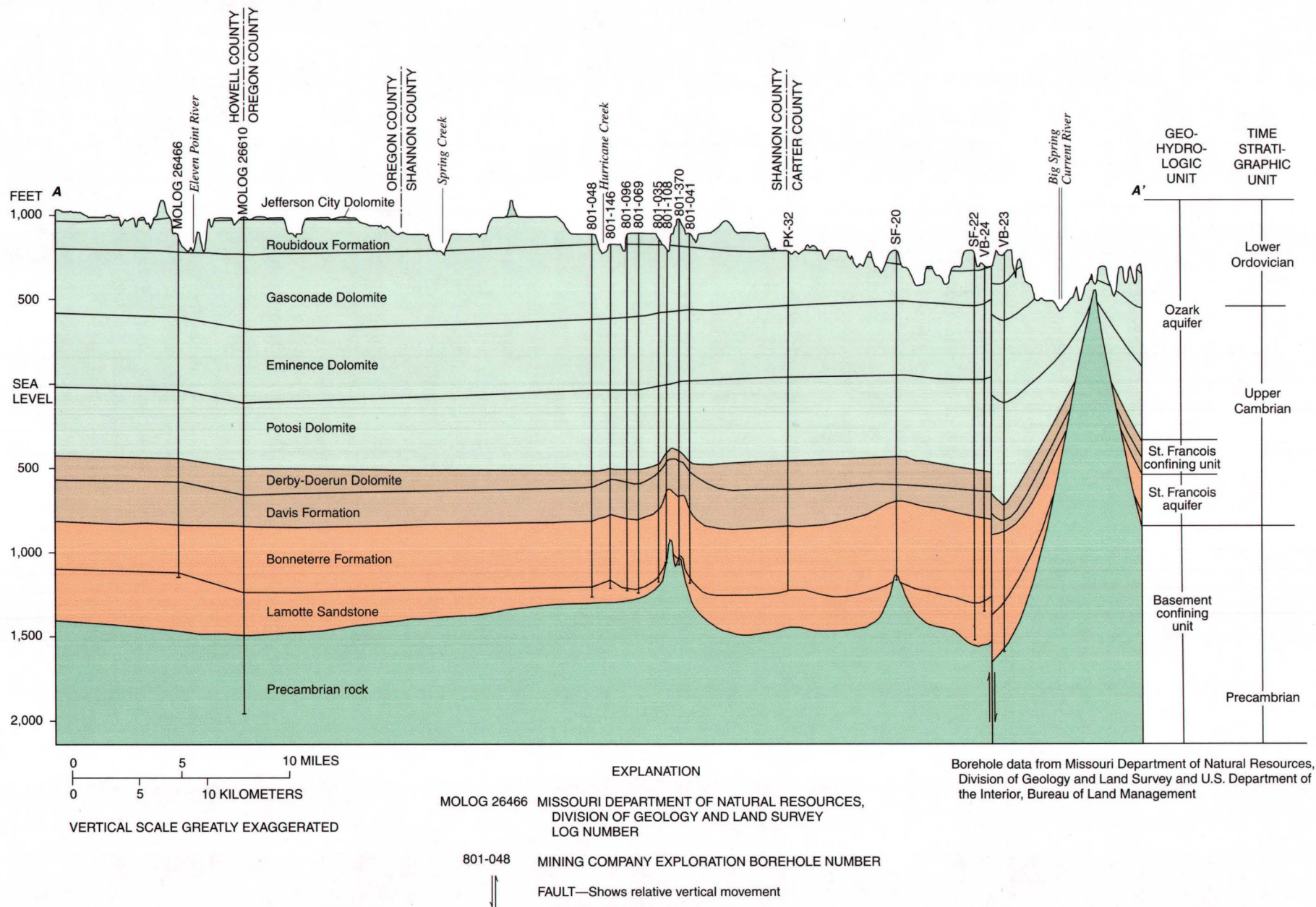
## **Purpose and Scope**

This report describes the stratigraphy and vertical hydraulic conductivity of the St. Francois confining unit (Derby-Doerun Dolomite and Davis Formation) in six townships (T. 25–27 N. and R. 01–02 W.) of Oregon, Carter, and Ripley Counties. This was accomplished by evaluating core log data from 340 boreholes and examining available rock core samples. These stratigraphic data were used to prepare maps that depict the altitude of the top of the formations in the St. Francois confining unit and St. Francois aquifer (Bonneterre Formation and Lamotte Sandstone), and the total thickness and net shale thickness (cumulative shale thicknesses) of the confining unit. Laboratory vertical hydraulic conductivity was measured in 43 rock core samples from the St. Francois confining unit and the St. Francois aquifer in the study area. The analyzed cores were obtained from the Doe Run Company and the DGLS.

## **Previous Investigations**

Lead-zinc mineralization in the prospecting area may be a southern extension of the Viburnum Trend (fig. 1) ore deposits located 20 mi (miles) to the north where lead-zinc mining currently (2001) is active. The geology and depositional environment of the prospecting area and of the Viburnum Trend mining area may have been similar during Late Cambrian time when the formations of the St. Francois aquifer and St. Francois





**Figure 2.** Generalized geohydrologic section from western Howell County to eastern Carter County across the prospecting area (trace of section is shown in fig. 1; section is preliminary and modified from Richard W. Harrison, U.S. Geological Survey, written commun., 2000).

confining unit were deposited. Studies of the Viburnum Trend by Palmer (1991) and Thacker and Anderson (1979) indicate that the clastic content (and confining ability) of sediments that became the St. Francois confining unit were controlled by the environment at the time of deposition.

The study area is adjacent to and immediately east of a similar assessment of the confining ability of the St. Francois confining unit that was reported in Kleeschulte and Seeger (2000). That work focused on the depositional environment, stratigraphy, and vertical hydraulic conductivity of the St. Francois confining unit in six townships (T. 25–27 N., R. 03–04 W.) that are centered on the prospecting area. Data from that report (238 core logs) were used to supplement data for this study area to ensure continuity of structure and thickness maps across the boundary between the study areas.

Kleeschulte and Seeger (2000) report the thickness of the confining unit appears to be uniform in the area, but that the net shale thickness of the confining unit decreases toward the east in the area between the prospecting area and Big Spring. It was concluded that the net shale thickness is not the only factor that limits the hydraulic conductivity of the confining unit. The vertical hydraulic conductivity of the carbonate rocks and shales in the confining unit are similar; therefore, the entire carbonate-shale thickness is important in determining the effectiveness of the confining unit. The vertical hydraulic conductivity for the St. Francois confining unit in that study area was estimated to range from  $3 \times 10^{-14}$  to  $1 \times 10^{-12}$  ft/s (foot per second). This range of vertical hydraulic conductivity values is small and the St. Francois confining unit will effectively impede the ground-water flow between the Ozark aquifer and the St. Francois aquifer in the studied area, unless preferred-path secondary permeability has developed along faults and fractures.

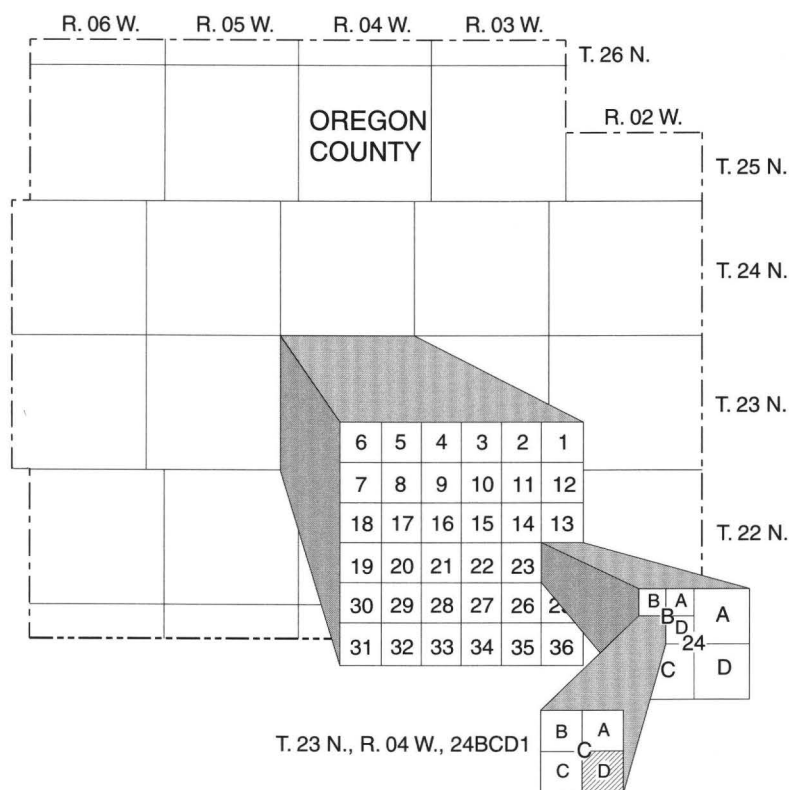
## Exploration Borehole Data

Several hundred exploration holes have been drilled in a four-county area of southeastern Missouri (Carter, Oregon, Shannon, and Ripley Counties) by mining companies during the approximately four decades of lead-zinc ore exploration in and near the Doniphan/Eleven Point Ranger District. The BLM, DGLS, and the Doe Run Company have copies of many of the core logs from the various mining companies that have performed exploratory drilling in this

area. The BLM receives copies of core logs from exploration holes drilled on Federal lands, the DGLS received copies of logs from several mining companies, and the Doe Run Company owns and operates all of the active mines in the Viburnum Trend and received core logs from predecessor companies. Consequently, 340 exploration borehole core logs ranging from 710 to 3,000 ft in depth (table 1, at the back of this report) were made available for inspection. Eighty-one of these boreholes are within the study area. The core logs provide general site information such as location and land surface altitude of the borehole, depths to formation tops, and total depth of the borehole. In some cases, the logs also provide detailed lithologic descriptions of the formations encountered from near the bottom of the Potosi Dolomite into the Lamotte Sandstone or Precambrian basement, typically an interval of 600 to 800 ft. These core logs along with available core samples that were examined as part of this project are the primary source of the stratigraphic data contained in this report.

The borehole location reported on the core log was defined to the nearest quarter-quarter-quarter section, or as distance from the north/south and east/west section line. Land surface altitudes were determined at the time of drilling using altimeters or topographic maps. The reported altitudes were verified during this study using USGS 7.5-minute topographic maps that generally had contour intervals of 20 ft, making the land surface altitude accurate to about 10 ft (one-half the contour interval). In a few instances, the reported land surface altitudes on the core log did not agree with the land surface altitudes shown on the topographic maps for the given location. When this situation occurred, the altitude shown on the topographic map at the borehole location was used. The altitudes used in contouring geologic formation tops were determined by subtracting the depth of the formation top reported on the core log from the land surface altitude.

In this report, the locations of exploration boreholes (table 1) are shown by latitude and longitude coordinates and by the local well number, which follows the General Land Office coordinate system (fig. 3). According to this system, the first three sets of numbers representing a hole location designate township, range, and section. The letters that follow indicate quarter section, quarter-quarter section, and quarter-quarter-quarter section. The quarter sections are represented by letters A, B, C, and D in counterclockwise



**Figure 3.** Well-numbering system.

order, starting in the northeastern quadrant. Two or more exploration holes in the same division are numbered serially in the order they were inventoried.

Considerable interpretation was necessary to identify stratigraphic boundaries in some of the reviewed logs because of transitional lithologies and the variable stratigraphic nomenclature applied by the different mining companies. The conformable and transitional contacts between the Bonneterre and Davis Formations; Davis Formation and Derby-Doerun Dolomite; and Derby-Doerun and Potosi Dolomites make it difficult to distinguish the contacts between these formations. This may account for some of the irregularity shown on structure maps in this report. The different mining companies may have used different criteria for assigning the contacts between these formations.

## Geohydrologic Units

Delineation of geohydrologic units is based on hydraulic properties and the hydrologic relation of each unit to adjacent geohydrologic units at a regional scale. The terms aquifer and confining unit, as defined regionally, may not adequately describe the water-

yielding capability of a sequence of rocks locally because of the variation in hydraulic properties of the same sequence from one area to another.

The lowermost geohydrologic unit is the Precambrian Basement confining unit, which is dominantly granite and rhyolite. Imes (1989) states that this confining unit is virtually impermeable. In areas where extensive faulting and fracturing has occurred Imes reports the Basement confining unit can yield small quantities of water. In areas where the unit crops out, well yields are less than 10 gallons per minute.

The St. Francois aquifer (Imes, 1990a) overlies the Basement confining unit and consists of the Bonneterre Formation and the Lamotte Sandstone. In areas of southeastern Missouri near the St. Francois Mountains (fig. 1) where this aquifer is close to land surface, it yields adequate supplies of water for domestic and small capacity public-supply wells. The thickness of the St. Francois aquifer can vary considerably because of the rugged surface of the underlying Precambrian basement rocks.

The Derby-Doerun Dolomite and the Davis Formation form the St. Francois confining unit (Imes, 1990b) that overlies the St. Francois aquifer. Imes and Emmett (1994) state that substantial secondary poros-



ity and permeability have not developed regionally in the St. Francois confining unit. The fine-grained nature of the formations indicates they have minimal permeability, even in areas containing little or no shale. The physical and hydraulic characteristics of the unit generally impede the circulation of ground water between the overlying Ozark aquifer and the underlying St. Francois aquifer (Imes and Emmett, 1994).

The Ozark aquifer (Imes, 1990c) is the uppermost geohydrologic unit in the study area and consists of rocks from the top of the Jefferson City Dolomite to the base of the Potosi Dolomite (fig. 2). This predominantly carbonate aquifer is made up of dolostone with some sandstone, and is the most widely used aquifer in southern Missouri. Ground water in the aquifer in the study area occurs under water-table conditions where the water is not confined by less permeable rocks.

## Acknowledgment

A special acknowledgment of gratitude is extended to Glenn Adams of the Doe Run Company for his assistance in obtaining rock core samples and for access to the core logs on file at the Doe Run Company. Much of the data in this report could not have been obtained without his cooperation.

## STRATIGRAPHY

The St. Francois confining unit consists primarily of carbonate and shale. Shale content usually is a good indicator of the effectiveness of a confining unit. Logging of available core samples and compiling data from core logs with detailed descriptions of lithologies were used to determine the net shale thickness. Usable logs for net shale thickness determination typically divided the cored section into small intervals in which the lithology had similar characteristics. The rock was described as to color, texture, grain size, physical features present in the rock (algal stromatolites, vugs, and staining), and the percentage of each rock type (shale, dolostone, and limestone). Net shale thickness at that borehole was calculated by multiplying the reported percent shale in each logged interval by the thickness of the described interval and summing the results. If core from an exploration hole was not described in sufficient detail to extract all the needed information to make a net shale thickness determination but the core was available, the core was then examined to determine the

net shale thickness. The shale in the upper Bonneterre Formation above the base of the informally recognized unit referred to as the False Davis was included in the net shale thickness determination of the confining unit. This shale unit appears to be present throughout the study area and was identified while logging the available rock core as part of this project. This additional shale in the Bonneterre Formation was included with the net shale total of the confining unit because it adds to the confining capability of the rock sequence. However, because many of the mining company core logs did not identify the False Davis unit, the base of the unit could not be used when preparing the thickness map for the confining unit. The thickness of the St. Francois confining unit was determined using the geologic contacts for the top of the Derby-Doerun Dolomite and the base of the Davis Formation, which were identified in many of the reviewed core logs.

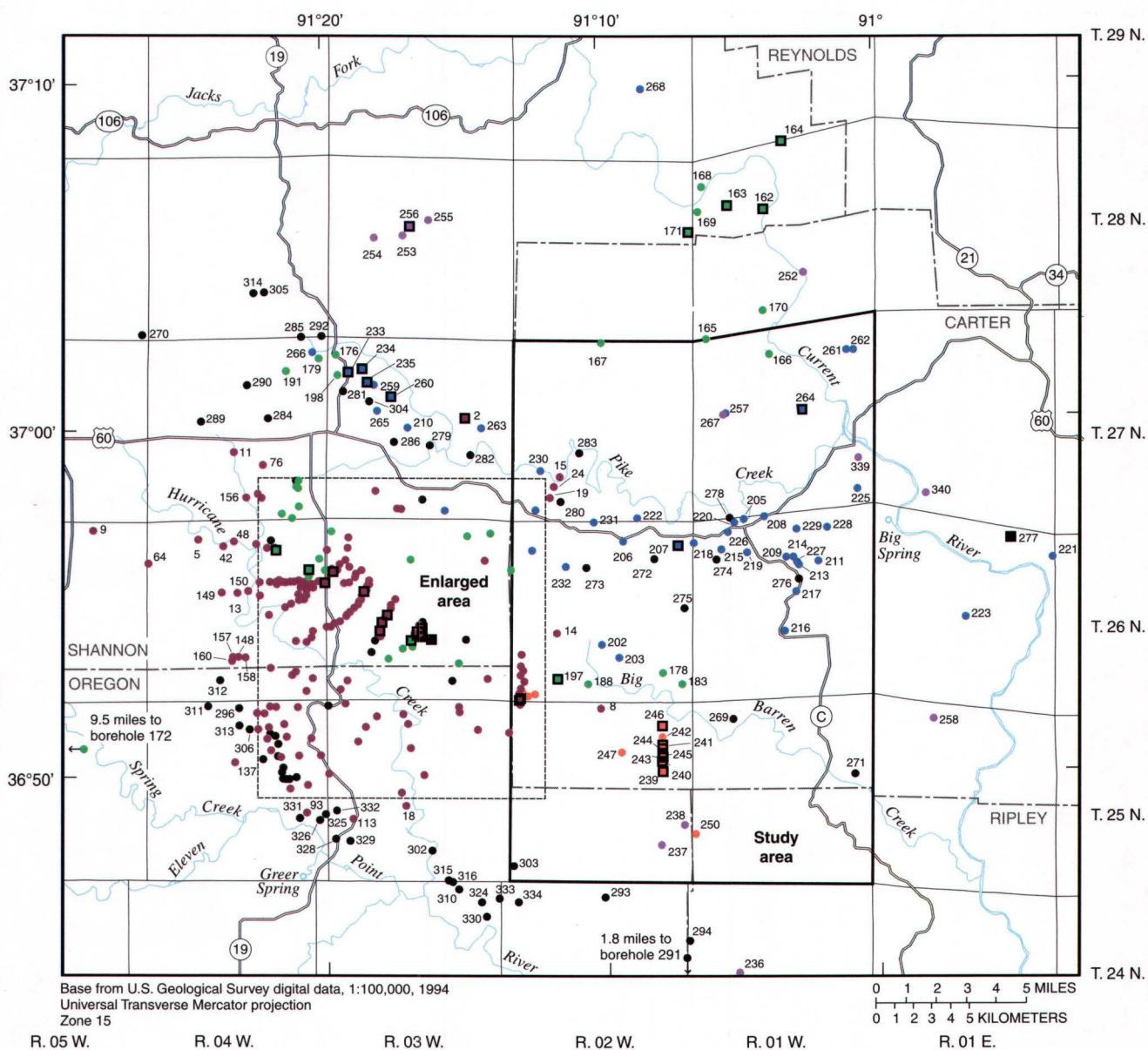
## Individual Geologic Units

The depositional environment and source material during the time of sedimentation largely determines formation lithology and permeability. The hydrologic properties of silts and clays that accumulate in a low-energy environment such as a deep offshore basin are different from properties of sediments that include sand and larger size particles common to high-energy environments such as reef or shoal areas. The paleodepositional environment of southern Missouri was discussed in detail in Kleeschulte and Seeger (2000) and is briefly summarized within descriptions of the individual geologic units in this report.

The Precambrian knobs on the surface of the Basement confining unit can provide source material for overlying formations or penetrate into or through these overlying formations. The confining ability of these formations can therefore be effected locally. While this report focuses on the St. Francois confining unit, descriptions of the geologic units from the Basement confining unit to the top of the St. Francois confining unit are included. This was done so that areas where Precambrian knobs exist and possibly affect the confining ability of the confining unit can be identified.

## Precambrian Rocks

According to core logs, 25 exploration boreholes in the study area penetrated the Precambrian basement rock (fig. 4). Of these 25 boreholes, 12 did not encoun-



#### EXPLANATION

BOREHOLE AND SITE NUMBER (table 1)

- Borehole completed in Precambrian basement rock. No Lamotte Sandstone penetrated
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 4.** Location of exploration boreholes.



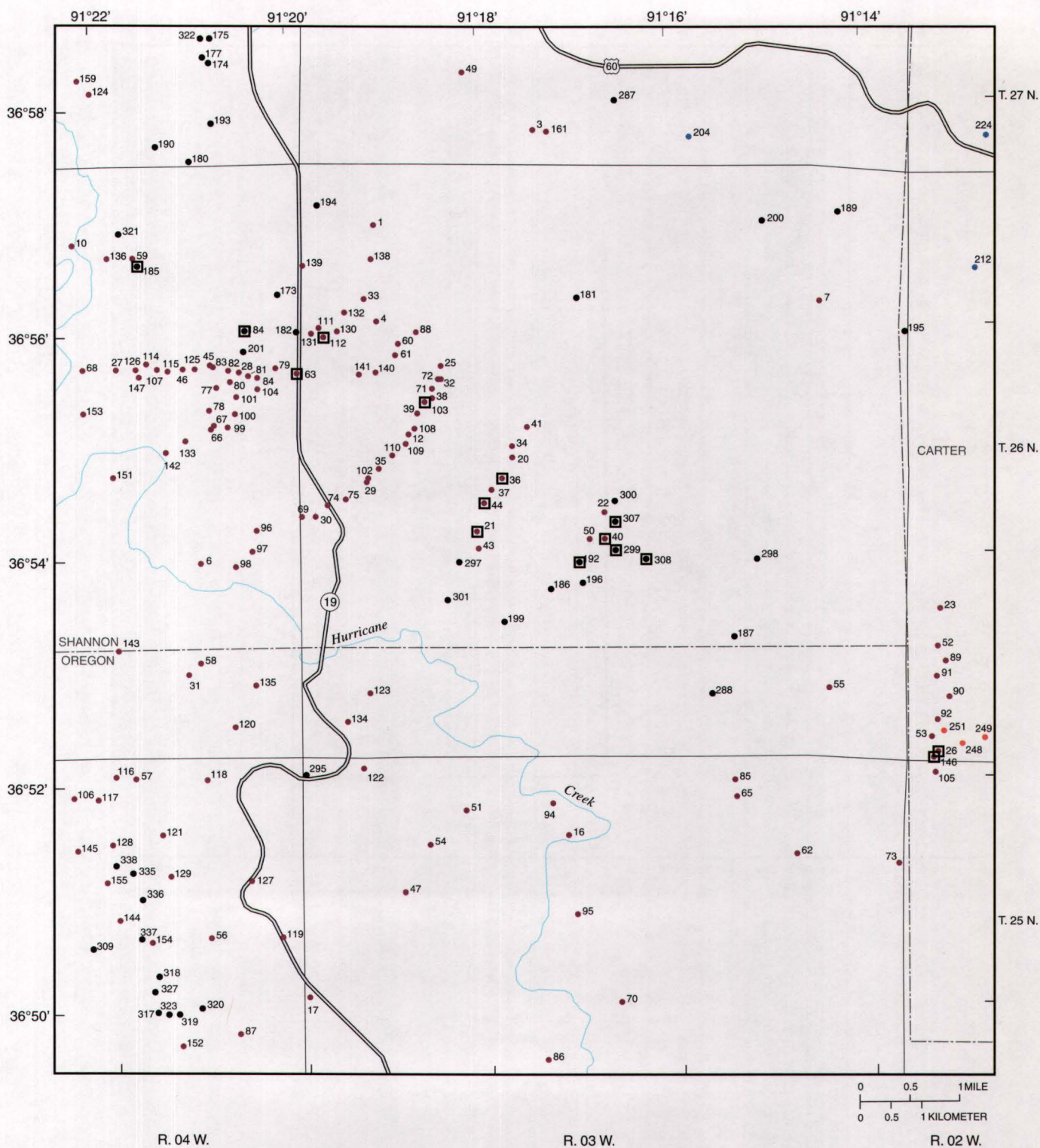


Figure 4. Location of exploration boreholes—Continued.



ter the Lamotte Sandstone. Logs of seven of these boreholes were used to identify a basement high in the northeast corner of T. 25 N., R. 02 W.; two logs helped extend a linear basement ridge that was identified in Kleeschulte and Seeger (2000) into the southwest corner of T. 26 N., R. 02 W. Precambrian knobs generally protrude less than 200 ft above the surrounding Precambrian basement rock; however, the knobs penetrated by these boreholes extend 300 to 350 ft above the surrounding basement rock. Logs of the remaining three boreholes (Asarco PK-34, Cominco SF-20, and Ph Dodge 15-01) indicated there may be other small, isolated Precambrian knobs in the study area. Core samples show that the Precambrian rock is rhyolite/felsite in the southern one-half and granite in the northern one-half of the study area.

### **Lamotte Sandstone**

The Lamotte Sandstone is present throughout the study area, except where it pinches out against Precambrian knobs. Most boreholes penetrated the Lamotte Sandstone (if present), but were terminated before the Lamotte Sandstone was fully penetrated. Based on 13 boreholes in the study area that penetrated the entire formation, the thickness of the Lamotte Sandstone ranged from 4 to 247 ft (median value is 87.5 ft).

The lower Lamotte Sandstone consists of alluvial fan-dominated deposits, debris and mudflows, fining-upward conglomerate-based sandstone channel deposits, and sheet-flood deposits (Yesberger, 1982). Up-section and away from uplifted areas, fan-dominated deposits grade to aggradational braided fluvial plain deposits with fining-upward sequences of trough and planar cross-bedded quartz-dominated sandstones (Houseknecht and Ethridge, 1978; Yesberger, 1982). Alluvial and fluvial sandstones are locally overlain by burrowed, cross-bedded marine sandstones interbedded with local fan delta deposits. The latter are derived from active alluvial fans in areas with exposed Precambrian knobs.

The Lamotte Sandstone is a white to light tan or gray, well-sorted, well-indurated mature quartzose sandstone. It generally varies from fine- to medium-grained, but can be very coarse-grained. Some sections are cross-bedded. The sandstone has locally abundant burrows and small unidentified fossils. Sandstones are dolomite-cemented in the upper part of the formation. Local white to brown and light gray-blue dolomite lenses contain glauconite, pelletal material (fecal pellets), occasional unidentified fossil fragments, burrows,

and rock fragment intraclasts. Some dolostone is bleached, recrystallized, porous, and vuggy. Minor secondary calcite fracture fill and calcite- and dolomite-lined vugs are reported.

Several cores contain Lamotte Sandstone that is all or partially arkosic or conglomeratic. Clasts are detrital porphyry or granite fragments, and are supported by poorly sorted and angular feldspathic quartzose sandstone; clast size is up to 1 ft in diameter. The thickest conglomerate section is 22 ft; the thickest arkosic section is 80 ft. Some clasts are scattered in thin beds throughout the sandstone, suggesting continual shedding of moderately worked material by erosion and/or continued uplift of the Precambrian highland area.

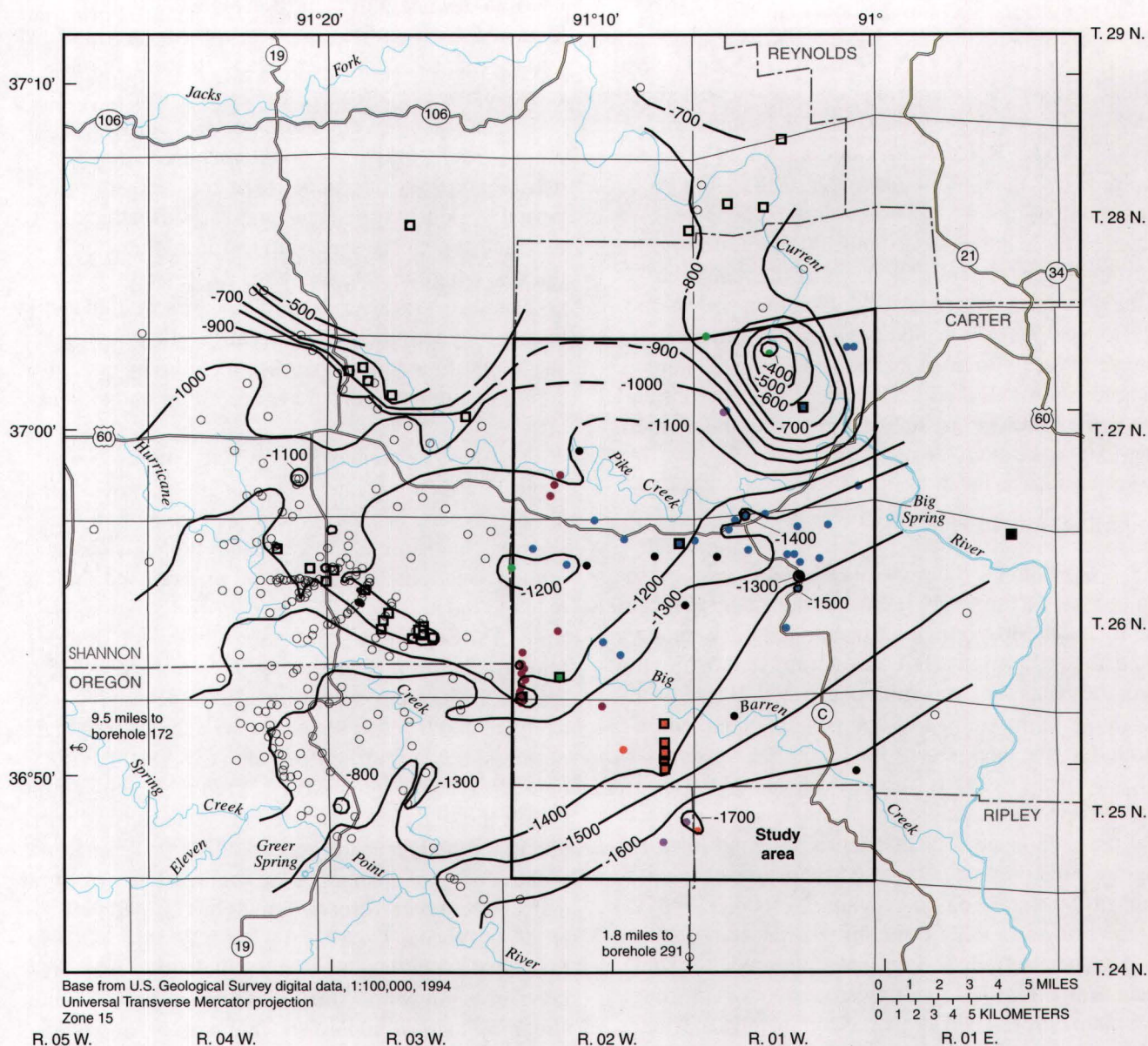
The shale content in complete Lamotte Sandstone core sections (intercepts) ranges from nearly 0 to almost 10 percent. Ten percent shale content in the Lamotte Sandstone is greater than is typically observed in the formation. A general trend of increased shale is noted to the north and the east.

The depth from land surface to the top of the Lamotte Sandstone, where present, ranges from 980 to 2,698 ft in the study area, with an altitude ranging from a high of 400 ft below sea level (site number 166) in the northeastern part of the study area to a low of 1,788 ft below sea level (site number 238) in the south-central part of the study area (table 1, fig. 5). In the northern part of the study area the general dip of the formation is to the south, but changes to the southeast in the central and southern part. Structural lows are located in T. 26 N., R. 02 W. and T. 25 N., R. 01–02 W. Both of these low areas are defined by two borehole logs. Four isolated areas (shown as small closed contours) of either structural lows or highs also were present. Each of these four structural anomalies is defined by one borehole log.

### **Lamotte Sandstone-Bonneterre Formation Transition Zone**

The contact between the Lamotte Sandstone and Bonneterre Formation is marked by a transition zone consisting of tan or light to medium gray medium-grained quartz sandstones with minor dolostone grainstone lenses, or sandy dolostone. The sandstones exhibit some cross-bedding and mottling, have locally abundant glauconite that may be pelletal (fecal pellets), and are cemented by fine-grained brown dolostone. Several cores have scattered green to dark-green and dark-gray crepey (crinkled appearance) shale partings.





#### EXPLANATION

— -1600 — — STRUCTURE CONTOUR—Shows altitude of the top of the Lamotte Sandstone. Dashed where approximately located. Contours drawn through local areas where Lamotte Sandstone is absent. Contour interval 100 feet. Datum is sea level

#### BOREHOLE

- Borehole terminated in Precambrian basement rock. No Lamotte Sandstone penetrated
- Borehole terminated in the Lamotte Sandstone outside of study area
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 5.** Structure of the top of the Lamotte Sandstone.

In several core intervals, the transition zone is pale to medium gray or tan to grayish-brown dolostone with localized sandstone lenses. The dolostone is shaley to sandy, fine to medium crystalline and fine- to medium-grained. Dolostones are grainstones, wackestones, and mudstones; the sequence appears to coarsen upward. Some mudstones are interbedded with grainstones, and scattered whiterock (coarsely crystalline dolomite, frequently bleached, and indicative of shallow or subaerially exposed rock) is reported. The dolostone is in some places mottled, burrowed and bioturbated (sediment disturbed or agitated by organisms), and nodular. Secondary calcite and dolomite vug fill and calcite fracture fill is present. Irregular, wavy, dark gray-green to greenish-gray or dark gray argillaceous partings as much as 1 in. (inch) thick are present. Dolostone porosity is noted, but no description of type or degree is reported on the borehole log. Both sandstone- and dolostone-dominant core intervals contain detrital igneous lithic fragments.

Interbedded Lamotte Sandstone-Bonnetterre Formation marine carbonates and sandstones are found where fan deltas were still active during basal Bonnetterre Formation deposition and discharged into tidal flats or shallow marine areas (Hayes and Knight, 1961; Yesberger, 1982). Differences between carbonate- and sandstone-dominated intercepts probably reflect distance from the clastic source, with carbonate-dominant facies likely deposited farther from the source of the clastic material.

## **Bonnetterre Formation**

The Bonnetterre Formation in the study area is similar to that of other Bonnetterre Formation platform margins in southeast Missouri (Larsen, 1977; Palmer, 1989), and changes to nearly all limestone or all coarse crystalline dolostone in relatively short distances. Retention of limestone in the basal part suggests that these areas are off-platform. Conversely, on-platform carbonates are dominated by vuggy coarse-crystalline dolostone. Intraclast conglomerate beds can be interpreted as storm-generated mass-flow deposits that moved down slopes of only a few degrees (Palmer, 1991). Storm-generated lithoclast conglomerates are noted in all the geologic units; it is not possible to tell if the clasts are autochthonous (formed in place where found) or allochthonous (formed elsewhere and transported to deposition site).

Depositional facies in the Bonnetterre Formation are varied; they range from transgressive drowned shelf and intrashelf basin to shallow water build-ups, shoal complexes, and platform interior facies. The lowermost shaley carbonate sequence suggests intrashelf basin deposition. Interbedded shales are indicative of increased clastics coming into the basin, which periodically suppressed stromatolite growth. Shale deposition may have been controlled by a series of small basins within a larger basin or platform setting, with each basin having a different degree of clastic deposition. The thinnest intercepts are over Precambrian highs. Stromatolitic zones indicate periods of limited clastic deposition and possible sediment starvation.

Between the lower shale-rich carbonates and the upper coarse crystalline dolostones, Bonnetterre Formation rocks are mostly non-argillaceous oolitic-cryptalgal reef dolostones and grainstones, suggesting a general shallowing of the sequence, with possible channel development. Oolitic horizons suggest shoaling.

Arkosic zones may be interpreted in several ways. If interbedded with whiterock or oolitic rocks, the zones may represent a near shore facies and suggest proximity to a knob. Alternately, if interbedded with only whiterock, the zones may represent an alluvial channel on subaerially exposed surfaces. Finally, if the zones are interbedded with dark-colored muddy dolostones, the zones may more likely represent grain flows.

Whiterock is found at the top of shallowing-upward cycles and thins in off-platform directions. Reddened hematitic patches remain in many whiterock sequences and grade outward to pale olive-green clay-rich coarse-crystalline dolostone, suggesting that reddened limestones were the precursor to whiterock dolostone (Howe, 1968; Palmer, 1991).

The Bonnetterre Formation is dominantly carbonate, with several shaley horizons and a siltstone (the Sullivan Siltstone Member). The formation appears to be present throughout the study area, even in the twelve boreholes that were drilled into the Precambrian basement, and no Lamotte Sandstone was encountered. The lower Bonnetterre Formation is subdivided into a basal part composed of carbonate with interbedded shale, and an upper part composed of dolostone with occasional shale layers or partings. Several logs note a basal sequence of the Taum Sauk Limestone Member.

The Taum Sauk Limestone Member of the lower Bonnetterre Formation is a light gray-white to greenish gray-white and red-mottled limestone with some dolo-



stone. Where present, the unit generally is found in the vicinity of the reef structures and ranges from 10 to almost 190 ft thick in the study area. It is fine- to medium-grained and moderately argillaceous with red and green shale and clay, and is locally burrowed.

The basal part of the lower Bonnetterre Formation primarily is dolostone. The basal unit ranges from 70 to more than 300 ft thick. The unit primarily is limestone in the southern part of the study area, with the dolostone content increasing to the north. The dolostones consist of mudstones to grainstones with mudstone-matrix boundstones and vary in color from gray to gray-tan, and tan. Argillaceous zones are pale green. Bleached zones suggest that parts of the section are whiterock. The dolostones are fine to medium crystalline, fine- to medium-grained, and have interbedded quartzose-rich to arkosic layers, primarily near the base (transition zone). In some cores, dark greenish-gray and gray to black shale is present in beds and as wispy partings. Other cores have minimal shale. Dolostones occasionally are mottled and have common bioturbation and burrowing. Algal structures are digitate (finger-like appearance) stromatolites as much as 1 ft high, occasional crypt-algal laminates, and minor hummocky algal forms. Grains are oolites and fossil fragments (type not specified); several cores have edgewise carbonate conglomerates. Minor porphyry conglomerate layers are noted in some core intervals. Occasional slump breccias were observed. Solution features include scattered stylolites, and vugs partially to completely occluded by calcite spar and pink dolomite. Vugs are the most common form of visible porosity and often are reported in algal zones. Noted porosity generally is 5 percent or less.

Limestone core intervals are more lithologically heterogeneous than equivalent dolostones, consisting of mudstones and grainstones, with interbedded wackestones and mudstone-matrix boundstones. They are light gray, tan and pale greenish-gray, and are fine crystalline and fine- to medium-grained. The limestones commonly are burrowed, mottled, sparsely to moderately glauconitic, and contain carbonate intraclasts, fossil fragments (type not noted), oolitic layers, and digitate stromatolite zones. They have rare vugs and pores that are partially to completely occluded by pink dolomite and calcite spar. Occasional, thin dolostone layers are present. Dark greenish-gray, thin wavy-bedded shales are interbedded with the limestone. Shale percentages are higher in the limestones than in the dolostones; the shales probably restricted the move-

ment of dolomitizing fluids. Dolostones similar to those described above bound the top and base of the limestone core intervals.

The upper part of the lower Bonnetterre Formation ranges from 30 to nearly 250 ft thick. It is composed of interbedded dolostone grainstones, mudstones, and grainstone- and mudstone-matrix boundstones, with occasional wackestones. The top of the unit generally is a grainstone underlain by whiterock. The dolostones are fine- to medium-grained and fine through coarse crystalline. The coarse crystalline dolostones probably are whiterock. Color ranges from light to medium gray, gray-tan, pale greenish-gray, and brown. The dolostone often is mottled and sometimes is irregularly banded. Algal reef zones are common and are well-defined digitate stromatolites with infrequent hummocky algal features; reef zones reach thicknesses of 100 ft. Burrowing also is common in the unit. Clastic material includes occasional shale partings, and quartzose, arkosic, and porphyry conglomeratic layers. Solution structures include stylolites, possible solution breccias, and vugs partially to completely occluded by calcite spar and pink dolomite. Several descriptions note porosity, but are not specific as to type and nature. Scattered subvertical fractures sometimes are partially healed by calcite and/or dolomite.

The whiterock consists of fine- to coarse-grained dolostone with green to greenish-gray intercrystalline clay. It ranges in color from white to light gray, pale brown-gray, light tan, and light blue gray. Where clays have not entirely occluded intercrystalline pores, the dolostone appears very porous or vuggy. Matrix dolostone grains are sometimes visibly overgrown by medium-grained pink or white dolomite.

The Sullivan Siltstone Member in the upper Bonnetterre Formation is a clastic-dominated facies located in the middle of the ramp that developed during a Late Cambrian transgression that was perhaps accompanied by southeastward-directed shelf subsidence aggrading to a ramp (Larsen, 1977; Palmer, 1991). The member is composed of light to dark gray or brown, finely laminated, well indurated, fine- to medium-grained quartzose siltstone. The siltstone has varying amounts of siliceous and dolomitic cement and is interbedded with thin dolostone lithoclast conglomerates, grainstone beds, and scattered thin dark green to dark gray wavy shale partings. Dolostones are tan, fine crystalline, and sometimes mottled, glauconitic, fossiliferous (type not noted), oolitic, and/or porous. Solution vugs and brecciation are common in some dolostones. Cores suggest



that an incipient facies change to dolostone may be present in the northern part of the study area. Intraclast conglomerate beds are interpreted as possible storm-generated debris flows and carbonate clasts are considered allochthonous, and were likely derived from an up-ramp source. The unit ranges from 2 to almost 30 ft thick in the study area, and thickens to the west and south.

The overlying Whetstone Creek Member depositional environment may have been similar to that of the upper part of the lower Bonneterre Formation. The carbonate-dominant nature of the unit suggests that a platform area nearby was not submerged during the early stages of shelf drowning that elsewhere accompanied the Late Cambrian transgression. The Whetstone Creek Member generally is 100 to 150 ft thick, although it ranges from 30 to 300 ft thick. The greater thicknesses in several cores may be related to syn-depositional tectonism. The unit is dolostone with some limestone and limey dolostone. Color ranges from light to medium gray and grayish brown to tan, light blue gray, and greenish gray. Carbonates are fine to medium crystalline, fine- to medium-grained mudstones and grainstones, with wackestone-packstones and mudstone-matrix boundstones. Grainstones and wackestone-packstones are oolitic, fossiliferous (type not specified), and contain intraclasts. All carbonates are mottled, burrowed, and glauconitic. Mottled and finely laminated dolostones alternate. Unlike most Whetstone Creek Member sections in other areas of southeastern Missouri, these cores do not show abundant pelletal glauconite. Digitate stromatolites and crypt-algal laminates are present. Crypt-algal laminates are underlain by mottled dolostone, which is underlain by laminated dolostone. Solution features are stylolites and vugs with dolomite. Fracturing is present, but not common. Where reported, fractures generally are subvertical, with rare medium-angle fractures; some fractures have been cemented by calcite. Porous zones are noted, but extent and type are not described. Some whiterock is present. Arkosic and igneous-conglomeratic layers are noted throughout the unit. Silt content is greater in the lower Whetstone Creek Member, near the contact with the Sullivan Siltstone Member.

Dark green shale partings are present throughout the Whetstone Creek Member. A prominent shale (2 to 71 ft thick) at the base of the unit is informally known as the False Davis. The False Davis appears to be present throughout the study area. The shale often is

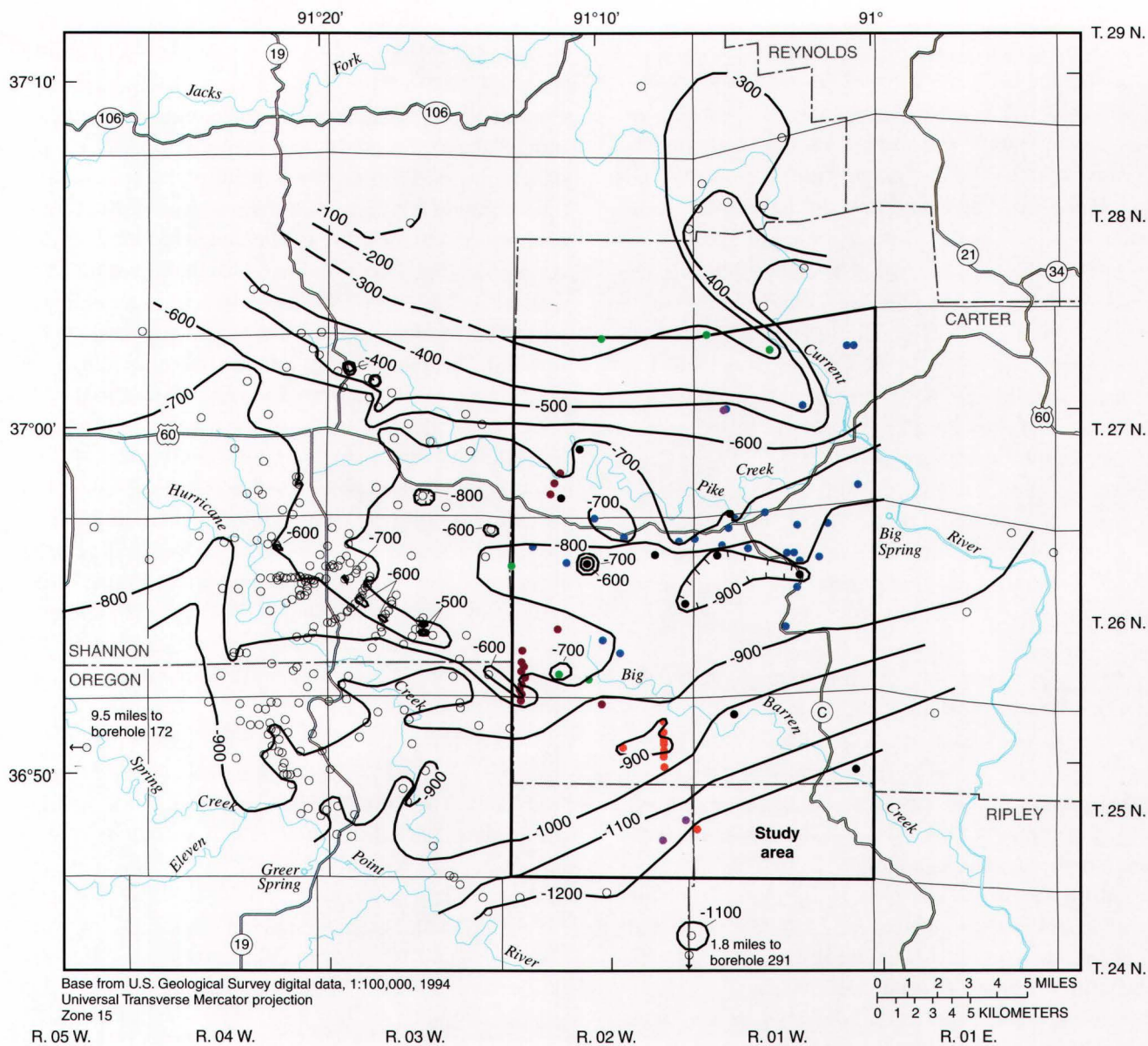
interbedded with dolostone grainstones; the dolostones contain fossil fragments (type not identified), oolites, and occasional pyrite.

The top of the Bonneterre Formation forms the base of the St. Francois confining unit. Based on 69 data points in the study area, the altitude of the top of the formation typically is below sea level; however, one exploration borehole log (site number 167, T. 27 N., R. 02 W.; fig. 6 and table 1) identified the top of the formation at 275 ft above sea level, which is anomalously high. This borehole log was incomplete concerning the formations encountered during drilling, with the top of the Bonneterre Formation as the only formation recorded on the core log. Based on the total depth of the hole, the altitude of land surface, and data from surrounding boreholes, this borehole may have been completed in the Derby-Doerun Dolomite and not the Bonneterre Formation as recorded. Because the Derby-Doerun Dolomite, Davis Formation, and Bonneterre Formation are all conformable (Koenig, 1961), identification of the Bonneterre Formation contact is difficult. Therefore, this borehole is included in table 1, but was not contoured on figure 6.

The top of the Bonneterre Formation ranges from 300 to more than 1,200 ft below sea level in the study area. The formation generally dips to the south in the northern part of the area, then dips to the southeast in the southern part of the area. The Precambrian high in the northeast quarter of T. 25 N., R. 02 W. and the Precambrian high extension in the southwestern part of T. 26 N., R. 02 W. are both evident as structural highs on this structure map of the Bonneterre Formation and are shown as closed contours. The structural low evident at the top of the Lamotte Sandstone in T. 26 N., R. 02 W. is evident as a trough feature at the top of the Bonneterre Formation. Based on 51 boreholes that penetrated the entire thickness of the formation, the thickness in the study area ranges from 190 to 692 ft, but typically is from 400 to 525 ft thick.

In much of the study area the shale content in the Davis Formation is small, and the contact between the Davis and Bonneterre Formations is obscured. Where the shaley False Davis is present in the upper Bonneterre Formation, the location of the contact between the Bonneterre and Davis Formations can be estimated; however, where the False Davis is absent or was not logged, it is difficult to accurately locate the contact. The isolated pinnacles and structural lows depicted on figure 6 may be caused by different mining companies





#### EXPLANATION

— -1200 — — STRUCTURE CONTOUR—Shows altitude of the top of the Bonneterre Formation. Dashed where approximately located. Hachures indicate depression. Contour interval 100 feet. Datum is sea level

#### BOREHOLE

- Borehole terminated in the Bonneterre Formation outside of study area
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 6.** Structure of the top of the Bonneterre Formation.



using different criteria for locating the top of the Bonneterre Formation, and may not be actual structural features.

### Davis Formation

The Davis Formation is an intrashelf basin facies consisting of a series of shales interbedded with shaley limestones, shale-free limestones, and local dolostones. In the study area, this facies grades laterally to dolostones like those of the middle Bonneterre Formation (Howe, 1968; Kurtz and others, 1975; Palmer, 1989, 1991). The Davis Formation intrashelf basin facies is a clastic sequence deposited within a regional carbonate shelf system. It composes the basal parts of large-scale shallowing-upward sequences. Horizontal burrows are suggestive of slow periodic deposition in a marine subtidal setting, when the shelf became flooded. Intraclast conglomerate beds can be interpreted as storm-generated mass-flow deposits that presumably moved down slopes of only a few degrees or less. Greater abundance of these beds in some cores suggests that those locations were near the intrashelf basin margin. An overall increase in the volume of carbonate beds indicates proximity to the edge of the intrashelf basin area. Oolites in some carbonate layers are likely grain flows. The oolitic dolostones of the shale-free sequences suggests development of shoals on a shallow shelf that surrounded the intrashelf basin.

Typical Davis Formation sequences appear to have formed in a basin that is elongate through the center of the study area, and is open to the north. Outside this basin, the Davis Formation sequences are almost entirely carbonate. The Davis Formation ranges from 24 to 320 ft thick in the study area, but the thickness is typically 100 to 200 ft. The thinner core intervals are over Precambrian knobs. Shales generally are light to dark green, with some gray to dark gray beds. Individual shale layers range from partings to 5 ft thick. Shale-dominant sequences can be tens of feet thick and contain as much as 90 percent shale. Limestone-filled burrows compose the only carbonate in some shale layers. Carbonate layers in shale-dominant horizons vary from less than 1 in. to several feet thick. Carbonate-dominant zones may be 70 ft thick or greater. Shale percentages in these zones can be as much as 50 percent or less than 10 percent. Shale interbeds in carbonate-dominant zones vary from partings to several feet thick.

Davis Formation carbonates primarily are limestone, with dolostone at the top and base of the formation, with the exception of the all-dolostone intercepts

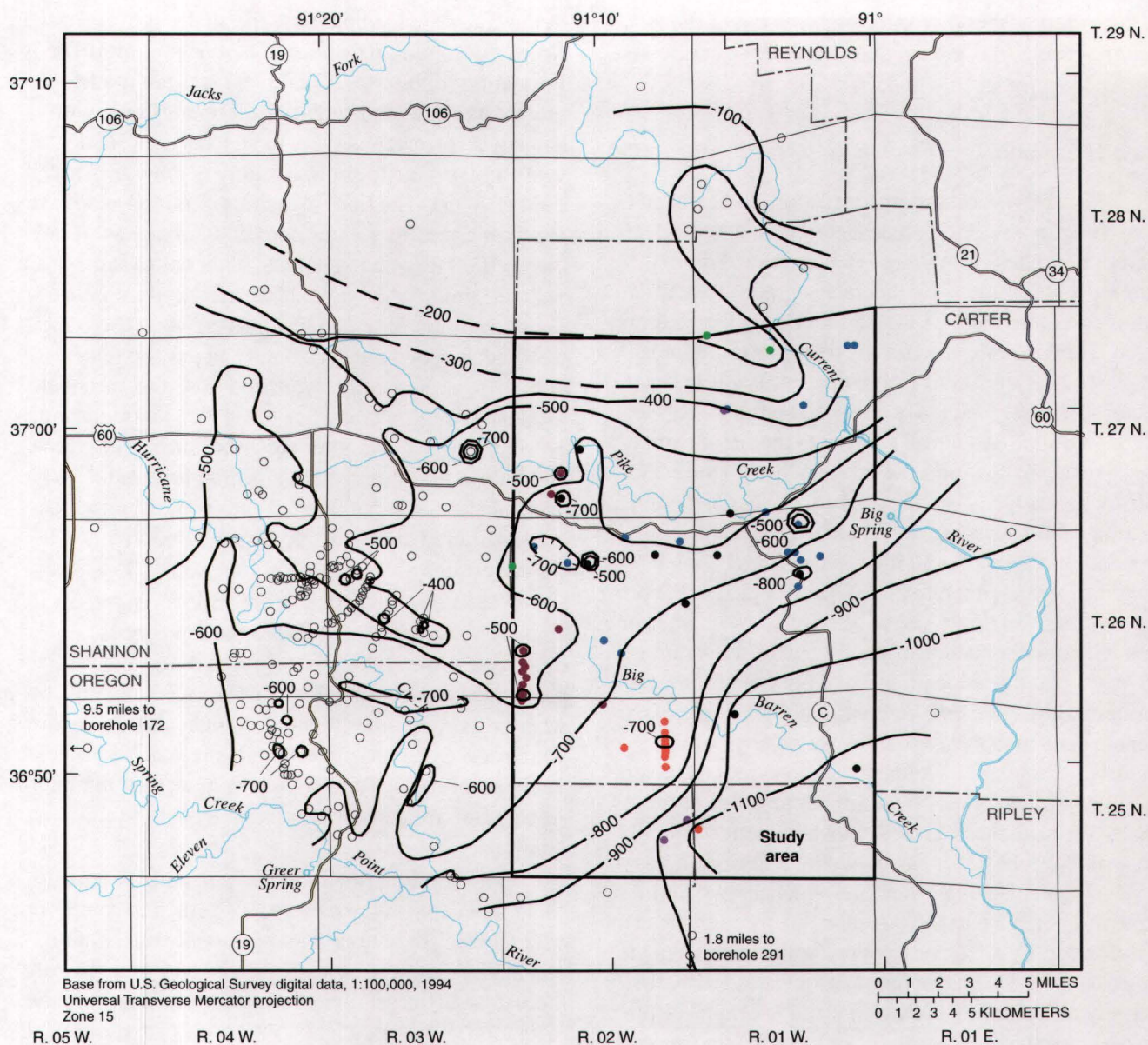
in the study area. Apparently the shales prevented the flow of dolomitizing fluids from reaching most Davis Formation limestones. The limestones are mudstone, grainstone, and mudstone-matrix boundstone, with some wackestone and occasional packstone. Color varies from light tan to brown or gray to dark gray and light gray-tan. The fine- to medium-grained and fine to medium crystalline limestones contain pellets, fossil unspecified fragments, oolites, glauconite (some are pelletal), relict crypt-algal laminates, and infrequent digitate stromatolites. Mudstones are sometimes bioturbated; burrows are horizontal and may be selectively dolomitized. Some layers are composed of carbonate intraclast conglomerate. Scattered vertical fracturing is present, but is less common than in formations above and below. Solution features include horizontal and vertical stylolites, and local solution and slump breccias. Scattered arkosic or porphyry conglomeratic layers are present.

The dolostones in Davis Formation intercepts containing shales are similar to the limestones described above. Coarse crystalline dolostone is present, especially in the upper Davis Formation, where it is sometimes medium to pale gray or green whiterock. Some gray mottling is present. The dolostone has more vugs and is more porous than the limestone; vugs are partially occluded by calcite and dolomite.

Davis Formation intercepts that are essentially shale free exist on the eastern, western, and southern edges of the study area. These sequences generally contain one percent or less of shale, and generally are more coarsely crystalline than other carbonates in the formation. Whiterock and oolitic zones are prominent; some porosity is from dissolution of oolites. Some vugs also are present.

Based on 56 data points, the depth from land surface to the top of the Davis Formation ranges from 620 to 2,022 ft, and the altitude of the top of the formation ranges from 40 ft below sea level (site number 166) in the northern part of the study area to 1,182 ft below sea level (site number 271) in the southern part of the study area (table 1, fig. 7). The structure map for the top of the Davis Formation shows the formation dip is similar to that of the Lamotte Sandstone and Bonneterre Formation in that the dip is to the south in the northern part of the area and to the southeast in the southern part. The dip angle is steeper in the southeast part of the study area. Remnants of the Precambrian highs in the western part of T. 25–26 N., R. 02 W. can be seen as small





#### EXPLANATION

— -1100 — — STRUCTURE CONTOUR—Shows altitude of the top of the Davis Formation. Dashed where approximately located. Hachures indicate depression. Contours drawn through local areas where Lamotte Sandstone is absent. Contour interval 100 feet. Datum is sea level

#### BOREHOLE

- Borehole terminated in the Davis Formation outside of study area
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 7.** Structure of the top of the Davis Formation.



domed features represented by closed contours on figure 7. The structure map does not show as irregular a surface or have as many isolated highs or lows as the top of the Bonneterre Formation; however, the depression in T. 26 N., R. 02 W. is still visible.

### **Derby-Doerun Dolomite**

The Derby-Doerun Dolomite overlies the Davis Formation within and at the margins of intrashelf basins. The Derby-Doerun Dolomite represents a pair of superimposed, carbonate ramp cycles, and mudstone-grainstone sequences and local lithoclast conglomerates support a homoclinal ramp (uniformly sloping ramp) model. Stromatolitic zones indicate isolated buildups within the ramp. Intraclast conglomerate beds (storm-generated mass-flow deposits) presumably moved down slopes of only a few degrees. Abundant intraclast beds in individual cores suggest that those locations were near the basin margin. Where present, the basal shaley sequence represents a transition with the Davis Formation.

The Derby-Doerun Dolomite is the uppermost formation mapped during this study. Based on 50 data points, the thickness of the formation in the study area ranges from a minimum of 50 ft to a maximum of 386 ft, but typically is 120 to 180 ft thick. The Derby-Doerun Dolomite is composed of light gray to gray or light tan to brown mudstones, grainstones, and mudstone-matrix boundstones, with some wackestones and wackestone-matrix boundstones. Dolostones are fine to coarse crystalline and fine- to medium-grained. White-rock is scattered throughout and some mottling is present. Bedding is thin to massive; thin disturbed beds may be burrowed. The dolostones contain fossil fragments (type not specified), oolites, and carbonate lithic clasts. Digitate stromatolites and crypt-algal laminates are present. Occasional scattered porphyry clasts are present. Thin black to dark gray and green shales are scattered throughout; shale content and bed thickness increases near the contact with the Davis Formation.

Similar to the Davis Formation discussed previously, the Derby-Doerun Dolomite varies from typical sequences with shales to areas that are entirely dolostone. Where shale is present, thin black to dark gray and green shales are scattered throughout; shale content and bed thickness increases near the contact with the Davis Formation.

Glaucanite is present near the base, where dolostones are interbedded with shales. Dolostones vary in visible porosity from none to extremely vuggy. Unlike

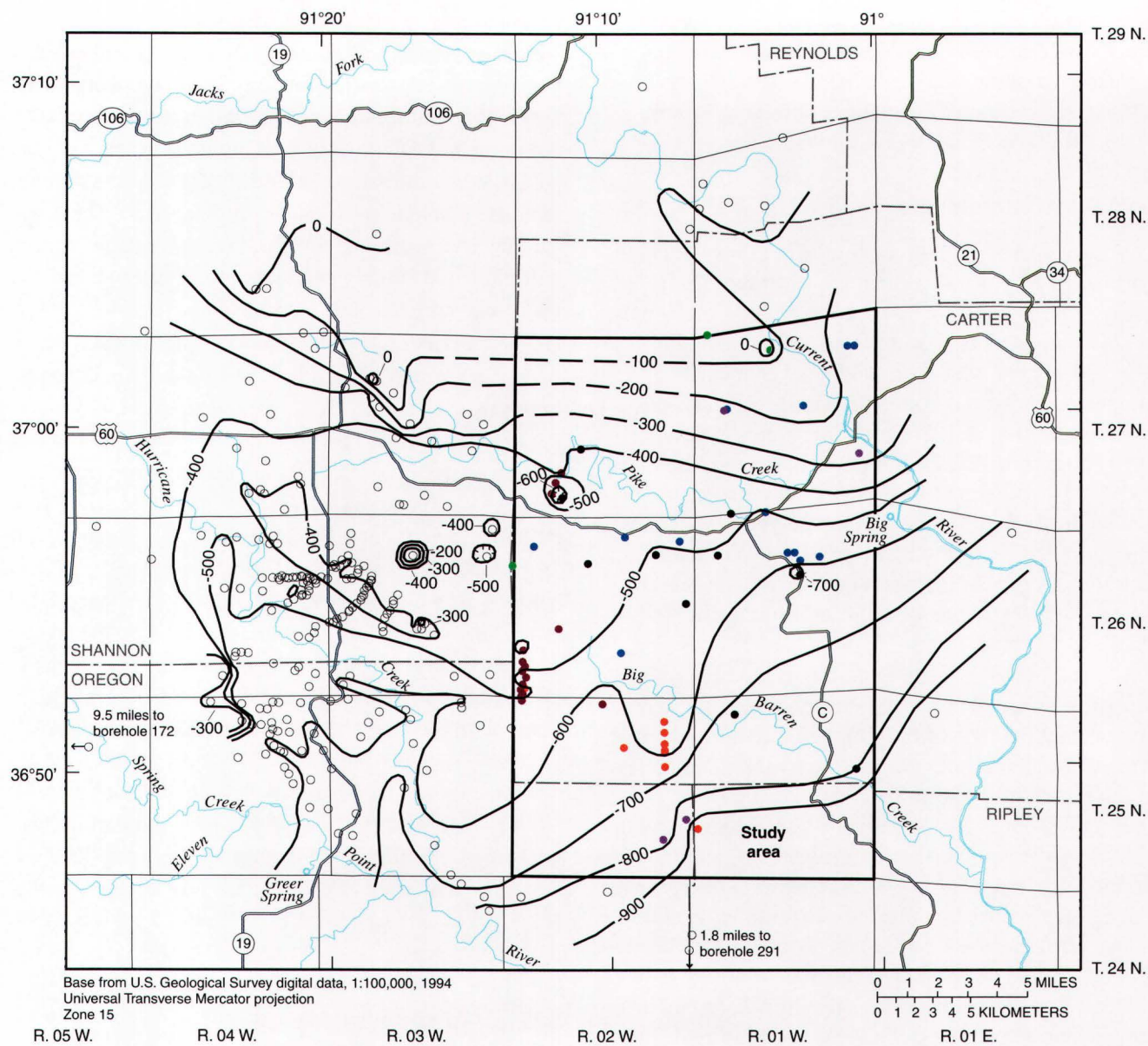
the overlying Potosi Dolomite, the Derby-Doerun Dolomite contains only minor chalcedony and quartz vug linings. Highly fractured zones are present, although not ubiquitous; some fractures are filled with dolomite and calcite. Breccias are present, but are in part filled by the same cements. Some fractures have minor to abundant iron oxide staining on the fracture surface. Many mining companies did not begin coring until they had already penetrated the Derby-Doerun Dolomite; consequently, complete core intervals of the Derby-Doerun Dolomite are not equally distributed.

Based on 53 data points in the study area, the top of the Derby-Doerun Dolomite ranges from 495 to 2,020 ft deep (table 1). The altitude of the top of the formation is highest in the northeastern part of the study area at 85 ft above sea level (site number 166; fig. 8). A borehole log (site number 251) in the west-central part of the study area shows the formation top at 1,510 ft below sea level; however, this altitude is anomalously low. The core log only recorded the depth to the top of the Potosi Dolomite and the top of the Derby-Doerun Dolomite. Data from 10 boreholes surrounding this borehole indicate the altitude of the Derby-Doerun Dolomite ranges from 370 to 510 ft below sea level in that area; therefore, this borehole is included in table 1, but was not contoured. In the southeastern part of the study area, the altitude of the top of the Derby-Doerun Dolomite is at a low of 947 ft below sea level. A depression in the southern part of T. 27 N., R. 02 W. is defined by 3 data points. The data indicate the altitude of the top of the Derby-Doerun Dolomite decreases more than 200 ft into a small basin, and that the feature is not large in extent. The dip of the formation top is to the south in the northern part of the area and to the southeast in the southeastern part of the area. The Derby-Doerun Dolomite structure map shows evidence of the structural high in T. 26 N., R. 02 W. that is seen on the previous structure maps. The high is represented as a ridge structure instead of the dome shape shown on the Davis and Bonneterre Formations structure maps.

### **St. Francois Confining Unit**

The thickness of the St. Francois confining unit varies across the study area, but generally is thickest in the central and southern parts. The thickness, as determined by 51 core logs that completely penetrate the





#### EXPLANATION

— -900 — — STRUCTURE CONTOUR—Shows altitude of the top of the Derby-Doerun Dolomite. Dashed where approximately located. Hachures indicate depression. Contour interval 100 feet. Datum is sea level

#### BOREHOLE

- Borehole terminated in the Derby-Doerun Dolomite outside of study area
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 8.** Structure of the top of the Derby-Doerun Dolomite.



unit, ranges from less than 200 ft in the northwestern and east-central parts of the study area to 411 ft in the central part of the study area, but typically ranges from 270 to 340 ft (table 1, fig. 9). The thinner area in T. 26–27 N., R. 02 W. corresponds with a low area on the Derby-Doerun Dolomite structure map (fig. 8). The small area in the northeastern part of T. 26 N., R. 01 W. where the thickness is more than 300 ft is defined by a data point not shown on figure 9. This point (site number 229) is not shown because the complete Derby-Doerun Dolomite section was not included in the borehole log; however, the part that was included was sufficient to show the confining unit was more than 300 ft thick at the borehole location.

The net shale thickness map (fig. 10) shows the cumulative shale thickness in the sequence of rock from the top of the Derby-Doerun Dolomite to the base of the False Davis shale horizon in the upper Bonneterre Formation. This criterion is consistent with the method used to determine the net shale thickness reported by Kleeschulte and Seeger (2000). Based on 29 data points, the net shale thickness ranges from 1.7 ft in the east-central part of the study area to 89 ft in the southwest part of the study area (fig. 10, table 1). Eight data values were calculated solely from core log descriptions (site numbers 23, 53, 89, 105, 274, 276, 278, and 303). Net shale thickness values for the remaining 21 data points were determined by logging available core at the DGLS McCracken Core Library. Core from 6 of these 21 boreholes (site numbers 92, 202, 217, 229, 232, and 261) did not include the entire Derby-Doerun Dolomite section. The shale contribution from the Derby-Doerun Dolomite to the total net shale thickness typically was small (usually less than 1 ft) in the cores from the other 15 boreholes where the entire Derby-Doerun Dolomite sequence was logged. Therefore, the net shale thickness values estimated using cores from these six boreholes were also included in table 1 and figure 10.

The results of the net shale thickness determinations are consistent with the current understanding of the depositional environment at the time these formations were deposited. Fletcher (1974) states that the clastic (includes sand and shales)-to-carbonate ratio in the Davis Formation increases westward from the presently exposed Precambrian highlands in the St. Francois Mountains east of the Viburnum Trend (fig. 1). The deeper part of the basin (low-energy environment) would have been to the southwest of the study area, and more shale would have accumulated in this area. The

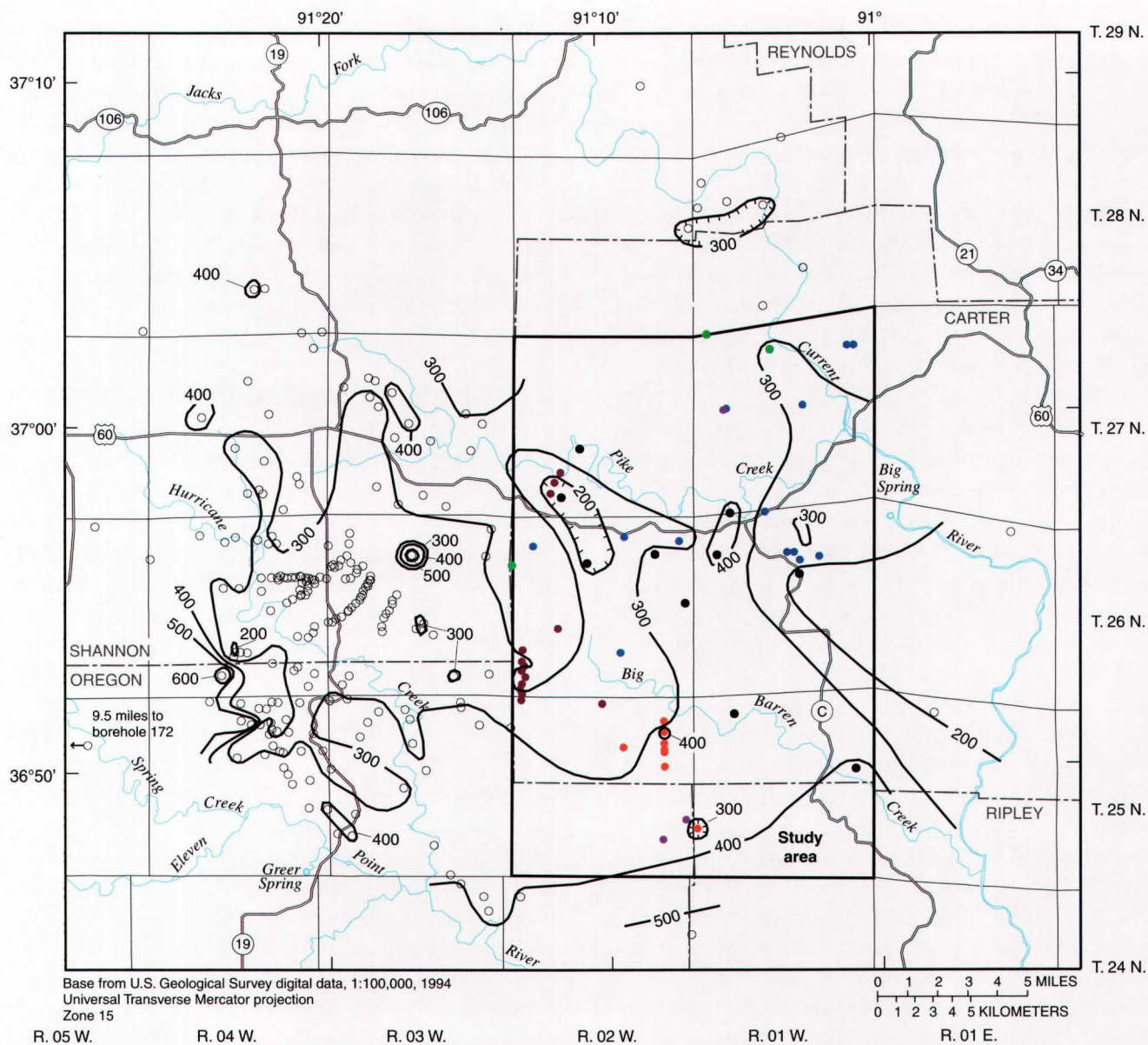
data indicate that the shale content of the combined St. Francois confining unit and upper Bonneterre Formation decreases considerably east of a northwest trending line that extends from the southeastern corner of T. 25 N., R. 02 W. to the northwestern corner of T. 27 N., R. 03 W. in the north-central part of the study area. The net shale thickness increases to more than 50 ft in a small area south of Pike Creek in T. 26–27 N., R. 01 W. Areas of smaller thickness and clastic/carbonate composition can more rapidly transmit ground water between the Ozark and St. Francois aquifers.

## VERTICAL HYDRAULIC CONDUCTIVITY

Laboratory testing was used to determine the vertical hydraulic conductivity and porosity of rock core samples from the St. Francois confining unit. Shale typically has a smaller permeability than carbonate rocks (Freeze and Cherry, 1979). By determining the thickness of the confining unit, estimating the net shale thickness of the confining unit plus the upper Bonneterre Formation (from the top of the formation to the base of the False Davis), and measuring the vertical hydraulic conductivity of the various rock types present in the unit, the effective vertical hydraulic conductivity of the unit can be estimated. Permeability is a function of the medium (rock core) alone and is not dependent on the fluid used or the force field causing the movement of the liquid (Lohman and others, 1972). Hydraulic conductivity is a measure of the ease with which a specific fluid can be transmitted through a porous medium, and is a function of the medium and of the density and viscosity of the fluid being transmitted. The transmitted fluid used during the permeability tests was similar to water that flows through the confining unit in the study area. This allowed corresponding vertical hydraulic conductivity values to be determined from laboratory core permeability results.

Forty-five rock core samples from 23 boreholes were sent to the Core Petrophysics, Inc. laboratory in Houston, Texas, for vertical hydraulic conductivity analysis. Two Derby-Doerun Dolomite samples were duplicates from the study conducted by Kleeschulte and Seeger (2000) and were from boreholes drilled outside of the study area (table 2, at the back of this report). These samples were sent for quality assurance/quality control purposes, and the results were not included with the analysis of the 43 core samples from the study area. However, these two additional vertical





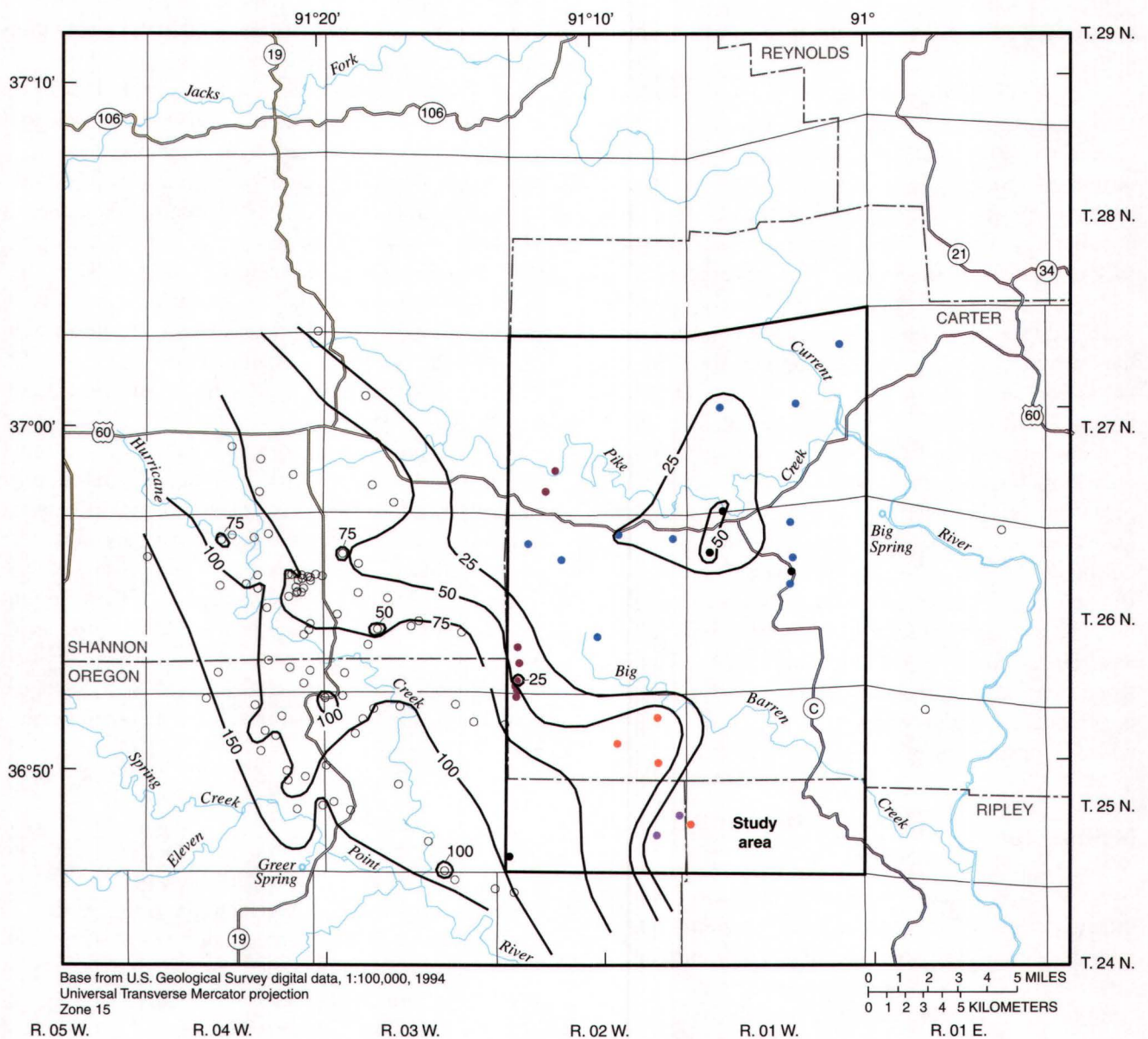
#### EXPLANATION

— 400 — LINE OF EQUAL THICKNESS—Shows thickness of the St. Francois confining unit. Hachures indicate depression. Contour interval 100 feet. Datum is sea level

#### BOREHOLE

- Borehole used in the determination of the thickness of the St. Francois confining unit outside of study area
- Amax Exploration, Inc.
- Asarco/American Smelter
- Cominco American, Inc./Phelps Dodge Mining Company
- Houston Minerals
- St. Joe Lead Company
- Other drilling companies

**Figure 9.** Thickness of the St. Francois confining unit.



- EXPLANATION
- |                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>— 400 — LINE OF EQUAL THICKNESS—Shows net shale thickness of the combined St. Francois confining unit and upper Bonneterre Formation. Contour interval 25 and 50 feet. Datum is sea level</p> | <p><b>BOREHOLE</b></p> <ul style="list-style-type: none"> <li>○ Borehole used in net shale thickness determination outside of study area</li> <li>● Amax Exploration, Inc.</li> <li>● Cominco American, Inc./Phelps Dodge Mining Company</li> <li>● Houston Minerals</li> <li>● St. Joe Lead Company</li> <li>● Other drilling companies</li> </ul> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Figure 10.** Net shale thickness of the combined St. Francois confining unit and the upper Bonneterre Formation.



hydraulic conductivity values for the duplicate samples were added to the data set from the prospecting area in table 2.

The core samples chosen were representative of formation lithology; however, if a sample was fractured or otherwise broken, it could not be used. This selection of unfractured samples was necessary to properly seal the sample in the instrument used to measure hydraulic conductivity. Thirty-three core samples representing rock types that compose the St. Francois confining unit and 10 core samples from the St. Francois aquifer were analyzed (table 2). Thirteen core samples were from the Derby-Doerun Dolomite, 20 samples were from the Davis Formation, 7 samples were from the Bonneterre Formation (2 samples from above the False Davis and 5 samples from below the False Davis), and 3 samples were from the Lamotte Sandstone. The two core samples from the Bonneterre Formation above the False Davis were grouped with the Davis Formation samples during the analysis. The other five samples from the Bonneterre Formation below the False Davis were grouped as Bonneterre Formation samples in the analysis. The Bonneterre Formation and Lamotte Sandstone samples were included for analysis to compare the vertical hydraulic conductivity of the confining unit with that of the aquifer.

## Methodology

Vertical permeability and porosity were determined in the laboratory for the rock core samples using methods described by the American Petroleum Institute (1998). The test conditions simulated the in-situ conditions at the depth from which each core sample was collected. The permeability of a medium is inversely proportional to the net confining stresses to which the medium is subjected. A net confining stress [calculated using a pressure gradient of 0.758 psi (pound per square inch) per foot depth] was applied to each core sample during the permeability analysis (Jim Seale, Core Petrophysics, Inc., written commun., 1999). A water sample from the city of Viburnum public-water supply, which pumps water from an abandoned lead-zinc mine in the Bonneterre Formation about 50 mi north of the study area, was sent with the core samples to the laboratory. This was the nearest available source that receives water from the St. Francois aquifer. The transmitting fluid used in the laboratory for vertical permeability analysis had similar density and viscosity properties as the water sample

from Viburnum; this allowed the laboratory-derived vertical permeability to be converted to vertical hydraulic conductivity.

The core samples were prepared for analysis by cutting each sample to a right-angle cylinder (using air as the bit lubricant), extracting any precipitated salt with methanol, then oven drying the sample for 24 hours at a temperature of 240 °F (degrees Fahrenheit). The bulk volumes of the cores were determined by fluid displacement (Archimedes' principle). Dry weights were recorded and the grain densities calculated. Helium porosity of the rock core at room condition was obtained by measuring grain volume using Boyle's Law (Jim Seale, Core Petrophysics, Inc., written commun., 1999).

The core samples were evacuated and pressure saturated at 1,000 psi with the simulated Viburnum water. Saturations were verified gravimetrically upon removal from the saturation cell. The core samples were then placed in individual core holders and the calculated net confining stress was applied. The differential flow pressure, time, and water volumes produced were recorded. The effective vertical permeability of the rock core was calculated using the following equation (Jim Seale, Core Petrophysics, Inc., written commun., 1999):

$$k = \frac{Q\mu L}{A(P_u - P_d)}$$

$k$  = effective permeability, in darcies (1 darcy =  $9.87 \times 10^{-9}$  centimeters squared)

$Q$  = flow rate, in cubic centimeters per second

$\mu$  = fluid viscosity, in centipoise (1 centipoise = 0.01 gram per centimeter-second)

$L$  = length, in centimeters

$A$  = area, in square centimeters

$P_u$  = upgradient pressure, in atmospheres

$P_d$  = downgradient pressure, in atmospheres

Hydraulic conductivity is related to permeability by (American Petroleum Institute, 1998):

$$K = \frac{k\rho g}{\mu}$$

$K$  = hydraulic conductivity, in centimeters per second

$k$  = effective permeability, in darcies

$\rho$  = mass density of the fluid, in grams per cubic centimeters

$g$  = acceleration of gravity, in centimeters per second squared

$\mu$  = fluid viscosity, in centipoise



After substitution, the conversion of vertical permeability, in darcies to vertical hydraulic conductivity in foot per second, becomes:

$$K = 3.17 \times 10^{-5} k$$

## Evaluation of Results

The computer software SYSTAT (SPSS Inc., 1998) was used for statistical hypothesis tests, summary statistics, and the preparation of boxplots. In all of the statistical analysis, a level of significance ( $\alpha$ -value) of 0.05 was used to test the null hypothesis that the vertical hydraulic conductivity of the data sets being compared are equal. The attained significance level ( $p$ -value) is a probability value determined by the data (Iman and Conover, 1983). The null hypothesis was rejected for all analysis with  $p$ -values for the pooled data that were less than 0.05.

Vertical hydraulic conductivities of the 35 rock core samples from the St. Francois confining unit (including the two samples from the Bonneterre Formation above the False Davis) in the study area ranged from  $7.6 \times 10^{-15}$  to  $2.1 \times 10^{-10}$  ft/s (tables 2 and 3). With the outliers, the reported vertical hydraulic conductivity of samples from the confining unit span nearly five orders of magnitude. A Lilliefors (two-tailed) test for normality (Iman and Conover, 1983) indicated the raw data set was not normally distributed ( $p = 0.000$ ); however, when a logarithmic transformation was applied the data became normally distributed ( $p = 0.910$ ). Therefore, boxplots (figs. 11 and 12) using logarithmic scales are used to present vertical hydraulic conductivity data.

Because the vertical hydraulic conductivity of the rock core samples from the St. Francois confining unit in the study area were normally distributed using a logarithmic transformation, the values were transformed, grouped by formation, and compared statistically using the two-sample  $t$ -test. Comparing the logarithm of the vertical hydraulic conductivities of the Derby-Doerun Dolomite and Davis Formation indicated the two formations were statistically similar ( $p$ -value = 0.073); however, this  $p$ -value did approach the level of significance value of 0.05.

Boxplots of the vertical hydraulic conductivity data from the study area grouped by formation (fig. 11A) show the conductivity of the Derby-Doerun Dolomite is larger (median value  $1.2 \times 10^{-12}$  ft/s) and less variable as shown by the interquartile range (the range between the lower and upper quartiles;  $5.5 \times 10^{-13}$  to  $2.2$

$\times 10^{-12}$  ft/s) than the Davis Formation (median  $4.5 \times 10^{-13}$  ft/s, interquartile range  $1.2 \times 10^{-13}$  to  $1.4 \times 10^{-12}$  ft/s). Boxplots representing eight core samples from the St. Francois aquifer (upper Bonneterre Formation below the base of the False Davis and Lamotte Sandstone) were included in figure 11A to compare the formations in the confining unit and aquifer. The median value of the vertical hydraulic conductivity of samples from the upper Bonneterre Formation was  $2.9 \times 10^{-13}$  ft/s and the interquartile range spanned an order of magnitude from  $4.5 \times 10^{-14}$  to  $4.2 \times 10^{-13}$  ft/s. These data show the vertical hydraulic conductivity of the upper Bonneterre Formation is comparable to the Davis Formation. Whereas the data set for the Lamotte Sandstone was small (3 samples), the vertical hydraulic conductivity for the Lamotte Sandstone was about three orders of magnitude larger (median value  $8.5 \times 10^{-10}$  ft/s) than the other formations.

An analysis of variance was used for multiple comparisons of the vertical hydraulic conductivity data grouped by rock type. The analysis of the 35 samples from the St. Francois confining unit in the study area shows the values for samples containing carbonate, shale, or both carbonate and shale, are statistically similar ( $p$ -value = 1.00 in all cases). Boxplots (fig. 11B) show these vertical hydraulic conductivity values along with the data from the three quartz samples from the Lamotte Sandstone of the St. Francois aquifer (shown for comparison purposes). Only the rock type composed of quartz (Lamotte Sandstone samples) was significantly different from the other rock types.

The porosity of samples from the confining unit in the study area ranged from a minimum of 0.50 percent to a maximum of 6.40 percent (fig. 11C). There is no significant difference ( $p$ -value = 0.303) between the porosity values of the Derby-Doerun Dolomite (median value 1.90 percent; interquartile range 1.56 to 2.60 percent) and the Davis Formation (median value 2.85 percent; interquartile range 1.91 to 3.78 percent). The porosity of samples from the St. Francois aquifer showed that the upper Bonneterre Formation samples were more similar to samples from the St. Francois confining unit than samples from the Lamotte Sandstone. The porosity of upper Bonneterre Formation samples ranged from 0.50 to 2.80 percent (median value 1.10 percent) and the porosity of samples from the Lamotte Sandstone ranged from 4.10 to 9.10 percent, with a median value of 6.10 percent. With the exception of the porosity value of 9.10 percent, the porosity values of all samples from the St. Francois



**Table 3.** Summary statistics for vertical hydraulic conductivity analysis

[ft/s, foot per second]

|                             |                   | Vertical hydraulic conductivity |                       |                       |                                                |
|-----------------------------|-------------------|---------------------------------|-----------------------|-----------------------|------------------------------------------------|
|                             | Number of samples | Minimum (ft/s)                  | Maximum (ft/s)        | Median (ft/s)         | Interquartile range (ft/s)                     |
| Study area                  |                   |                                 |                       |                       |                                                |
| St. Francois confining unit | 35                | $7.6 \times 10^{-15}$           | $2.1 \times 10^{-10}$ | $6.7 \times 10^{-13}$ | $2.0 \times 10^{-13}$ to $2.2 \times 10^{-12}$ |
| Derby-Doerun Dolomite       | 13                | $3.7 \times 10^{-14}$           | $2.1 \times 10^{-10}$ | $1.2 \times 10^{-12}$ | $5.5 \times 10^{-13}$ to $2.2 \times 10^{-12}$ |
| Davis Formation             | <sup>1</sup> 22   | $7.6 \times 10^{-15}$           | $8.8 \times 10^{-12}$ | $4.5 \times 10^{-13}$ | $1.2 \times 10^{-13}$ to $1.4 \times 10^{-12}$ |
| St. Francois confining unit |                   |                                 |                       |                       |                                                |
| Rock type                   |                   |                                 |                       |                       |                                                |
| Carbonate                   | 26                | $7.6 \times 10^{-15}$           | $2.1 \times 10^{-10}$ | $8.2 \times 10^{-13}$ | $2.4 \times 10^{-13}$ to $2.2 \times 10^{-12}$ |
| Shale                       | 2                 | $1.6 \times 10^{-13}$           | $7.8 \times 10^{-13}$ |                       |                                                |
| Carbonate and shale         | 7                 | $3.8 \times 10^{-14}$           | $8.8 \times 10^{-12}$ | $4.0 \times 10^{-13}$ | $2.3 \times 10^{-13}$ to $3.5 \times 10^{-12}$ |
| St. Francois aquifer        |                   |                                 |                       |                       |                                                |
| Bonneterre Formation        | 5                 | $1.8 \times 10^{-14}$           | $2.0 \times 10^{-11}$ | $2.9 \times 10^{-13}$ | $4.5 \times 10^{-14}$ to $4.2 \times 10^{-13}$ |
| Lamotte Sandstone           | 3                 | $7.6 \times 10^{-10}$           | $2.5 \times 10^{-9}$  | $8.5 \times 10^{-10}$ |                                                |
| Prospecting area            |                   |                                 |                       |                       |                                                |
| St. Francois confining unit | 63                | $3.2 \times 10^{-14}$           | $8.7 \times 10^{-8}$  | $2.2 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $1.1 \times 10^{-12}$ |
| Derby-Doerun Dolomite       | 20                | $3.2 \times 10^{-14}$           | $8.7 \times 10^{-8}$  | $4.4 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $6.3 \times 10^{-10}$ |
| Davis Formation             | 43                | $3.2 \times 10^{-14}$           | $2.6 \times 10^{-10}$ | $1.6 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $7.4 \times 10^{-13}$ |
| Rock type                   |                   |                                 |                       |                       |                                                |
| Carbonate                   | 33                | $3.2 \times 10^{-14}$           | $8.7 \times 10^{-8}$  | $3.2 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $6.1 \times 10^{-12}$ |
| Shale                       | 16                | $3.2 \times 10^{-14}$           | $3.1 \times 10^{-12}$ | $3.0 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $7.8 \times 10^{-13}$ |
| Carbonate and shale         | 14                | $3.2 \times 10^{-14}$           | $2.6 \times 10^{-10}$ | $1.9 \times 10^{-13}$ | $3.2 \times 10^{-14}$ to $5.7 \times 10^{-13}$ |

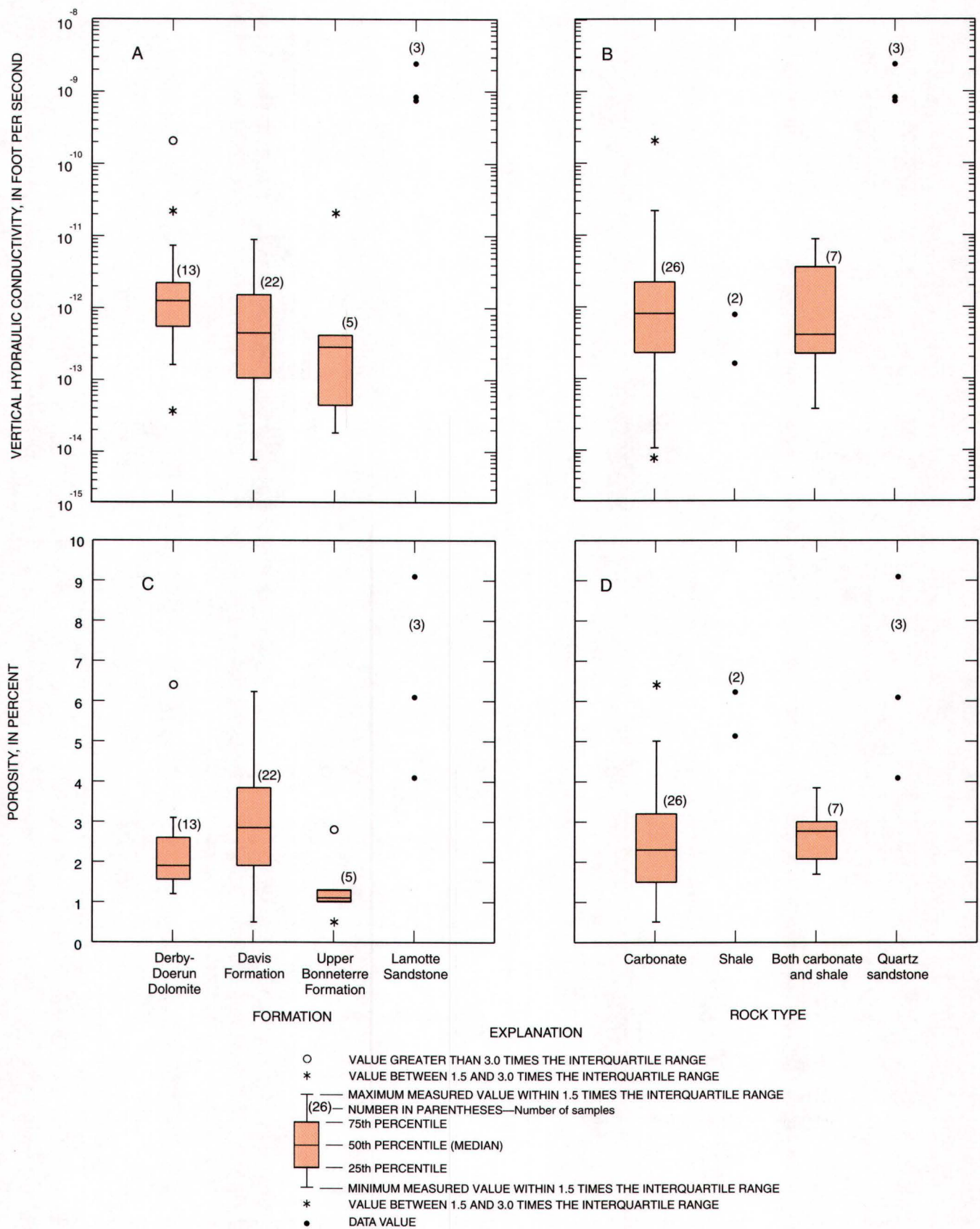
<sup>1</sup>Data set includes two samples from the Bonnetterre Formation above the False Davis.

aquifer were within the range of those for the confining unit. The median porosity of the Lamotte Sandstone is considerably larger than the typical porosity of the other formations. When the porosity data were compared by rock type (fig. 11D), the results showed that samples from the confining unit that contained carbonate, or both carbonate and shale, were similar, but these samples were different from the samples that contained shale or quartz sandstone. There is not a strong correlation between the vertical hydraulic conductivity and porosity.

Comparisons of the vertical hydraulic conductivity data from the confining unit in the study area with data from the prospecting area to the west (data from

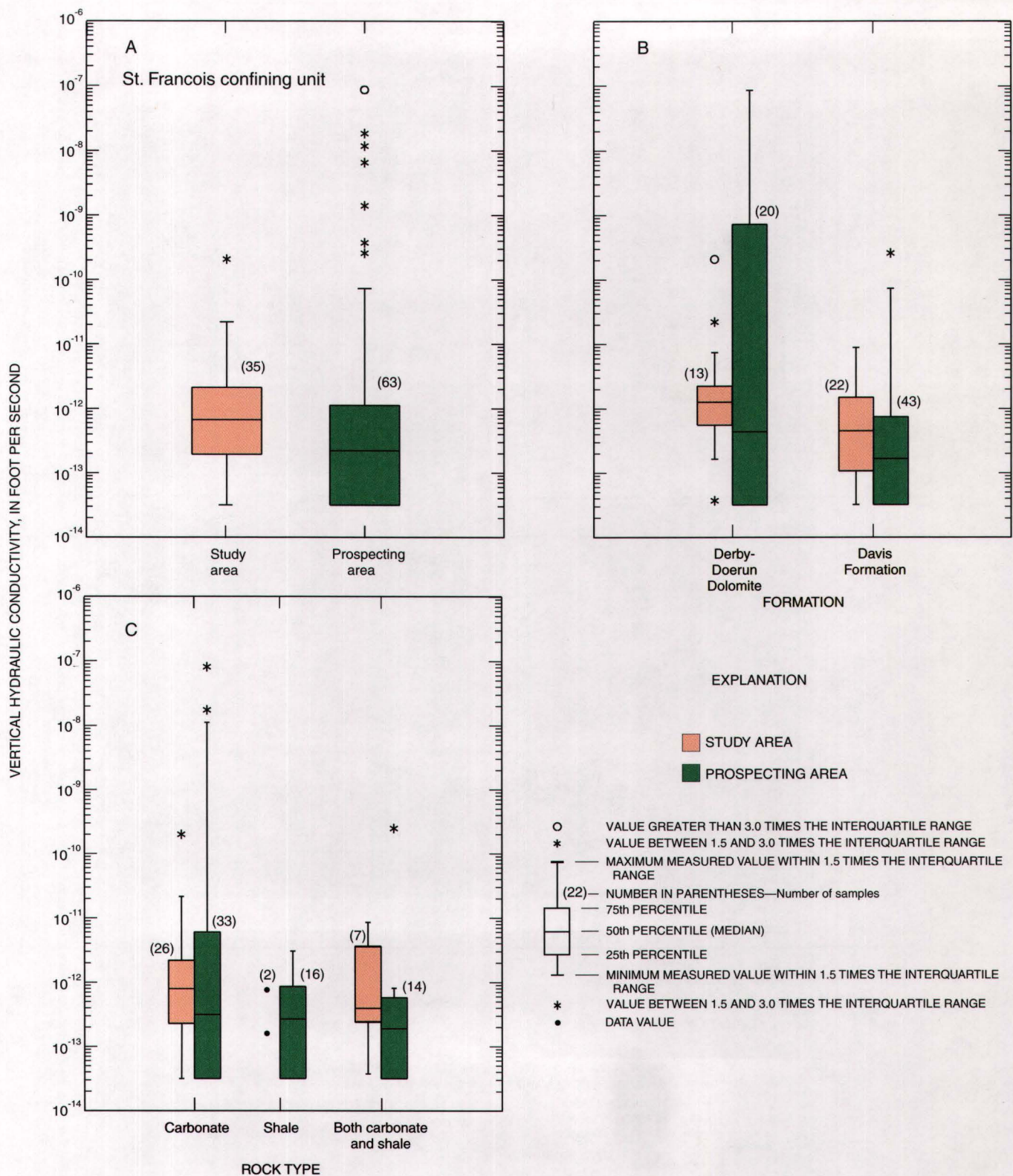
Kleeschulte and Seeger, 2000) were made to assess regional variations in the vertical hydraulic conductivity. A Lilliefors (two-tailed) test for normality (Iman and Conover, 1983) shows that the combined vertical hydraulic conductivity data from the two areas are not normally distributed. This mainly is because 39 of the 61 vertical hydraulic conductivity values from the prospecting area reported in Kleeschulte and Seeger (2000) were censored values that were less than the reporting limit of  $3.17 \times 10^{-14}$  ft/s.

Because these data are not normally distributed and could not be transformed into a normal distribution, the data were ranked and nonparametric statistical hypothesis tests were used. The nonparametric



**Figure 11.** Boxplots showing the vertical hydraulic conductivity and porosity of formations and rock types in the study area.





**Figure 12.** Boxplots showing the vertical hydraulic conductivity of the St. Francois confining unit, formations, and rock types in the study area and prospecting area.

Kruskal-Wallis test was used to test for differences between the two groups of data (study and prospecting areas). When only two groups are considered, the test essentially reduces to the Mann-Whitney test (SPSS Inc., 1998). Vertical hydraulic conductivity values for three core samples from the study area were less than the reporting limit ( $3.17 \times 10^{-14}$  ft/s) stated in Kleeschulte and Seeger (2000) for core samples analyzed from the prospecting area. Consequently, before ranking the data, these three data values were censored and a value of  $3.17 \times 10^{-14}$  ft/s was substituted for each so that the lower limit of both data sets would be equal. An analysis of variance was used to perform multiple-comparisons when more than two data sets were evaluated (Iman and Conover, 1983).

The ranked vertical hydraulic conductivity data from formations of the confining unit in both the study and prospecting areas were combined. Comparisons of the data show that the confining unit in the two areas is statistically different ( $p$ -value = 0.020). Even though the statistical analysis was performed on the ranked data, the actual vertical hydraulic conductivity values are plotted on a logarithmic scale on figure 12A to show the data value distribution. The boxplots show that the median value of the vertical hydraulic conductivity data from the study area ( $6.7 \times 10^{-13}$  ft/s) is three times larger than the median vertical hydraulic conductivity value from the prospecting area ( $2.2 \times 10^{-13}$  ft/s). The interquartile range shows that the variability of the confining unit data from the study area spans one order of magnitude ( $2.0 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s) and that the corresponding data from the prospecting area span nearly two orders of magnitude ( $3.2 \times 10^{-14}$  to  $1.1 \times 10^{-12}$  ft/s).

The ranked vertical hydraulic conductivities of the Derby-Doerun Dolomite in the two areas statistically are similar ( $p$ -value = 0.514). The median vertical hydraulic conductivity value of the Derby-Doerun Dolomite data from the study area ( $1.2 \times 10^{-12}$  ft/s) is about three times greater than the median value of the corresponding data set from the prospecting area ( $4.4 \times 10^{-13}$  ft/s; fig. 12B). The variability of the data, as shown by the interquartile range, was less in the study area ( $5.5 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s; spanning less than one order of magnitude) than in the prospecting area ( $3.2 \times 10^{-14}$  to  $6.3 \times 10^{-10}$  ft/s; spanning more than four orders of magnitude).

The ranked vertical hydraulic conductivities of the Davis Formation in the two areas statistically are similar ( $p$ -value = 0.076), although approaching the

level of significance value of 0.05. The median vertical hydraulic conductivity value of samples from the study area ( $4.5 \times 10^{-13}$  ft/s) was three times greater than the median value of the data from the prospecting area ( $1.6 \times 10^{-13}$  ft/s). The interquartile range of data from the study area spanned one order of magnitude ( $1.2 \times 10^{-13}$  to  $1.4 \times 10^{-12}$  ft/s) and the corresponding data from the prospecting area spanned nearly 1.5 orders of magnitude ( $3.2 \times 10^{-14}$  to  $7.4 \times 10^{-13}$  ft/s).

The vertical hydraulic conductivity values of carbonate rock core samples from the study area were combined with the carbonate rock core data from the prospecting area. The data were ranked, grouped by location, and then analyzed statistically using the Mann-Whitney test. The other two rock type groups (shale samples and samples that contained both carbonate and shale) were analyzed the same way. The results showed, when comparing the same rock types from the study and prospecting areas, that the vertical hydraulic conductivity values for samples containing carbonates ( $p$ -value = 0.225), shales ( $p$ -value = 0.668), and carbonates and shales ( $p$ -value = 0.227) in both areas are similar. This is shown by the considerably overlapping interquartile range of the boxplots and the similar median values (fig. 12C, table 3). However, for each of the three data sets, the study area data have larger median values and less variability in the interquartile range than the samples from the prospecting area. The greater variability of samples from the prospecting area may be caused by the sample sets from that area being larger.

Because the vertical hydraulic conductivity of the various rock types in the confining unit of the study area are statistically similar (fig. 11B), the entire carbonate-shale thickness is the primary factor determining the effectiveness of the confining unit, not the net shale thickness. This conclusion is similar to that stated in Kleeschulte and Seeger (2000) for the samples analyzed from the prospecting area.

The range of effective vertical hydraulic conductivity values for the St. Francois confining unit in the study area was estimated using a minimum thickness of 131 and a maximum thickness of 411 ft for the confining unit (fig. 9; table 1) and a minimum and maximum thickness of 2 and 89 ft for the net shale thickness (fig. 10; table 1). The upper and lower quartiles range of  $2.4 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s for carbonate rocks and the minimum and maximum values of  $1.6 \times 10^{-13}$  and  $7.8 \times 10^{-13}$  ft/s for shales were used as estimates of vertical hydraulic conductivities in the calculation.



The effective vertical hydraulic conductivity of the confining unit was calculated using the expression for two rock layers (shale and carbonate rock) in series having different vertical hydraulic conductivities:

$$\frac{d_t}{K_t} = \frac{d_1}{K_1} + \frac{d_2}{K_2}$$

- $d_t$  = total thickness of the confining unit
- $d_1, d_2$  = thickness of layer 1 and layer 2
- $K_t$  = effective vertical hydraulic conductivity of unit
- $K_1, K_2$  = vertical hydraulic conductivity of layer 1 and layer 2

By using appropriate extreme values of net shale thickness and vertical hydraulic conductivity, the range of effective vertical hydraulic conductivity for the confining unit in the study area was estimated to be a minimum of  $3 \times 10^{-13}$  ft/s and a maximum of  $2 \times 10^{-12}$  ft/s. This range of effective vertical hydraulic conductivity is similar to the  $3 \times 10^{-14}$  to  $1 \times 10^{-12}$  ft/s range calculated for the prospecting area in Kleeschulte and Seeger (2000). However, the minimum value for the study area is about an order of magnitude greater than that calculated for the prospecting area. The range of vertical hydraulic conductivity values that were calculated for the study area are small, and the confining unit effectively impedes the ground-water flow between the Ozark aquifer and the St. Francois aquifer, unless preferred-path secondary permeability has developed along faults and fractures that extend through the confining unit.

## SUMMARY

The vertical hydraulic conductivity of the St. Francois confining unit (Derby-Doerun Dolomite and Davis Formation) in six townships (T. 25–27 N. and R. 01–02 W.) of Oregon, Carter, and Ripley Counties of southeastern Missouri was evaluated by describing the stratigraphy and measuring the vertical hydraulic conductivity of core samples. Geologic formations from the Jefferson City Dolomite to the Potosi Dolomite form the surficial Ozark aquifer, the primary source of water for domestic and public-water supplies and major springs in southern Missouri. The St. Francois confining unit lies beneath the Ozark aquifer and impedes the circulation of water between the overlying Ozark aquifer and the underlying St. Francois aquifer (Bonnetterre Formation and Lamotte Sandstone). The Bonnetterre

Formation is the potential host formation for lead-zinc deposits in the area. Potential mines in the Bonnetterre Formation would be at depths greater than 1,300 ft (feet) below land surface in the prospecting area and would have to be dewatered before lead-zinc minerals can be extracted. There is concern that mine dewatering could lower water levels in the Ozark aquifer.

The Lamotte Sandstone is present throughout the study area, except where it pinches out against Precambrian knobs. Based on 13 boreholes in the study area that penetrated the entire formation, the thickness of the Lamotte Sandstone ranged from 4 to 247 ft (median value is 87.5 ft). The lower Lamotte Sandstone consists of alluvial fan-dominated deposits, debris and mudflows, fining-upward conglomerate-based sandstone channel deposits, and sheet-flood deposits. The shale content in complete Lamotte Sandstone core sections ranges from nearly 0 to almost 10 percent, and increases to the north and the east. The top of the Lamotte Sandstone, where present, ranges from 980 to 2,698 ft deep, and ranges in altitude from 400 ft below sea level in the northeastern part of the study area to 1,788 ft below sea level in the south-central part of the study area.

Depositional facies in the Bonnetterre Formation range from transgressive drowned shelf and intrashelf basin to shallow water build-ups, shoal complexes, and platform interior facies. The Bonnetterre Formation is dominantly carbonate with several shaley horizons and a siltstone (the Sullivan Siltstone Member). In the study area, the altitude of the top of the formation ranges from 300 to more than 1,200 ft below sea level. Based on 51 fully penetrating boreholes, the formation ranges from 190 to 692 ft thick, but typically is from 400 to 525 ft thick.

The Davis Formation is an intrashelf basin facies consisting of a series of shales interbedded with shaley limestones, shale-free limestones, and local dolostones. Carbonate beds are thicker near the edge of the intrashelf basin area. Davis Formation sequences appear to have formed in a basin that is elongate through the center of the study area, and is open to the north. The Davis Formation sequences are almost entirely carbonate outside of this basin.

The Davis Formation ranges from 24 to 320 ft thick, but typically is 100 to 200 ft thick in the study area. The formation thins over Precambrian knobs. Individual shale layers range from partings to 5 ft thick. Shale-dominant sequences can be tens of feet thick and contain as much as 90 percent shale. Carbonate-domi-

nant zones may be 70 ft thick or greater. Shale percentages in these zones can be as much as 50 percent, or less than 10 percent. The shales apparently prevented dolomitizing fluids from reaching most Davis Formation limestones. Davis Formation intercepts that are essentially shale free exist on the eastern, western, and southern edges of the study area. These sequences generally contain one percent or less of shale.

The top of the Davis Formation (based on 56 data points) ranges from 620 to 2,022 ft deep and ranges in altitude from 40 ft below sea level in the northern part of the study area, to 1,182 ft below sea level in the southern part of the study area.

The Derby-Doerun Dolomite overlies the Davis Formation within and at the margins of intrashelf basins and represents a pair of superimposed carbonate ramp cycles. Mudstone-grainstone sequences and local lithoclast conglomerates support a homoclinal ramp model. Where present, the basal shaley sequence represents a transition with the Davis Formation. The formation (based on 50 data points) ranges from 50 to 386 ft thick in the study area, but typically is 120 to 180 ft thick. The top of the Derby-Doerun Dolomite ranges from 495 to 2,020 ft deep (based on 53 data points), and ranges in altitude from 85 ft above sea level to 947 ft below sea level.

The St. Francois confining unit is thickest in the central and southern parts of the study area. The thickness, as determined by 51 core logs that completely penetrate the unit, ranges from less than 200 ft in the northwestern and east-central parts of the study area to 411 ft in the central part, but typically ranges from 270 to 340 ft. The net shale thickness of the confining unit (based on 29 data points) ranges from 1.7 ft in the east-central part of the study area to 89 ft in the southwest part. These thickness values include the cumulative shale thickness present in the sequence of rock from the top of the Derby-Doerun Dolomite to the base of the False Davis.

Vertical hydraulic conductivities of the 35 rock core samples from the St. Francois confining unit in the study area ranged from  $7.6 \times 10^{-15}$  to  $2.1 \times 10^{-10}$  ft/s (foot per second). With the outliers, the reported vertical hydraulic conductivity of samples from the confining unit span nearly five orders of magnitude. The logarithmic transformed vertical hydraulic conductivities of the Derby-Doerun Dolomite and Davis Formation were compared using the statistical two-sample t-test, and were shown to be statistically similar ( $p$ -value = 0.073); however, this  $p$ -value did approach the level

of significance value of 0.05. The vertical hydraulic conductivity of the Derby-Doerun Dolomite is larger and less variable than the Davis Formation. When grouped by rock type, the vertical hydraulic conductivity of samples that contained carbonate, shale, or both carbonate and shale, were similar.

Porosity values for core samples from the confining unit ranged from 0.50 to 6.40 percent. There is no significant difference ( $p$ -value = 0.303) between the porosity values of the Derby-Doerun Dolomite and Davis Formation. There is not a strong correlation between the vertical hydraulic conductivity and porosity.

The combined vertical hydraulic conductivity data from the St. Francois confining unit in the study and prospecting areas were not normally distributed and could not be transformed into a normal distribution. A comparison on the ranked data using the Mann-Whitney test shows the confining unit in the two areas is statistically different ( $p$ -value = 0.020). The median value of the vertical hydraulic conductivity data from the study area ( $6.7 \times 10^{-13}$  ft/s) is three times larger than the median vertical hydraulic conductivity value for the prospecting area ( $2.2 \times 10^{-13}$  ft/s). The interquartile range shows that the variability of the data from the study area spans one order of magnitude ( $2.0 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s) and that the corresponding data from the prospecting area spans nearly two orders of magnitude ( $3.2 \times 10^{-14}$  to  $1.1 \times 10^{-12}$  ft/s).

The ranked vertical hydraulic conductivities of the Derby-Doerun Dolomite in the two areas are statistically similar ( $p$ -value = 0.514). The median vertical hydraulic conductivity value of the data from the study area ( $1.2 \times 10^{-12}$  ft/s) is about three times greater than the median value of data from the prospecting area ( $4.4 \times 10^{-13}$  ft/s). The variability of the data, as shown by the interquartile range, was less in the study area ( $5.5 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s; spanning less than one order of magnitude) than in the prospecting area ( $3.2 \times 10^{-14}$  to  $6.3 \times 10^{-10}$  ft/s; spanning more than four orders of magnitude).

A comparison of the ranked vertical hydraulic conductivities of the Davis Formation in the two areas also showed these data sets were statistically similar ( $p$ -value = 0.076), although approaching the level of significance value of 0.05. The median vertical hydraulic conductivity value of samples from the study area ( $4.5 \times 10^{-13}$  ft/s) was three times greater than the median value of the data from the prospecting area ( $1.6 \times 10^{-13}$  ft/s). The interquartile range of data from the study area



spanned one order of magnitude ( $1.2 \times 10^{-13}$  to  $1.4 \times 10^{-12}$  ft/s) and the corresponding data from the prospecting area spanned nearly 1.5 orders of magnitude ( $3.2 \times 10^{-14}$  to  $7.4 \times 10^{-13}$  ft/s).

The ranked vertical hydraulic conductivities of each rock type from the study area were compared to the same rock type in the prospecting area using the Mann-Whitney test. Statistically, the vertical hydraulic conductivity values for samples containing carbonates (p-value = 0.225), shales (p-value = 0.668), and carbonates and shales (p-value = 0.227) in both areas are similar. However, in each of the three cases the samples from the study area have larger median values and less variability than the samples from the prospecting area.

Because the vertical hydraulic conductivity of the various rock types of the confining unit in the study area are statistically similar, the entire carbonate-shale thickness is the primary factor determining the effectiveness of the confining unit, not the net shale thickness. The range of effective vertical hydraulic conductivity values for the St. Francois confining unit in the study area was estimated using a minimum thickness of 131 ft and a maximum thickness of 411 ft. A minimum net shale thickness of 2 ft and a maximum net shale thickness of 89 ft were used to define the shale content of the confining unit. Vertical hydraulic conductivities were used in the calculation that represented the upper and lower quartiles range of  $2.4 \times 10^{-13}$  to  $2.2 \times 10^{-12}$  ft/s for the carbonate rocks, and the minimum and maximum values of  $1.6 \times 10^{-13}$  and  $7.8 \times 10^{-13}$  ft/s for shales in the study area. By using appropriate extreme values of net shale thickness and vertical hydraulic conductivity, the range of effective vertical hydraulic conductivity for the confining unit in the study area was estimated to be a minimum of  $3 \times 10^{-13}$  ft/s and a maximum of  $2 \times 10^{-12}$  ft/s. The vertical hydraulic conductivity of the St. Francois confining unit is small, and the confining unit effectively impedes the ground-water flow between the Ozark aquifer and the St. Francois aquifer, unless preferred-path secondary permeability has developed along faults and fractures that extend through the confining unit.

## REFERENCES CITED

- American Petroleum Institute, 1998, Recommended practices for core analysis: Washington, D.C., American Petroleum Institute, 195 p.
- Fletcher, C.S., 1974, The geology and hydrogeology of the New Lead Belt, Missouri: University of Missouri-Rolla, unpublished M.S. thesis, 91 p.
- Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 604 p.
- Hauck, H.S., and Nagel, C.D., 2001, Water resources data Missouri water year 2000: U.S. Geological Survey Water-Data Report MO-00-1, 448 p.
- Hayes, W.C., and Knight, R.D., 1961, Cambrian System, in Koenig, J.W., ed., revised 1995, Thompson, T.L., ed., Stratigraphic Succession in Missouri: Missouri Geological and Water Resources, v. 40, second series, p. 14–20.
- Houseknecht, D.W., and Ethridge, F.G., 1978, Depositional history of the Lamotte Sandstone of southeastern Missouri: *Journal of Sedimentary Petrology*, v. 48, no. 2, p. 575–586.
- Howe, W.B., 1968, Planar stromatolite and burrowed carbonate mud facies in Cambrian strata of the St. Francois Mountain area: Missouri Geological Survey and Water Resources Report of Investigations No. 41, 113 p.
- Iman, R.L., and Conover, W.J., 1983, A modern approach to statistics: New York, John Wiley and Sons, 497 p.
- Imes, J.L., 1989, Major geohydrologic units in and adjacent to the Ozark Plateaus province, Missouri, Arkansas, Kansas, and Oklahoma—Basement confining unit: U.S. Geological Survey Hydrologic Investigations Atlas HA-711-B, 1 sheet.
- 1990a, Major geohydrologic units in and adjacent to the Ozark Plateaus province, Missouri, Arkansas, Kansas, and Oklahoma—St. Francois aquifer: U.S. Geological Survey Hydrologic Investigations Atlas HA-711-C, 2 sheets.
- 1990b, Major geohydrologic units in and adjacent to the Ozark Plateaus province, Missouri, Arkansas, Kansas, and Oklahoma—St. Francois confining unit: U.S. Geological Survey Hydrologic Investigations Atlas HA-711-D, 3 sheets.
- 1990c, Major geohydrologic units in and adjacent to the Ozark Plateaus province, Missouri, Arkansas, Kansas, and Oklahoma—Ozark aquifer: U.S. Geological Survey Hydrologic Investigations Atlas HA-711-E, 3 sheets.

- Imes, J.L., and Emmett, L.F., 1994, Geohydrology of the Ozark Plateaus aquifer system in parts of Missouri, Arkansas, Oklahoma, and Kansas: U.S. Geological Survey Professional Paper 1414-D, 127 p.
- Kleeschulte, M.J., and Seeger, C.M., 2000, Depositional environment, stratigraphy, and vertical hydraulic conductivity of the St. Francois confining unit in the Fristoe Unit of the Mark Twain National Forest, Missouri: U.S. Geological Survey Water-Resources Investigations Report 00-4037, 65 p.
- Koenig, J.W., ed., 1961, The stratigraphic succession in Missouri: Rolla, Missouri Division of Geology and Land Survey, v. 40, second series, 185 p.
- Kurtz, V.E., Thacker, J.L., Anderson, K.M., and Gerdemann, P.E., 1975, Traverse in Late Cambrian strata from the St. Francois Mountains, Missouri, to Delaware County, Oklahoma: Rolla, Missouri Division of Geology and Land Survey Report of Investigations 55, 112 p.
- Larsen, K.G., 1977, Sedimentology of the Bonnetterre Formation, southeast Missouri: *Economic Geology*, v. 72, p. 408-419.
- Lohman, S.W., and others, 1972, Definitions of selected ground-water terms—Revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.
- Palmer, J.R., 1989, Late Upper Cambrian shelf depositional facies and history, southern Missouri, *in* Gregg, Jay M., Palmer, James R., and Kurtz, Vincent E., eds., *Field guide to the Upper Cambrian of southeastern Missouri: stratigraphy, sedimentology, and economic geology*: Department of Geology and Geophysics, University of Missouri-Rolla, p. 1-24.
- 1991, Distribution of lithofacies and inferred depositional environments in the Cambrian System, *in* Martin, J.A., and Pratt, W.P., eds., *Geology and mineral-resource assessment of the Springfield 1° x 2° quadrangle, Missouri, as appraised in September 1985*: U.S. Geological Survey Bulletin 1942, 115 p.
- SPSS Inc., 1998, STSTAT user's guide, version 8.0: Chicago, Illinois, 1,086 p.
- Thacker, J.L., and Anderson, K.H., 1979, Preliminary carbonate lithofacies maps of the Cambrian Davis Formation, Rolla 1° X 2° quadrangle, Missouri 1:250,000: Rolla, Missouri Division of Geology and Land Survey, 2 sheets.
- Wharton, H.M., 1975, Introduction to the southeast Missouri lead district, *in* Vineyard, J.D., ed., *The geology and ore deposits of selected mines, Viburnum Trend, Missouri*: Rolla, Missouri Division of Geology and Land Survey Report of Investigations 58, p. 3-14.
- Yesberger, W.L., 1982, Paleoenvironments and depositional history of the Upper Cambrian Lamotte Sandstone in southeast Missouri: University of Missouri-Columbia, unpublished M.A. thesis, 287 p.





---

---

# TABLES

---

---



Table 1. Core log analysis data

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 1                       | 365658               | 0911908               | AMAX 766-002                                 | T26N R03W 06DBB   | 1,022                          | 2,155                  | 1,420                 | -398     | 80        | 1,500           | -478     | 210       | 290                                         | --        |
| 2                       | 370022               | 0911452               | AMAX 801-001                                 | T27N R03W 14CAA   | 900                            | 1,586                  | 1,170                 | -270     | 60        | 1,230           | -330     | 200       | 260                                         | --        |
| 3                       | 365747               | 0911722               | AMAX 801-002                                 | T27N R03W 33CBD   | 1,006                          | 2,135                  | 1,440                 | -434     | 60        | 1,500           | -494     | 240       | 300                                         | 71        |
| 4                       | 365607               | 0911907               | AMAX 801-003                                 | T26N R03W 07DBA   | 886                            | 1,975                  | 1,280                 | -394     | 60        | 1,340           | -454     | 220       | 280                                         | --        |
| 5                       | 365658               | 0912432               | AMAX 801-004                                 | T26N R04W 05DAB   | 962                            | 2,105                  | 1,380                 | -418     | 80        | 1,460           | -498     | 290       | 370                                         | --        |
| 6                       | 365400               | 0912105               | AMAX 801-005                                 | T26N R04W 26AAA   | 820                            | 2,056                  | 1,340                 | -520     | 90        | 1,430           | -610     | 190       | 280                                         | --        |
| 7                       | 365614               | 0911415               | AMAX 801-006                                 | T26N R03W 12BCB   | 835                            | 2,020                  | 1,340                 | -505     | 40        | 1,380           | -545     | 260       | 300                                         | --        |
| 8                       | 365154               | 0911010               | AMAX 801-007                                 | T25N R02W 04AAD   | 780                            | 2,125                  | 1,400                 | -620     | 80        | 1,480           | -700     | 212       | 292                                         | --        |
| 9                       | 365716               | 0912818               | AMAX 801-008                                 | T26N R05W 02BCA   | 1,015                          | 2,128                  | 1,400                 | -385     | 60        | 1,460           | -445     | 310       | 370                                         | --        |
| 10                      | 365649               | 0912227               | AMAX 801-009                                 | T26N R04W 03DCA   | 895                            | 2,030                  | 1,380                 | -485     | 40        | 1,420           | -525     | 220       | 260                                         | 82        |
| 11                      | 365929               | 0912312               | AMAX 801-010                                 | T27N R04W 21DAD   | 985                            | 2,089                  | 1,480                 | -495     | 20        | 1,500           | -515     | 270       | 290                                         | 84        |
| 12                      | 365507               | 0911847               | AMAX 801-011                                 | T26N R03W 18DDA   | 895                            | 1,803                  | 1,230                 | -335     | 60        | 1,290           | -395     | 190       | 250                                         | --        |
| 13                      | 365525               | 0912309               | AMAX 801-012                                 | T26N R04W 15BCC   | 960                            | 2,109                  | 1,400                 | -440     | 60        | 1,460           | -500     | 260       | 320                                         | --        |
| 14                      | 365406               | 0911142               | AMAX 801-013                                 | T26N R02W 20DBC   | 905                            | 2,070                  | 1,350                 | -445     | 70        | 1,420           | -515     | 260       | 330                                         | --        |
| 15                      | 365837               | 0911130               | AMAX 801-014                                 | T27N R02W 29DBB   | 830                            | 1,919                  | 1,154                 | -324     | 145       | 1,299           | -469     | 149       | 294                                         | 19.5      |
| 16                      | 365133               | 0911706               | AMAX 801-015                                 | T25N R03W 04DCA   | 635                            | 1,985                  | 1,240                 | -605     | 50        | 1,290           | -655     | 240       | 290                                         | --        |
| 17                      | 365009               | 0911958               | AMAX 801-016                                 | T25N R03W 18BCC   | 905                            | 2,245                  | 1,520                 | -615     | 70        | 1,590           | -685     | 220       | 290                                         | 125       |
| 18                      | 364911               | 0911713               | AMAX 801-017                                 | T25N R03W 21ACC   | 590                            | 1,875                  | --                    | --       | --        | 1,170           | -580     | 250       | --                                          | --        |
| 19                      | 365801               | 0911152               | AMAX 801-018                                 | T27N R02W 32BBD   | 780                            | 1,963                  | 1,333                 | -553     | 79        | 1,412           | -632     | 106       | 185                                         | 4.4       |
| 20                      | 365454               | 0911739               | AMAX 801-019                                 | T26N R03W 16CCC   | 950                            | 2,080                  | 1,370                 | -420     | 60        | 1,430           | -480     | 250       | 310                                         | --        |
| 21                      | 365415               | 0911803               | AMAX 801-020                                 | T26N R03W 20DBD   | 920                            | 2,026                  | 1,350                 | -430     | 80        | 1,430           | -510     | 190       | 270                                         | --        |
| 22                      | 365424               | 0911639               | AMAX 801-021                                 | T26N R03W 21DAA   | 975                            | 2,111                  | 1,380                 | -405     | 60        | 1,440           | -465     | 250       | 310                                         | --        |
| 23                      | 365330               | 0911259               | AMAX 801-022                                 | T26N R02W 30BDC   | 980                            | 2,147                  | 1,350                 | -370     | 90        | 1,440           | -460     | 260       | 350                                         | 33        |
| 24                      | 365820               | 0911143               | AMAX 801-024                                 | T27N R02W 29CDA   | 730                            | 1,867                  | 1,270                 | -540     | --        | --              | --       | --        | 190                                         | --        |
| 25                      | 365543               | 0911825               | AMAX 801-025                                 | T26N R03W 17BAB   | 940                            | 2,048                  | 1,350                 | -410     | 60        | 1,410           | -470     | 220       | 280                                         | --        |
| 26                      | 365214               | 0911302               | AMAX 801-026                                 | T26N R02W 31CDC   | 975                            | 1,924                  | 1,354                 | -379     | 97        | 1,451           | -476     | 164       | 261                                         | 61.9      |
| 27                      | 365543               | 0912159               | AMAX 801-027                                 | T26N R04W 14BBA   | 990                            | 2,136                  | 1,400                 | -410     | 120       | 1,520           | -530     | 200       | 320                                         | --        |
| 28                      | 365541               | 0912038               | AMAX 801-028                                 | T26N R04W 13BAA   | 985                            | 2,055                  | 1,430                 | -445     | 60        | 1,490           | -505     | 210       | 270                                         | --        |
| 29                      | 365442               | 0911915               | AMAX 801-029                                 | T26N R03W 19ABC   | 920                            | 2,102                  | 1,430                 | -510     | 60        | 1,490           | -570     | 210       | 270                                         | --        |
| 30                      | 365424               | 0911949               | AMAX 801-030                                 | T26N R03W 19CBB   | 880                            | 2,095                  | 1,370                 | -490     | 80        | 1,450           | -570     | 210       | 290                                         | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 1                       | 365658               | 0911908               | AMAX 766-002                                 | T26N R03W 06DBB   | 1,022                          | 2,155                  | 1,710                | -688     | 400       | 2,110             | -1,088   | --        | --               | --       |
| 2                       | 370022               | 0911452               | AMAX 801-001                                 | T27N R03W 14CAA   | 900                            | 1,586                  | 1,430                | -530     | 120       | --                | --       | 0         | 1,550            | -650     |
| 3                       | 365747               | 0911722               | AMAX 801-002                                 | T27N R03W 33CBD   | 1,006                          | 2,135                  | 1,740                | -734     | 390       | 2,130             | -1,124   | --        | --               | --       |
| 4                       | 365607               | 0911907               | AMAX 801-003                                 | T26N R03W 07DBA   | 886                            | 1,975                  | 1,560                | -674     | 410       | 1,970             | -1,084   | --        | --               | --       |
| 5                       | 365658               | 0912432               | AMAX 801-004                                 | T26N R04W 05DAB   | 962                            | 2,105                  | 1,750                | -788     | 320       | 2,070             | -1,108   | --        | --               | --       |
| 6                       | 365400               | 0912105               | AMAX 801-005                                 | T26N R04W 26AAA   | 820                            | 2,056                  | 1,620                | -800     | 430       | 2,050             | -1,230   | --        | --               | --       |
| 7                       | 365614               | 0911415               | AMAX 801-006                                 | T26N R03W 12BCB   | 835                            | 2,020                  | 1,640                | -805     | 380       | 2,020             | -1,185   | --        | --               | --       |
| 8                       | 365154               | 0911010               | AMAX 801-007                                 | T25N R02W 04AAD   | 780                            | 2,125                  | 1,692                | -912     | 415       | 2,107             | -1,327   | --        | --               | --       |
| 9                       | 365716               | 0912818               | AMAX 801-008                                 | T26N R05W 02BCA   | 1,015                          | 2,128                  | 1,770                | -755     | 340       | 2,110             | -1,095   | --        | --               | --       |
| 10                      | 365649               | 0912227               | AMAX 801-009                                 | T26N R04W 03DCA   | 895                            | 2,030                  | 1,640                | -745     | 370       | 2,010             | -1,115   | --        | --               | --       |
| 11                      | 365929               | 0912312               | AMAX 801-010                                 | T27N R04W 21DAD   | 985                            | 2,089                  | 1,770                | -785     | 300       | 2,070             | -1,085   | --        | --               | --       |
| 12                      | 365507               | 0911847               | AMAX 801-011                                 | T26N R03W 18DDA   | 895                            | 1,803                  | 1,480                | -585     | --        | --                | --       | --        | --               | --       |
| 13                      | 365525               | 0912309               | AMAX 801-012                                 | T26N R04W 15BCC   | 960                            | 2,109                  | 1,720                | -760     | 370       | 2,090             | -1,130   | --        | --               | --       |
| 14                      | 365406               | 0911142               | AMAX 801-013                                 | T26N R02W 20DBC   | 905                            | 2,070                  | 1,680                | -775     | 390       | 2,070             | -1,165   | --        | --               | --       |
| 15                      | 365837               | 0911130               | AMAX 801-014                                 | T27N R02W 29DBB   | 830                            | 1,919                  | 1,448                | -618     | 459       | 1,907             | -1,077   | --        | --               | --       |
| 16                      | 365133               | 0911706               | AMAX 801-015                                 | T25N R03W 04DCA   | 635                            | 1,985                  | 1,530                | -895     | 430       | 1,960             | -1,325   | --        | --               | --       |
| 17                      | 365009               | 0911958               | AMAX 801-016                                 | T25N R03W 18BCC   | 905                            | 2,245                  | 1,810                | -905     | 430       | 2,240             | -1,335   | --        | --               | --       |
| 18                      | 364911               | 0911713               | AMAX 801-017                                 | T25N R03W 21ACC   | 590                            | 1,875                  | 1,420                | -830     | 450       | 1,870             | -1,280   | --        | --               | --       |
| 19                      | 365801               | 0911152               | AMAX 801-018                                 | T27N R02W 32BBB   | 780                            | 1,963                  | 1,518                | -738     | 421       | 1,939             | -1,159   | --        | --               | --       |
| 20                      | 365454               | 0911739               | AMAX 801-019                                 | T26N R03W 16CCC   | 950                            | 2,080                  | 1,680                | -730     | 380       | 2,060             | -1,110   | --        | --               | --       |
| 21                      | 365415               | 0911803               | AMAX 801-020                                 | T26N R03W 20DBD   | 920                            | 2,026                  | 1,620                | -700     | 400       | --                | --       | 0         | 2,020            | -1,100   |
| 22                      | 365424               | 0911639               | AMAX 801-021                                 | T26N R03W 21DAA   | 975                            | 2,111                  | 1,690                | -715     | 390       | 2,080             | -1,105   | 20        | 2,100            | -1,125   |
| 23                      | 365330               | 0911259               | AMAX 801-022                                 | T26N R02W 30BDC   | 980                            | 2,147                  | 1,700                | -720     | 400       | 2,100             | -1,120   | --        | --               | --       |
| 24                      | 365820               | 0911143               | AMAX 801-024                                 | T27N R02W 29CDA   | 730                            | 1,867                  | 1,460                | -730     | 400       | 1,860             | -1,130   | --        | --               | --       |
| 25                      | 365543               | 0911825               | AMAX 801-025                                 | T26N R03W 17BAB   | 940                            | 2,048                  | 1,630                | -690     | 420       | 2,050             | -1,110   | --        | --               | --       |
| 26                      | 365214               | 0911302               | AMAX 801-026                                 | T26N R02W 31CDC   | 975                            | 1,924                  | 1,615                | -640     | 299       | --                | --       | 0         | 1,914            | -939     |
| 27                      | 365543               | 0912159               | AMAX 801-027                                 | T26N R04W 14BBA   | 990                            | 2,136                  | 1,720                | -730     | 390       | 2,110             | -1,120   | --        | --               | --       |
| 28                      | 365541               | 0912038               | AMAX 801-028                                 | T26N R04W 13BAA   | 985                            | 2,055                  | 1,700                | -715     | 350       | 2,050             | -1,065   | --        | --               | --       |
| 29                      | 365442               | 0911915               | AMAX 801-029                                 | T26N R03W 19ABC   | 920                            | 2,102                  | 1,700                | -780     | 370       | 2,070             | -1,150   | --        | --               | --       |
| 30                      | 365424               | 0911949               | AMAX 801-030                                 | T26N R03W 19CBB   | 880                            | 2,095                  | 1,660                | -780     | 430       | 2,090             | -1,210   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 31                      | 365301               | 0912114                | AMAX 801-031                                 | T26N R04W 35AAC   | 920                            | 2,190                  | 1,460                 | -540     | 80        | 1,540           | -620     | 220       | 300                                         | 80        |
| 32                      | 365536               | 0911825                | AMAX 801-032                                 | T26N R03W 17BAC   | 920                            | 2,033                  | 1,370                 | -450     | 30        | 1,400           | -480     | 220       | 250                                         | --        |
| 33                      | 365619               | 0911915                | AMAX 801-033                                 | T26N R03W 07ACB   | 880                            | 1,977                  | 1,290                 | -410     | 70        | 1,360           | -480     | 210       | 280                                         | 94        |
| 34                      | 365500               | 0911739                | AMAX 801-034                                 | T26N R03W 16CCB   | 930                            | 2,116                  | 1,370                 | -440     | 40        | 1,410           | -480     | 220       | 260                                         | 61        |
| 35                      | 365449               | 0911907                | AMAX 801-035                                 | T26N R03W 19ABA   | 880                            | 2,020                  | 1,340                 | -460     | 40        | 1,380           | -500     | 220       | 260                                         | --        |
| 36                      | 365443               | 0911746                | AMAX 801-036                                 | T26N R03W 20AAD   | 970                            | 1,983                  | 1,370                 | -400     | 30        | 1,400           | -430     | 210       | 240                                         | --        |
| 37                      | 365437               | 0911753                | AMAX 801-037                                 | T26N R03W 20ADB   | 1,035                          | 2,090                  | 1,410                 | -375     | 70        | 1,480           | -445     | 200       | 270                                         | --        |
| 38                      | 365526               | 0911831                | AMAX 801-038                                 | T26N R03W 17BCA   | 920                            | 2,097                  | 1,350                 | -430     | 70        | 1,420           | -500     | 220       | 290                                         | --        |
| 39                      | 365518               | 0911841                | AMAX 801-039                                 | T26N R03W 17CBB   | 830                            | 1,832                  | 1,190                 | -360     | 70        | 1,260           | -430     | 200       | 270                                         | --        |
| 40                      | 365410               | 0911639                | AMAX 801-040                                 | T26N R03W 21DDA   | 980                            | 1,945                  | 1,310                 | -330     | 50        | 1,360           | -380     | 260       | 310                                         | --        |
| 41                      | 365510               | 0911729                | AMAX 801-041                                 | T26N R03W 16CBD   | 960                            | 2,120                  | 1,420                 | -460     | 50        | 1,470           | -510     | 210       | 260                                         | --        |
| 42                      | 365646               | 0912338                | AMAX 801-042                                 | T26N R04W 04DCC   | 980                            | 2,147                  | 1,510                 | -530     | 70        | 1,580           | -600     | 230       | 300                                         | 71        |
| 43                      | 365406               | 0911802                | AMAX 801-043                                 | T26N R03W 20DCD   | 905                            | 2,106                  | 1,370                 | -465     | 90        | 1,460           | -555     | 210       | 300                                         | 46        |
| 44                      | 365430               | 0911758                | AMAX 801-044                                 | T26N R03W 20ADC   | 970                            | 1,738                  | 1,300                 | -330     | 60        | 1,360           | -390     | 190       | 250                                         | --        |
| 45                      | 365545               | 0912057                | AMAX 801-045                                 | T26N R04W 13BBB   | 940                            | 2,007                  | 1,360                 | -420     | 70        | 1,430           | -490     | 220       | 290                                         | --        |
| 46                      | 365543               | 0912115                | AMAX 801-046                                 | T26N R04W 14AAB   | 830                            | 1,957                  | 1,280                 | -450     | 80        | 1,360           | -530     | 210       | 290                                         | 49        |
| 47                      | 365104               | 0911854                | AMAX 801-047                                 | T25N R03W 08BCB   | 895                            | 2,247                  | 1,460                 | -565     | 70        | 1,530           | -635     | 270       | 340                                         | 106       |
| 48                      | 365654               | 0912315                | AMAX 801-048                                 | T26N R04W 04DAD   | 890                            | 2,038                  | 1,340                 | -450     | 130       | 1,470           | -580     | 190       | 320                                         | 96        |
| 49                      | 365818               | 0911808                | AMAX 801-049                                 | T27N R03W 32BAA   | 1,030                          | 2,137                  | 1,460                 | -430     | 50        | 1,510           | -480     | 200       | 250                                         | 57        |
| 50                      | 365410               | 0911649                | AMAX 801-050                                 | T26N R03W 21DDB   | 960                            | 2,072                  | 1,360                 | -400     | 60        | 1,420           | -460     | 200       | 260                                         | 77        |
| 51                      | 365147               | 0911813                | AMAX 801-051                                 | T25N R03W 05ACD   | 840                            | 2,185                  | 1,430                 | -590     | 60        | 1,490           | -650     | 260       | 320                                         | 100       |
| 52                      | 365310               | 0911301                | AMAX 801-052                                 | T26N R02W 30CDB   | 990                            | 2,200                  | 1,460                 | -470     | 60        | 1,520           | -530     | 200       | 260                                         | --        |
| 53                      | 365222               | 0911306                | AMAX 801-053                                 | T26N R02W 31CDB   | 985                            | 2,169                  | 1,450                 | -465     | 50        | 1,500           | -515     | 260       | 310                                         | 58        |
| 54                      | 365129               | 0911837                | AMAX 801-054                                 | T25N R03W 05CDB   | 920                            | 2,267                  | 1,470                 | -550     | 60        | 1,530           | -610     | 290       | 350                                         | 72        |
| 55                      | 365249               | 0911413                | AMAX 801-055                                 | T26N R03W 36BCA   | 795                            | 1,947                  | 1,240                 | -445     | 70        | 1,310           | -515     | 180       | 250                                         | --        |
| 56                      | 365041               | 0912102                | AMAX 801-056                                 | T25N R04W 12CCB   | 920                            | 2,247                  | 1,450                 | -530     | 60        | 1,510           | -590     | 290       | 350                                         | --        |
| 57                      | 365206               | 0912150                | AMAX 801-057                                 | T25N R04W 02BAC   | 980                            | 2,234                  | 1,490                 | -510     | 60        | 1,550           | -570     | 290       | 350                                         | --        |
| 58                      | 365307               | 0912106                | AMAX 801-058                                 | T26N R04W 35AAA   | 920                            | 2,195                  | 1,490                 | -570     | 80        | 1,570           | -650     | 200       | 280                                         | --        |
| 59                      | 365642               | 0912147                | AMAX 801-059                                 | T26N R04W 02CDD   | 985                            | 1,968                  | 1,320                 | -335     | 70        | 1,390           | -405     | 240       | 310                                         | --        |
| 60                      | 365555               | 0911853                | AMAX 801-060                                 | T26N R03W 07DDA   | 865                            | 1,972                  | 1,300                 | -435     | 60        | 1,360           | -495     | 190       | 250                                         | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 31                      | 365301               | 0912114                | AMAX 801-031                                 | T26N R04W 35AAC   | 920                            | 2,190                  | 1,760                | -840     | 420       | 2,180             | -1,260   | --        | --               | --       |
| 32                      | 365536               | 0911825                | AMAX 801-032                                 | T26N R03W 17BAC   | 920                            | 2,033                  | 1,620                | -700     | 410       | 2,030             | -1,110   | --        | --               | --       |
| 33                      | 365619               | 0911915                | AMAX 801-033                                 | T26N R03W 07ACB   | 880                            | 1,977                  | 1,570                | -690     | 370       | 1,940             | -1,060   | --        | --               | --       |
| 34                      | 365500               | 0911739                | AMAX 801-034                                 | T26N R03W 16CCB   | 930                            | 2,116                  | 1,630                | -700     | 480       | 2,110             | -1,180   | --        | --               | --       |
| 35                      | 365449               | 0911907                | AMAX 801-035                                 | T26N R03W 19ABA   | 880                            | 2,020                  | 1,600                | -720     | 410       | 2,010             | -1,130   | --        | --               | --       |
| 36                      | 365443               | 0911746                | AMAX 801-036                                 | T26N R03W 20AAD   | 970                            | 1,983                  | 1,610                | -640     | 370       | --                | --       | 0         | 1,980            | -1,010   |
| 37                      | 365437               | 0911753                | AMAX 801-037                                 | T26N R03W 20ADB   | 1,035                          | 2,090                  | 1,680                | -645     | 380       | 2,060             | -1,025   | 20        | 2,080            | -1,045   |
| 38                      | 365526               | 0911831                | AMAX 801-038                                 | T26N R03W 17BCA   | 920                            | 2,097                  | 1,640                | -720     | 440       | 2,080             | -1,160   | --        | --               | --       |
| 39                      | 365518               | 0911841                | AMAX 801-039                                 | T26N R03W 17CBB   | 830                            | 1,832                  | 1,460                | -630     | 360       | 1,820             | -990     | --        | --               | --       |
| 40                      | 365410               | 0911639                | AMAX 801-040                                 | T26N R03W 21DDA   | 980                            | 1,945                  | 1,620                | -640     | 290       | --                | --       | 0         | 1,910            | -930     |
| 41                      | 365510               | 0911729                | AMAX 801-041                                 | T26N R03W 16CBD   | 960                            | 2,120                  | 1,680                | -720     | 420       | 2,100             | -1,140   | --        | --               | --       |
| 42                      | 365646               | 0912338                | AMAX 801-042                                 | T26N R04W 04DCC   | 980                            | 2,147                  | 1,810                | -830     | 320       | 2,130             | -1,150   | --        | --               | --       |
| 43                      | 365406               | 0911802                | AMAX 801-043                                 | T26N R03W 20DCD   | 905                            | 2,106                  | 1,670                | -765     | 420       | 2,090             | -1,185   | --        | --               | --       |
| 44                      | 365430               | 0911758                | AMAX 801-044                                 | T26N R03W 20ADC   | 970                            | 1,738                  | 1,550                | -580     | 120       | --                | --       | 0         | 1,670            | -700     |
| 45                      | 365545               | 0912057                | AMAX 801-045                                 | T26N R04W 13BBB   | 940                            | 2,007                  | 1,650                | -710     | 350       | 2,000             | -1,060   | --        | --               | --       |
| 46                      | 365543               | 0912115                | AMAX 801-046                                 | T26N R04W 14AAB   | 830                            | 1,957                  | 1,570                | -740     | 360       | 1,930             | -1,100   | --        | --               | --       |
| 47                      | 365104               | 0911854                | AMAX 801-047                                 | T25N R03W 08BCB   | 895                            | 2,247                  | 1,800                | -905     | 430       | 2,230             | -1,335   | --        | --               | --       |
| 48                      | 365654               | 0912315                | AMAX 801-048                                 | T26N R04W 04DAD   | 890                            | 2,038                  | 1,660                | -770     | 350       | 2,010             | -1,120   | --        | --               | --       |
| 49                      | 365818               | 0911808                | AMAX 801-049                                 | T27N R03W 32BAA   | 1,030                          | 2,137                  | 1,710                | -680     | 390       | 2,100             | -1,070   | --        | --               | --       |
| 50                      | 365410               | 0911649                | AMAX 801-050                                 | T26N R03W 21DDB   | 960                            | 2,072                  | 1,620                | -660     | 430       | 2,050             | -1,090   | --        | --               | --       |
| 51                      | 365147               | 0911813                | AMAX 801-051                                 | T25N R03W 05ACD   | 840                            | 2,185                  | 1,750                | -910     | 430       | 2,180             | -1,340   | --        | --               | --       |
| 52                      | 365310               | 0911301                | AMAX 801-052                                 | T26N R02W 30CDB   | 990                            | 2,200                  | 1,720                | -730     | 470       | 2,190             | -1,200   | --        | --               | --       |
| 53                      | 365222               | 0911306                | AMAX 801-053                                 | T26N R02W 31CDB   | 985                            | 2,169                  | 1,760                | -775     | 390       | 2,150             | -1,165   | --        | --               | --       |
| 54                      | 365129               | 0911837                | AMAX 801-054                                 | T25N R03W 05CDB   | 920                            | 2,267                  | 1,820                | -900     | 430       | 2,250             | -1,330   | --        | --               | --       |
| 55                      | 365249               | 0911413                | AMAX 801-055                                 | T26N R03W 36BCA   | 795                            | 1,947                  | 1,490                | -695     | 440       | 1,930             | -1,135   | --        | --               | --       |
| 56                      | 365041               | 0912102                | AMAX 801-056                                 | T25N R04W 12CCB   | 920                            | 2,247                  | 1,800                | -880     | 430       | 2,230             | -1,310   | --        | --               | --       |
| 57                      | 365206               | 0912150                | AMAX 801-057                                 | T25N R04W 02BAC   | 980                            | 2,234                  | 1,840                | -860     | 390       | 2,230             | -1,250   | --        | --               | --       |
| 58                      | 365307               | 0912106                | AMAX 801-058                                 | T26N R04W 35AAA   | 920                            | 2,195                  | 1,770                | -850     | 420       | 2,190             | -1,270   | --        | --               | --       |
| 59                      | 365642               | 0912147                | AMAX 801-059                                 | T26N R04W 02CDD   | 985                            | 1,968                  | 1,630                | -645     | 330       | 1,960             | -975     | --        | --               | --       |
| 60                      | 365555               | 0911853                | AMAX 801-060                                 | T26N R03W 07DDA   | 865                            | 1,972                  | 1,550                | -685     | 400       | 1,950             | -1,085   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 61                      | 365549               | 0911855               | AMAX 801-061                                 | T26N R03W 07DDC   | 855                            | 1,977                  | 1,280                 | -425     | 80        | 1,360           | -505     | 190       | 270                                         | --        |
| 62                      | 365121               | 0911436               | AMAX 801-062                                 | T25N R03W 02DDD   | 1,010                          | 2,325                  | 1,570                 | -560     | 70        | 1,640           | -630     | 240       | 310                                         | 88        |
| 63                      | 365540               | 0912000               | AMAX 801-063                                 | T26N R04W 13AAA   | 980                            | 1,972                  | 1,350                 | -370     | 70        | 1,420           | -440     | 210       | 280                                         | 51        |
| 64                      | 365618               | 0912620               | AMAX 801-064                                 | T26N R04W 07BCA   | 980                            | 2,099                  | 1,370                 | -390     | 90        | 1,460           | -480     | 240       | 330                                         | 162       |
| 65                      | 365152               | 0911515               | AMAX 801-065                                 | T25N R03W 02BDC   | 950                            | 2,257                  | 1,500                 | -550     | 60        | 1,560           | -610     | 240       | 300                                         | 80        |
| 66                      | 365511               | 0912057               | AMAX 801-066                                 | T26N R04W 13CBC   | 915                            | 2,137                  | 1,430                 | -515     | 70        | 1,500           | -585     | 220       | 290                                         | 71        |
| 67                      | 365513               | 0912055               | AMAX 801-067                                 | T26N R04W 13CBD   | 945                            | 2,148                  | 1,420                 | -475     | 110       | 1,530           | -585     | 200       | 310                                         | 59        |
| 68                      | 365543               | 0912221               | AMAX 801-068                                 | T26N R04W 15AAB   | 900                            | 2,062                  | 1,380                 | -480     | 70        | 1,450           | -550     | 190       | 260                                         | 79        |
| 69                      | 365424               | 0911958               | AMAX 801-069                                 | T26N R03W 19CBB   | 885                            | 2,117                  | 1,380                 | -495     | 90        | 1,470           | -585     | 210       | 300                                         | --        |
| 70                      | 365004               | 0911633               | AMAX 801-070                                 | T25N R03W 15BDC   | 640                            | 1,926                  | 1,160                 | -520     | 60        | 1,220           | -580     | 240       | 300                                         | --        |
| 71                      | 365531               | 0911831               | AMAX 801-071                                 | T26N R03W 17BCA   | 930                            | 2,100                  | 1,350                 | -420     | 80        | 1,430           | -500     | 200       | 280                                         | --        |
| 72                      | 365536               | 0911827               | AMAX 801-072                                 | T26N R03W 17BAC   | 930                            | 2,068                  | 1,360                 | -430     | 70        | 1,430           | -500     | 200       | 270                                         | --        |
| 73                      | 365115               | 0911329               | AMAX 801-073                                 | T25N R03W 12AAA   | 990                            | 2,345                  | 1,560                 | -570     | 70        | 1,630           | -640     | 220       | 290                                         | 71        |
| 74                      | 365430               | 0911941               | AMAX 801-074                                 | T26N R03W 19BCD   | 900                            | 2,108                  | 1,390                 | -490     | 90        | 1,480           | -580     | 200       | 290                                         | --        |
| 75                      | 365433               | 0911929               | AMAX 801-075                                 | T26N R03W 19BDC   | 830                            | 2,018                  | 1,300                 | -470     | 80        | 1,380           | -550     | 210       | 290                                         | 54        |
| 76                      | 365906               | 0912210               | AMAX 801-076                                 | T27N R04W 27AAD   | 1,090                          | 2,142                  | 1,540                 | -450     | 110       | 1,650           | -560     | 150       | 260                                         | 43        |
| 77                      | 365533               | 0912053               | AMAX 801-077                                 | T26N R04W 13BCA   | 985                            | 2,088                  | 1,450                 | -465     | 70        | 1,520           | -535     | 200       | 270                                         | 74        |
| 78                      | 365521               | 0912058               | AMAX 801-078                                 | T26N R04W 13BCC   | 940                            | 2,135                  | 1,440                 | -500     | 60        | 1,500           | -560     | 220       | 280                                         | 72        |
| 79                      | 365543               | 0912014               | AMAX 801-079                                 | T26N R04W 13AAB   | 950                            | 2,036                  | 1,340                 | -390     | 60        | 1,400           | -450     | 200       | 260                                         | 62        |
| 80                      | 365536               | 0912044               | AMAX 801-080                                 | T26N R04W 13BAC   | 975                            | 2,078                  | 1,450                 | -475     | 70        | 1,520           | -545     | 190       | 260                                         | 50        |
| 81                      | 365539               | 0912032               | AMAX 801-081                                 | T26N R04W 13BAD   | 960                            | 2,084                  | 1,390                 | -430     | 80        | 1,470           | -510     | 200       | 280                                         | 62        |
| 82                      | 365542               | 0912045               | AMAX 801-082                                 | T26N R04W 13BAB   | 955                            | 2,058                  | 1,370                 | -415     | 80        | 1,450           | -495     | 210       | 290                                         | 62        |
| 83                      | 365544               | 0912055               | AMAX 801-083                                 | T26N R04W 13BBA   | 920                            | 1,989                  | 1,340                 | -420     | 70        | 1,410           | -490     | 210       | 280                                         | 98        |
| 84                      | 365538               | 0912026               | AMAX 801-084                                 | T26N R04W 13ABC   | 920                            | 2,053                  | 1,350                 | -430     | 70        | 1,420           | -500     | 210       | 280                                         | 63        |
| 85                      | 365201               | 0911516               | AMAX 801-085                                 | T25N R03W 02BAC   | 920                            | 2,285                  | 1,560                 | -640     | 60        | 1,620           | -700     | 200       | 260                                         | --        |
| 86                      | 364934               | 0911722               | AMAX 801-086                                 | T25N R03W 21BAA   | 690                            | 2,148                  | 1,410                 | -720     | 80        | 1,490           | -800     | 210       | 290                                         | 143       |
| 87                      | 364950               | 0912044               | AMAX 801-087                                 | T25N R04W 13CDB   | 890                            | 2,248                  | 1,500                 | -610     | 50        | 1,550           | -660     | 270       | 320                                         | 87        |
| 88                      | 365601               | 0911841               | AMAX 801-088                                 | T26N R03W 08CBC   | 870                            | 1,974                  | 1,290                 | -420     | 60        | 1,350           | -480     | 190       | 250                                         | 44        |
| 89                      | 365302               | 0911256               | AMAX 801-089                                 | T26N R02W 30CDD   | 1,000                          | 2,165                  | 1,470                 | -470     | 70        | 1,540           | -540     | 220       | 290                                         | 47        |
| 90                      | 365243               | 0911254               | AMAX 801-090                                 | T26N R02W 31BDA   | 970                            | 2,218                  | 1,480                 | -510     | 70        | 1,550           | -580     | 230       | 300                                         | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 61                      | 365549               | 0911855               | AMAX 801-061                                 | T26N R03W 07DDC   | 855                            | 1,977                  | 1,550                | -695     | 420       | 1,970             | -1,115   | --        | --               | --       |
| 62                      | 365121               | 0911436               | AMAX 801-062                                 | T25N R03W 02DDD   | 1,010                          | 2,325                  | 1,880                | -870     | 440       | 2,320             | -1,310   | --        | --               | --       |
| 63                      | 365540               | 0912000               | AMAX 801-063                                 | T26N R04W 13AAA   | 980                            | 1,972                  | 1,630                | -650     | 300       | --                | --       | 0         | 1,930            | -950     |
| 64                      | 365618               | 0912620               | AMAX 801-064                                 | T26N R04W 07BCA   | 980                            | 2,099                  | 1,700                | -720     | 360       | 2,060             | -1,080   | --        | --               | --       |
| 65                      | 365152               | 0911515               | AMAX 801-065                                 | T25N R03W 02BDC   | 950                            | 2,257                  | 1,800                | -850     | 440       | 2,240             | -1,290   | --        | --               | --       |
| 66                      | 365511               | 0912057               | AMAX 801-066                                 | T26N R04W 13CBC   | 915                            | 2,137                  | 1,720                | -805     | 400       | 2,120             | -1,205   | --        | --               | --       |
| 67                      | 365513               | 0912055               | AMAX 801-067                                 | T26N R04W 13CBD   | 945                            | 2,148                  | 1,730                | -785     | 310       | 2,040             | -1,095   | --        | --               | --       |
| 68                      | 365543               | 0912221               | AMAX 801-068                                 | T26N R04W 15AAB   | 900                            | 2,062                  | 1,640                | -740     | 390       | 2,030             | -1,130   | --        | --               | --       |
| 69                      | 365424               | 0911958               | AMAX 801-069                                 | T26N R03W 19CBB   | 885                            | 2,117                  | 1,680                | -795     | 420       | 2,100             | -1,215   | --        | --               | --       |
| 70                      | 365004               | 0911633               | AMAX 801-070                                 | T25N R03W 15BDC   | 640                            | 1,926                  | 1,460                | -820     | 440       | 1,900             | -1,260   | --        | --               | --       |
| 71                      | 365531               | 0911831               | AMAX 801-071                                 | T26N R03W 17BCA   | 930                            | 2,100                  | 1,630                | -700     | 470       | 2,100             | -1,170   | --        | --               | --       |
| 72                      | 365536               | 0911827               | AMAX 801-072                                 | T26N R03W 17BAC   | 930                            | 2,068                  | 1,630                | -700     | 420       | 2,050             | -1,120   | --        | --               | --       |
| 73                      | 365115               | 0911329               | AMAX 801-073                                 | T25N R03W 12AAA   | 990                            | 2,345                  | 1,850                | -860     | 490       | 2,340             | -1,350   | --        | --               | --       |
| 74                      | 365430               | 0911941               | AMAX 801-074                                 | T26N R03W 19BCD   | 900                            | 2,108                  | 1,680                | -780     | 420       | 2,100             | -1,200   | --        | --               | --       |
| 75                      | 365433               | 0911929               | AMAX 801-075                                 | T26N R03W 19BDC   | 830                            | 2,018                  | 1,590                | -760     | 410       | 2,000             | -1,170   | --        | --               | --       |
| 76                      | 365906               | 0912210               | AMAX 801-076                                 | T27N R04W 27AAD   | 1,090                          | 2,142                  | 1,800                | -710     | 340       | 2,140             | -1,050   | --        | --               | --       |
| 77                      | 365533               | 0912053               | AMAX 801-077                                 | T26N R04W 13BCA   | 985                            | 2,088                  | 1,720                | -735     | 340       | 2,060             | -1,075   | --        | --               | --       |
| 78                      | 365521               | 0912058               | AMAX 801-078                                 | T26N R04W 13BCC   | 940                            | 2,135                  | 1,720                | -780     | 400       | 2,120             | -1,180   | --        | --               | --       |
| 79                      | 365543               | 0912014               | AMAX 801-079                                 | T26N R04W 13AAB   | 950                            | 2,036                  | 1,600                | -650     | 400       | 2,000             | -1,050   | --        | --               | --       |
| 80                      | 365536               | 0912044               | AMAX 801-080                                 | T26N R04W 13BAC   | 975                            | 2,078                  | 1,710                | -735     | 360       | 2,070             | -1,095   | --        | --               | --       |
| 81                      | 365539               | 0912032               | AMAX 801-081                                 | T26N R04W 13BAD   | 960                            | 2,084                  | 1,670                | -710     | 400       | 2,070             | -1,110   | --        | --               | --       |
| 82                      | 365542               | 0912045               | AMAX 801-082                                 | T26N R04W 13BAB   | 955                            | 2,058                  | 1,660                | -705     | 380       | 2,040             | -1,085   | --        | --               | --       |
| 83                      | 365544               | 0912055               | AMAX 801-083                                 | T26N R04W 13BBA   | 920                            | 1,989                  | 1,620                | -700     | 350       | 1,970             | -1,050   | --        | --               | --       |
| 84                      | 365538               | 0912026               | AMAX 801-084                                 | T26N R04W 13ABC   | 920                            | 2,053                  | 1,630                | -710     | 410       | 2,040             | -1,120   | --        | --               | --       |
| 85                      | 365201               | 0911516               | AMAX 801-085                                 | T25N R03W 02BAC   | 920                            | 2,285                  | 1,820                | -900     | 440       | 2,260             | -1,340   | --        | --               | --       |
| 86                      | 364934               | 0911722               | AMAX 801-086                                 | T25N R03W 21BAA   | 690                            | 2,148                  | 1,700                | -1,010   | 440       | 2,140             | -1,450   | --        | --               | --       |
| 87                      | 364950               | 0912044               | AMAX 801-087                                 | T25N R04W 13CDB   | 890                            | 2,248                  | 1,820                | -930     | 410       | 2,230             | -1,340   | --        | --               | --       |
| 88                      | 365601               | 0911841               | AMAX 801-088                                 | T26N R03W 08CBC   | 870                            | 1,974                  | 1,540                | -670     | 410       | 1,950             | -1,080   | --        | --               | --       |
| 89                      | 365302               | 0911256               | AMAX 801-089                                 | T26N R02W 30CDD   | 1,000                          | 2,165                  | 1,760                | -760     | 350       | 2,110             | -1,110   | 40        | 2,150            | -1,150   |
| 90                      | 365243               | 0911254               | AMAX 801-090                                 | T26N R02W 31BDA   | 970                            | 2,218                  | 1,780                | -810     | 400       | 2,180             | -1,210   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 91                      | 365254               | 0911302               | AMAX 801-091                                 | T26N R02W 31BAC   | 980                            | 2,173                  | 1,450                 | -470     | 70        | 1,520           | -540     | 240       | 310                                         | --        |
| 92                      | 365231               | 0911302               | AMAX 801-092                                 | T26N R02W 31CAB   | 990                            | 2,223                  | 1,500                 | -510     | 90        | 1,590           | -600     | 220       | 310                                         | 8.7       |
| 93                      | 364902               | 0912047               | AMAX 801-093                                 | T25N R04W 24CAC   | 580                            | 1,962                  | 1,190                 | -610     | 100       | 1,290           | -710     | 220       | 320                                         | --        |
| 94                      | 365150               | 0911716               | AMAX 801-094                                 | T25N R03W 04ACC   | 640                            | 2,002                  | 1,280                 | -640     | 70        | 1,350           | -710     | 210       | 280                                         | 102       |
| 95                      | 365051               | 0911701               | AMAX 801-095                                 | T25N R03W 09DAB   | 830                            | 2,221                  | 1,500                 | -670     | 80        | 1,580           | -750     | 200       | 280                                         | --        |
| 96                      | 365417               | 0912028               | AMAX 801-096                                 | T26N R04W 24DBC   | 910                            | 2,128                  | 1,430                 | -520     | 60        | 1,490           | -580     | 210       | 270                                         | 74        |
| 97                      | 365406               | 0912031               | AMAX 801-097                                 | T26N R04W 24DCC   | 890                            | 2,111                  | 1,400                 | -510     | 90        | 1,490           | -600     | 200       | 290                                         | 77        |
| 98                      | 365358               | 0912042               | AMAX 801-098                                 | T26N R04W 25BAB   | 840                            | 2,096                  | 1,380                 | -540     | 80        | 1,460           | -620     | 210       | 290                                         | 89        |
| 99                      | 365512               | 0912046               | AMAX 801-099                                 | T26N R04W 13CAC   | 900                            | 2,085                  | 1,390                 | -490     | 60        | 1,450           | -550     | 200       | 260                                         | 73        |
| 100                     | 365519               | 0912041               | AMAX 801-100                                 | T26N R04W 13CAB   | 900                            | 2,073                  | 1,380                 | -480     | 70        | 1,450           | -550     | 190       | 260                                         | 73        |
| 101                     | 365528               | 0912040               | AMAX 801-101                                 | T26N R04W 13BDB   | 960                            | 2,124                  | 1,410                 | -450     | 80        | 1,490           | -530     | 210       | 290                                         | --        |
| 102                     | 365444               | 0911914               | AMAX 801-102                                 | T26N R03W 19ABC2  | 910                            | 2,088                  | 1,390                 | -480     | 70        | 1,460           | -550     | 190       | 260                                         | --        |
| 103                     | 365524               | 0911836               | AMAX 801-103                                 | T26N R03W 17BCD   | 940                            | 1,854                  | 1,290                 | -350     | 70        | 1,360           | -420     | 180       | 250                                         | --        |
| 104                     | 365532               | 0912026               | AMAX 801-104                                 | T26N R04W 13ACB   | 900                            | 2,058                  | 1,330                 | -430     | 70        | 1,400           | -500     | 210       | 280                                         | 41        |
| 105                     | 365203               | 0911304               | AMAX 801-105                                 | T25N R02W 06BAB1  | 970                            | 2,204                  | 1,470                 | -500     | 70        | 1,540           | -570     | 210       | 280                                         | 69        |
| 106                     | 365156               | 0912231               | AMAX 801-106                                 | T25N R04W 03ACD1  | 986                            | 2,278                  | 1,530                 | -544     | 100       | 1,630           | -644     | 210       | 310                                         | 104       |
| 107                     | 365543               | 0912132               | AMAX 801-107                                 | T26N R04W 14ABB   | 950                            | 2,138                  | 1,410                 | -460     | 90        | 1,500           | -550     | 190       | 280                                         | --        |
| 108                     | 365510               | 0911843               | AMAX 801-108                                 | T26N R03W 17CBC   | 840                            | 1,882                  | 1,220                 | -380     | 60        | 1,280           | -440     | 190       | 250                                         | 57        |
| 109                     | 365502               | 0911849               | AMAX 801-109                                 | T26N R03W 18DDA3  | 910                            | 2,278                  | 1,240                 | -330     | 70        | 1,310           | -400     | 180       | 250                                         | --        |
| 110                     | 365456               | 0911858               | AMAX 801-110                                 | T26N R03W 18DDC1  | 900                            | 1,944                  | 1,300                 | -400     | 60        | 1,360           | -460     | 190       | 250                                         | --        |
| 111                     | 365604               | 0911945               | AMAX 801-111                                 | T26N R03W 07CBC1  | 880                            | 1,987                  | 1,300                 | -420     | 60        | 1,360           | -480     | 150       | 210                                         | --        |
| 112                     | 365559               | 0911942               | AMAX 801-112                                 | T26N R03W 07C 1   | 930                            | 1,987                  | 1,310                 | -380     | 50        | 1,360           | -430     | 200       | 250                                         | --        |
| 113                     | 364850               | 0911907               | AMAX 801-114                                 | T25N R03W 19DDC   | 925                            | 2,328                  | 1,560                 | -635     | 50        | 1,610           | -685     | 260       | 310                                         | 114       |
| 114                     | 365546               | 0912139               | AMAX 801-115                                 | T26N R04W 14BAA   | 960                            | 2,099                  | 1,410                 | -450     | 90        | 1,500           | -540     | 190       | 280                                         | --        |
| 115                     | 365542               | 0912125               | AMAX 801-116                                 | T26N R04W 14ABA   | 945                            | 2,100                  | 1,390                 | -445     | 90        | 1,480           | -535     | 190       | 280                                         | --        |
| 116                     | 365207               | 0912203               | AMAX 801-117                                 | T25N R04W 02BBC1  | 979                            | 2,258                  | 1,530                 | -551     | 100       | 1,630           | -651     | 210       | 310                                         | --        |
| 117                     | 365155               | 0912215               | AMAX 801-118                                 | T25N R04W 03ADD1  | 960                            | 2,258                  | 1,520                 | -560     | 110       | 1,630           | -670     | 200       | 310                                         | --        |
| 118                     | 365205               | 0912103               | AMAX 801-119                                 | T25N R04W 01BBC   | 960                            | 2,258                  | 1,550                 | -590     | 60        | 1,610           | -650     | 230       | 290                                         | --        |
| 119                     | 365041               | 0912015               | AMAX 801-120                                 | T25N R04W 12DDB1  | 920                            | 2,268                  | 1,530                 | -610     | 70        | 1,600           | -680     | 220       | 290                                         | --        |
| 120                     | 365233               | 0912044               | AMAX 801-121                                 | T26N R04W 36CAC   | 940                            | 2,251                  | 1,520                 | -580     | 100       | 1,620           | -680     | 190       | 290                                         | 63        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 91                      | 365254               | 0911302                | AMAX 801-091                                 | T26N R02W 31BAC   | 980                            | 2,173                  | 1,760                | -780     | 400       | 2,160             | -1,180   | 10        | 2,170            | -1,190   |
| 92                      | 365231               | 0911302                | AMAX 801-092                                 | T26N R02W 31CAB   | 990                            | 2,223                  | 1,810                | -820     | 410       | 2,220             | -1,230   | --        | --               | --       |
| 93                      | 364902               | 0912047                | AMAX 801-093                                 | T25N R04W 24CAC   | 580                            | 1,962                  | 1,510                | -930     | 440       | 1,950             | -1,370   | --        | --               | --       |
| 94                      | 365150               | 0911716                | AMAX 801-094                                 | T25N R03W 04ACC   | 640                            | 2,002                  | 1,560                | -920     | 430       | 1,990             | -1,350   | --        | --               | --       |
| 95                      | 365051               | 0911701                | AMAX 801-095                                 | T25N R03W 09DAB   | 830                            | 2,221                  | 1,780                | -950     | 440       | 2,220             | -1,390   | --        | --               | --       |
| 96                      | 365417               | 0912028                | AMAX 801-096                                 | T26N R04W 24DBC   | 910                            | 2,128                  | 1,700                | -790     | 420       | 2,120             | -1,210   | --        | --               | --       |
| 97                      | 365406               | 0912031                | AMAX 801-097                                 | T26N R04W 24DCC   | 890                            | 2,111                  | 1,690                | -800     | 410       | 2,100             | -1,210   | --        | --               | --       |
| 98                      | 365358               | 0912042                | AMAX 801-098                                 | T26N R04W 25BAB   | 840                            | 2,096                  | 1,670                | -830     | 410       | 2,080             | -1,240   | --        | --               | --       |
| 99                      | 365512               | 0912046                | AMAX 801-099                                 | T26N R04W 13CAC   | 900                            | 2,085                  | 1,650                | -750     | 420       | 2,070             | -1,170   | --        | --               | --       |
| 100                     | 365519               | 0912041                | AMAX 801-100                                 | T26N R04W 13CAB   | 900                            | 2,073                  | 1,640                | -740     | 410       | 2,050             | -1,150   | --        | --               | --       |
| 101                     | 365528               | 0912040                | AMAX 801-101                                 | T26N R04W 13BDB   | 960                            | 2,124                  | 1,700                | -740     | 400       | 2,100             | -1,140   | --        | --               | --       |
| 102                     | 365444               | 0911914                | AMAX 801-102                                 | T26N R03W 19ABC2  | 910                            | 2,088                  | 1,650                | -740     | 420       | 2,070             | -1,160   | --        | --               | --       |
| 103                     | 365524               | 0911836                | AMAX 801-103                                 | T26N R03W 17BCD   | 940                            | 1,854                  | 1,540                | -600     | 300       | --                | --       | 0         | 1,840            | -900     |
| 104                     | 365532               | 0912026                | AMAX 801-104                                 | T26N R04W 13ACB   | 900                            | 2,058                  | 1,610                | -710     | 410       | 2,020             | -1,120   | --        | --               | --       |
| 105                     | 365203               | 0911304                | AMAX 801-105                                 | T25N R02W 06BAB1  | 970                            | 2,204                  | 1,750                | -780     | 410       | 2,160             | -1,190   | 30        | 2,190            | -1,220   |
| 106                     | 365156               | 0912231                | AMAX 801-106                                 | T25N R04W 03ACD1  | 986                            | 2,278                  | 1,840                | -854     | 420       | 2,260             | -1,274   | --        | --               | --       |
| 107                     | 365543               | 0912132                | AMAX 801-107                                 | T26N R04W 14ABB   | 950                            | 2,138                  | 1,690                | -740     | 420       | 2,110             | -1,160   | --        | --               | --       |
| 108                     | 365510               | 0911843                | AMAX 801-108                                 | T26N R03W 17CBC   | 840                            | 1,882                  | 1,470                | -630     | 400       | 1,870             | -1,030   | 10        | 1,880            | -1,040   |
| 109                     | 365502               | 0911849                | AMAX 801-109                                 | T26N R03W 18DDA3  | 910                            | 2,278                  | 1,490                | -580     | 240       | 1,730             | -820     | 10        | 1,740            | -830     |
| 110                     | 365456               | 0911858                | AMAX 801-110                                 | T26N R03W 18DDC1  | 900                            | 1,944                  | 1,550                | -650     | 380       | 1,930             | -1,030   | 10        | 1,940            | -1,040   |
| 111                     | 365604               | 0911945                | AMAX 801-111                                 | T26N R03W 07CBC1  | 880                            | 1,987                  | 1,510                | -630     | 430       | 1,940             | -1,060   | --        | --               | --       |
| 112                     | 365559               | 0911942                | AMAX 801-112                                 | T26N R03W 07C 1   | 930                            | 1,987                  | 1,560                | -630     | 320       | --                | --       | 0         | 1,880            | -950     |
| 113                     | 364850               | 0911907                | AMAX 801-114                                 | T25N R03W 19DDC   | 925                            | 2,328                  | 1,870                | -945     | 430       | 2,300             | -1,375   | --        | --               | --       |
| 114                     | 365546               | 0912139                | AMAX 801-115                                 | T26N R04W 14BAA   | 960                            | 2,099                  | 1,690                | -730     | 410       | 2,100             | -1,140   | --        | --               | --       |
| 115                     | 365542               | 0912125                | AMAX 801-116                                 | T26N R04W 14ABA   | 945                            | 2,100                  | 1,670                | -725     | 400       | 2,070             | -1,125   | --        | --               | --       |
| 116                     | 365207               | 0912203                | AMAX 801-117                                 | T25N R04W 02BBC1  | 979                            | 2,258                  | 1,840                | -861     | 400       | 2,240             | -1,261   | --        | --               | --       |
| 117                     | 365155               | 0912215                | AMAX 801-118                                 | T25N R04W 03ADD1  | 960                            | 2,258                  | 1,830                | -870     | 420       | 2,250             | -1,290   | --        | --               | --       |
| 118                     | 365205               | 0912103                | AMAX 801-119                                 | T25N R04W 01BBC   | 960                            | 2,258                  | 1,840                | -880     | 410       | 2,250             | -1,290   | --        | --               | --       |
| 119                     | 365041               | 0912015                | AMAX 801-120                                 | T25N R04W 12DDB1  | 920                            | 2,268                  | 1,820                | -900     | 430       | 2,250             | -1,330   | --        | --               | --       |
| 120                     | 365233               | 0912044                | AMAX 801-121                                 | T26N R04W 36CAC   | 940                            | 2,251                  | 1,810                | -870     | 430       | 2,240             | -1,300   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 121                     | 365136               | 0912133               | AMAX 801-122                                 | T25N R04W 02DCB1  | 930                            | 2,258                  | 1,520                 | -590     | 110       | 1,630           | -700     | 190       | 300                                         | 75        |
| 122                     | 365210               | 0911920               | AMAX 801-123                                 | T25N R03W 06AB    | 935                            | 2,263                  | 1,520                 | -585     | 100       | 1,620           | -685     | 200       | 300                                         | 79        |
| 123                     | 365250               | 0911915               | AMAX 801-124                                 | T26N R03W 31ACB   | 900                            | 2,428                  | 1,480                 | -580     | 80        | 1,560           | -660     | 210       | 290                                         | 76        |
| 124                     | 365809               | 0912214               | AMAX 801-125                                 | T27N R04W 34ADA   | 1,020                          | 2,178                  | 1,480                 | -460     | 80        | 1,560           | -540     | 200       | 280                                         | 60        |
| 125                     | 365543               | 0912107               | AMAX 801-126                                 | T26N R04W 14AAA   | 945                            | 2,078                  | 1,400                 | -455     | 60        | 1,460           | -515     | 200       | 260                                         | 66        |
| 126                     | 365543               | 0912146               | AMAX 801-127                                 | T26N R04W 14BAB   | 990                            | 2,123                  | 1,430                 | -440     | 90        | 1,520           | -530     | 200       | 290                                         | --        |
| 127                     | 365111               | 0912035               | AMAX 801-128                                 | T25N R04W 12BDA1  | 940                            | 2,278                  | 1,540                 | -600     | 80        | 1,620           | -680     | 220       | 300                                         | --        |
| 128                     | 365131               | 0912206               | AMAX 801-129                                 | T25N R04W 02CCC1  | 855                            | 2,278                  | 1,400                 | -545     | 100       | 1,500           | -645     | 200       | 300                                         | --        |
| 129                     | 365114               | 0912128               | AMAX 801-131                                 | T25N R04W 11ABD1  | 890                            | 2,248                  | 1,480                 | -590     | 80        | 1,560           | -670     | 210       | 290                                         | --        |
| 130                     | 365602               | 0911933               | AMAX 801-132                                 | T26N R03W 07C 2   | 870                            | 2,248                  | 1,280                 | -410     | 80        | 1,360           | -490     | 200       | 280                                         | --        |
| 131                     | 365601               | 0911950               | AMAX 801-133                                 | T26N R03W 07CBC2  | 885                            | 2,008                  | 1,300                 | -415     | 50        | 1,350           | -465     | 200       | 250                                         | --        |
| 132                     | 365612               | 0911928               | AMAX 801-134                                 | T26N R03W 07DBB   | 950                            | 2,068                  | 1,370                 | -420     | 70        | 1,440           | -490     | 200       | 270                                         | --        |
| 133                     | 365505               | 0912114               | AMAX 801-135                                 | T26N R04W 14ddb   | 960                            | 2,160                  | 1,460                 | -500     | 70        | 1,530           | -570     | 200       | 270                                         | 64        |
| 134                     | 365235               | 0911930               | AMAX 801-136                                 | T26N R03W 31CAD   | 880                            | 2,258                  | 1,520                 | -640     | 80        | 1,600           | -720     | 200       | 280                                         | --        |
| 135                     | 365255               | 0912030               | AMAX 801-137                                 | T26N R04W 36ACB   | 905                            | 2,208                  | 1,500                 | -595     | 70        | 1,570           | -665     | 200       | 270                                         | 82        |
| 136                     | 365642               | 0912204               | AMAX 801-138                                 | T26N R04W 02CCC   | 925                            | 2,068                  | 1,340                 | -415     | 90        | 1,430           | -505     | 200       | 290                                         | --        |
| 137                     | 365031               | 0912320               | AMAX 801-139                                 | T25N R04W 16AAA   | 680                            | 2,041                  | 1,250                 | -570     | 60        | 1,310           | -630     | 230       | 290                                         | --        |
| 138                     | 365640               | 0911910               | AMAX 801-142                                 | T26N R03W 06DCC   | 950                            | 2,074                  | 1,390                 | -440     | 70        | 1,460           | -510     | 190       | 260                                         | --        |
| 139                     | 365637               | 0911955               | AMAX 801-143                                 | T26N R03W 07BBB   | 980                            | 2,088                  | 1,390                 | -410     | 70        | 1,460           | -480     | 200       | 270                                         | --        |
| 140                     | 365540               | 0911908               | AMAX 801-144                                 | T26N R03W 18ABA   | 853                            | 2,088                  | 1,270                 | -417     | 70        | 1,340           | -487     | 190       | 260                                         | --        |
| 141                     | 365539               | 0911919               | AMAX 801-145                                 | T26N R03W 18ABB   | 920                            | 2,068                  | 1,360                 | -440     | 60        | 1,420           | -500     | 200       | 260                                         | --        |
| 142                     | 365459               | 0912127               | AMAX 801-146                                 | T26N R04W 14DCC   | 800                            | 2,000                  | 1,290                 | -490     | 60        | 1,350           | -550     | 200       | 260                                         | --        |
| 143                     | 365314               | 0912200               | AMAX 801-147                                 | T26N R04W 26CCD   | 955                            | 2,216                  | 1,510                 | -555     | 80        | 1,590           | -635     | 220       | 300                                         | 85        |
| 144                     | 365051               | 0912202               | AMAX 801-148                                 | T25N R04W 11CBD   | 920                            | 2,241                  | 1,530                 | -610     | 90        | 1,620           | -700     | 200       | 290                                         | --        |
| 145                     | 365128               | 0912229               | AMAX 801-149                                 | T25N R04W 03DCD   | 910                            | 2,241                  | 1,490                 | -580     | 80        | 1,570           | -660     | 200       | 280                                         | --        |
| 146                     | 365211               | 0911305               | AMAX 801-150                                 | T26N R02W 31CDC   | 975                            | 1,870                  | 1,390                 | -415     | 70        | 1,460           | -485     | 200       | 270                                         | --        |
| 147                     | 365539               | 0912144               | AMAX 801-151                                 | T26N R04W 14BAB   | 865                            | 2,020                  | 1,320                 | -455     | 80        | 1,400           | -535     | 200       | 280                                         | --        |
| 148                     | 365334               | 0912309               | AMAX 801-152                                 | T26N R04W 27CBB   | 984                            | 2,229                  | 1,560                 | -576     | 80        | 1,640           | -656     | 200       | 280                                         | --        |
| 149                     | 365526               | 0912343               | AMAX 801-153                                 | T26N R04W 16ACC   | 875                            | 2,030                  | 1,400                 | -525     | 80        | 1,480           | -605     | 200       | 280                                         | 125       |
| 150                     | 365528               | 0912246               | AMAX 801-154                                 | T26N R04W 15BDA   | --                             | 1,200                  | --                    | --       | --        | --              | --       | --        | --                                          | 99        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 121                     | 365136               | 0912133               | AMAX 801-122                                 | T25N R04W 02DCB1  | 930                            | 2,258                  | 1,820                | -890     | 420       | 2,240             | -1,310   | --        | --               | --       |
| 122                     | 365210               | 0911920               | AMAX 801-123                                 | T25N R03W 06AB    | 935                            | 2,263                  | 1,820                | -885     | 430       | 2,250             | -1,315   | --        | --               | --       |
| 123                     | 365250               | 0911915               | AMAX 801-124                                 | T26N R03W 31ACB   | 900                            | 2,428                  | 1,770                | -870     | --        | --                | --       | 0         | --               | --       |
| 124                     | 365809               | 0912214               | AMAX 801-125                                 | T27N R04W 34ADA   | 1,020                          | 2,178                  | 1,760                | -740     | 380       | 2,140             | -1,120   | --        | --               | --       |
| 125                     | 365543               | 0912107               | AMAX 801-126                                 | T26N R04W 14AAA   | 945                            | 2,078                  | 1,660                | -715     | 400       | 2,060             | -1,115   | --        | --               | --       |
| 126                     | 365543               | 0912146               | AMAX 801-127                                 | T26N R04W 14BAB   | 990                            | 2,123                  | 1,720                | -730     | 400       | 2,120             | -1,130   | --        | --               | --       |
| 127                     | 365111               | 0912035               | AMAX 801-128                                 | T25N R04W 12BDA1  | 940                            | 2,278                  | 1,840                | -900     | 430       | 2,270             | -1,330   | --        | --               | --       |
| 128                     | 365131               | 0912206               | AMAX 801-129                                 | T25N R04W 02CCC1  | 855                            | 2,278                  | 1,700                | -845     | 430       | 2,130             | -1,275   | --        | --               | --       |
| 129                     | 365114               | 0912128               | AMAX 801-131                                 | T25N R04W 11ABD1  | 890                            | 2,248                  | 1,770                | -880     | 430       | 2,200             | -1,310   | --        | --               | --       |
| 130                     | 365602               | 0911933               | AMAX 801-132                                 | T26N R03W 07C 2   | 870                            | 2,248                  | 1,560                | -690     | 370       | 1,930             | -1,060   | --        | --               | --       |
| 131                     | 365601               | 0911950               | AMAX 801-133                                 | T26N R03W 07CBC2  | 885                            | 2,008                  | 1,550                | -665     | 360       | 1,910             | -1,025   | --        | --               | --       |
| 132                     | 365612               | 0911928               | AMAX 801-134                                 | T26N R03W 07DBB   | 950                            | 2,068                  | 1,640                | -690     | 390       | 2,030             | -1,080   | --        | --               | --       |
| 133                     | 365505               | 0912114               | AMAX 801-135                                 | T26N R04W 14ddb   | 960                            | 2,160                  | 1,730                | -770     | 410       | 2,140             | -1,180   | --        | --               | --       |
| 134                     | 365235               | 0911930               | AMAX 801-136                                 | T26N R03W 31CAD   | 880                            | 2,258                  | 1,800                | -920     | 430       | 2,230             | -1,350   | --        | --               | --       |
| 135                     | 365255               | 0912030               | AMAX 801-137                                 | T26N R04W 36ACB   | 905                            | 2,208                  | 1,770                | -865     | 420       | 2,190             | -1,285   | --        | --               | --       |
| 136                     | 365642               | 0912204               | AMAX 801-138                                 | T26N R04W 02CCC   | 925                            | 2,068                  | 1,630                | -705     | 390       | 2,020             | -1,095   | --        | --               | --       |
| 137                     | 365031               | 0912320               | AMAX 801-139                                 | T25N R04W 16AAA   | 680                            | 2,041                  | 1,540                | -860     | 400       | 1,940             | -1,260   | --        | --               | --       |
| 138                     | 365640               | 0911910               | AMAX 801-142                                 | T26N R03W 06DCC   | 950                            | 2,074                  | 1,650                | -700     | 400       | 2,050             | -1,100   | --        | --               | --       |
| 139                     | 365637               | 0911955               | AMAX 801-143                                 | T26N R03W 07BBB   | 980                            | 2,088                  | 1,660                | -680     | 410       | 2,070             | -1,090   | --        | --               | --       |
| 140                     | 365540               | 0911908               | AMAX 801-144                                 | T26N R03W 18ABA   | 853                            | 2,088                  | 1,530                | -677     | 420       | 1,950             | -1,097   | --        | --               | --       |
| 141                     | 365539               | 0911919               | AMAX 801-145                                 | T26N R03W 18ABB   | 920                            | 2,068                  | 1,620                | -700     | 420       | 2,040             | -1,120   | --        | --               | --       |
| 142                     | 365459               | 0912127               | AMAX 801-146                                 | T26N R04W 14DCC   | 800                            | 2,000                  | 1,550                | -750     | 400       | 1,950             | -1,150   | --        | --               | --       |
| 143                     | 365314               | 0912200               | AMAX 801-147                                 | T26N R04W 26CCD   | 955                            | 2,216                  | 1,810                | -855     | 400       | 2,210             | -1,255   | --        | --               | --       |
| 144                     | 365051               | 0912202               | AMAX 801-148                                 | T25N R04W 11CBD   | 920                            | 2,241                  | 1,820                | -900     | 420       | 2,240             | -1,320   | --        | --               | --       |
| 145                     | 365128               | 0912229               | AMAX 801-149                                 | T25N R04W 03DCD   | 910                            | 2,241                  | 1,770                | -860     | 420       | 2,190             | -1,280   | --        | --               | --       |
| 146                     | 365211               | 0911305               | AMAX 801-150                                 | T26N R02W 31CDC   | 975                            | 1,870                  | 1,660                | -685     | 200       | --                | --       | 0         | 1,860            | -885     |
| 147                     | 365539               | 0912144               | AMAX 801-151                                 | T26N R04W 14BAB   | 865                            | 2,020                  | 1,600                | -735     | 400       | 2,000             | -1,135   | --        | --               | --       |
| 148                     | 365334               | 0912309               | AMAX 801-152                                 | T26N R04W 27CBB   | 984                            | 2,229                  | 1,840                | -856     | 370       | 2,210             | -1,226   | --        | --               | --       |
| 149                     | 365526               | 0912343               | AMAX 801-153                                 | T26N R04W 16ACC   | 875                            | 2,030                  | 1,680                | -805     | 340       | 2,020             | -1,145   | --        | --               | --       |
| 150                     | 365528               | 0912246               | AMAX 801-154                                 | T26N R04W 15BDA   | --                             | 1,200                  | --                   | --       | --        | --                | --       | --        | --               | --       |

Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 151                     | 365446               | 0912202               | AMAX 801-155                                 | T26N R04W 23BBC   | 910                            | 2,134                  | 1,420                 | -510     | 80        | 1,500           | -590     | 200       | 280                                         | 74        |
| 152                     | 364944               | 0912122               | AMAX 801-156                                 | T25N R04W 14DDC   | 845                            | 2,194                  | 1,420                 | -575     | 90        | 1,510           | -665     | 210       | 300                                         | 90        |
| 153                     | 365520               | 0912221               | AMAX 801-157                                 | T26N R04W 15ADC   | 1,035                          | 2,228                  | 1,510                 | -475     | 90        | 1,600           | -565     | 190       | 280                                         | 104       |
| 154                     | 365039               | 0912141               | AMAX 801-158                                 | T25N R04W 11CDD   | 927                            | 2,268                  | 1,540                 | -613     | 70        | 1,610           | -683     | 210       | 280                                         | --        |
| 155                     | 365111               | 0912210               | AMAX 801-159                                 | T25N R04W 11BCB   | 941                            | 2,248                  | 1,540                 | -599     | 80        | 1,620           | -679     | 200       | 280                                         | 72        |
| 156                     | 365810               | 0912247               | AMAX 801-163                                 | T27N R04W 34BAD   | 935                            | 2,063                  | 1,310                 | -375     | 140       | 1,450           | -515     | 210       | 350                                         | --        |
| 157                     | 365334               | 0912321               | AMAX 801-164                                 | T26N R04W 28DAA   | 930                            | 2,229                  | 1,510                 | -580     | 50        | 1,560           | -630     | 140       | 190                                         | --        |
| 158                     | 365333               | 0912254               | AMAX 801-165                                 | T26N R04W 27CAB   | 930                            | 2,208                  | 1,500                 | -570     | 70        | 1,570           | -640     | 170       | 240                                         | --        |
| 159                     | 365816               | 0912222               | AMAX 801-166                                 | T27N R04W 34AAC   | 940                            | 2,078                  | 1,390                 | -450     | 80        | 1,470           | -530     | 190       | 270                                         | --        |
| 160                     | 365327               | 0912323               | AMAX 801-167                                 | T26N R04W 28DA    | 960                            | 2,208                  | 1,540                 | -580     | 60        | 1,600           | -640     | 160       | 220                                         | --        |
| 161                     | 365746               | 0911713               | AMAX 801-Z                                   | T27N R03W 33CBD   | 1,006                          | 1,665                  | 1,330                 | -324     | 160       | 1,490           | -484     | --        | --                                          | --        |
| 162                     | 370614               | 0910400               | AMER SMLT P-02                               | T28N R01W 09CDC   | 510                            | 914                    | 515                   | -5       | 105       | 620             | -110     | 155       | 260                                         | --        |
| 163                     | 370621               | 0910518               | AMER SMLT P-04                               | T28N R01W 08CBC   | 850                            | 1,655                  | 940                   | -90      | 140       | 1,080           | -230     | 175       | 315                                         | --        |
| 164                     | 370811               | 0910318               | AMER SMLT P-12                               | T28N R01W 04AAA   | 530                            | 1,173                  | 565                   | -35      | 115       | 680             | -150     | 210       | 325                                         | --        |
| 165                     | 370231               | 0910609               | AMER SMLT P-14                               | T28N R01W 31CCD   | 589                            | 1,418                  | 600                   | -11      | 150       | 750             | -161     | 170       | 320                                         | --        |
| 166                     | 370203               | 0910353               | AMER SMLT                                    | T27N R01W 04CCD   | 580                            | 1,025                  | 495                   | 85       | 125       | 620             | -40      | 170       | 295                                         | --        |
| 167                     | 370228               | 0910956               | AMER SMLT                                    | T27N R02W 04AAA   | 770                            | 880                    | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 168                     | 370654               | 0910613               | AMER SMLT                                    | T28N R01W 06CDB   | 560                            | 1,475                  | 640                   | -80      | 145       | 785             | -225     | 170       | 315                                         | --        |
| 169                     | 370611               | 0910622               | AMER SMLT                                    | T28N R01W 07CCC   | 540                            | 1,425                  | 630                   | -90      | 140       | 770             | -230     | 170       | 310                                         | --        |
| 170                     | 370319               | 0910405               | AMER SMLT                                    | T28N R01W 33BDB   | 510                            | 1,316                  | 670                   | -160     | 170       | 840             | -330     | 175       | 345                                         | --        |
| 171                     | 370536               | 0910643               | AMER SMLT                                    | T28N R02W 13ADC   | 600                            | 1,455                  | 750                   | -150     | 105       | 855             | -255     | 175       | 280                                         | --        |
| 172                     | 365105               | 0913905               | AMER SMLT                                    | T25N R06W 07CAA   | 720                            | 3,000                  | 1,220                 | -500     | 140       | 1,360           | -640     | 190       | 330                                         | --        |
| 173                     | 365622               | 0912012               | AMSELCO PK-42                                | T26N R04W 12ADB   | 915                            | 2,004                  | --                    | --       | --        | 1,410           | -495     | 170       | --                                          | --        |
| 174                     | 365825               | 0912055               | AMSELCO PK-43                                | T27N R04W 25CCC   | 1,025                          | 2,133                  | 1,400                 | -375     | 140       | 1,540           | -515     | 190       | 330                                         | --        |
| 175                     | 365838               | 0912054               | AMSELCO PK-44                                | T27N R04W 25CBC   | 1,010                          | 2,135                  | --                    | --       | --        | 1,510           | -500     | 190       | --                                          | --        |
| 176                     | 370215               | 0911929               | ASARCO PK-08                                 | T27N R03W 06CAB   | 1,125                          | 1,260                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 177                     | 365828               | 0912059               | ASARCO PK-09                                 | T27N R04W 25CCC   | 1,020                          | 2,124                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 178                     | 365254               | 0910755               | ASARCO PK-11                                 | T26N R02W 36BBB   | --                             | 920                    | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 179                     | 370209               | 0912006               | ASARCO PK-12                                 | T27N R04W 01DBD   | 1,110                          | 1,976                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 180                     | 365733               | 0912109               | ASARCO PK-13                                 | T27N R04W 35DDD   | 1,025                          | 2,117                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |



**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 151                     | 365446               | 0912202                | AMAX 801-155                                 | T26N R04W 23BBC   | 910                            | 2,134                  | 1,700                | -790     | 400       | 2,100             | -1,190   | --        | --               | --       |
| 152                     | 364944               | 0912122                | AMAX 801-156                                 | T25N R04W 14DDC   | 845                            | 2,194                  | 1,720                | -875     | 430       | 2,150             | -1,305   | --        | --               | --       |
| 153                     | 365520               | 0912221                | AMAX 801-157                                 | T26N R04W 15ADC   | 1,035                          | 2,228                  | 1,790                | -755     | 410       | 2,200             | -1,165   | --        | --               | --       |
| 154                     | 365039               | 0912141                | AMAX 801-158                                 | T25N R04W 11CDD   | 927                            | 2,268                  | 1,820                | -893     | 430       | 2,250             | -1,323   | --        | --               | --       |
| 155                     | 365111               | 0912210                | AMAX 801-159                                 | T25N R04W 11BCB   | 941                            | 2,248                  | 1,820                | -879     | 410       | 2,230             | -1,289   | --        | --               | --       |
| 156                     | 365810               | 0912247                | AMAX 801-163                                 | T27N R04W 34BAD   | 935                            | 2,063                  | 1,660                | -725     | 360       | 2,020             | -1,085   | --        | --               | --       |
| 157                     | 365334               | 0912321                | AMAX 801-164                                 | T26N R04W 28DAA   | 930                            | 2,229                  | 1,700                | -770     | --        | --                | --       | --        | --               | --       |
| 158                     | 365333               | 0912254                | AMAX 801-165                                 | T26N R04W 27CAB   | 930                            | 2,208                  | 1,740                | -810     | --        | --                | --       | --        | --               | --       |
| 159                     | 365816               | 0912222                | AMAX 801-166                                 | T27N R04W 34AAC   | 940                            | 2,078                  | 1,660                | -720     | 380       | 2,040             | -1,100   | --        | --               | --       |
| 160                     | 365327               | 0912323                | AMAX 801-167                                 | T26N R04W 28DA    | 960                            | 2,208                  | 1,760                | -800     | --        | --                | --       | --        | --               | --       |
| 161                     | 365746               | 0911713                | AMAX 801-Z                                   | T27N R03W 33CBD   | 1,006                          | 1,665                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 162                     | 370614               | 0910400                | AMER SMLT P-02                               | T28N R01W 09CDC   | 510                            | 914                    | 775                  | -265     | 95        | --                | --       | 0         | 870              | -360     |
| 163                     | 370621               | 0910518                | AMER SMLT P-04                               | T28N R01W 08CBC   | 850                            | 1,655                  | 1,255                | -405     | 385       | --                | --       | 0         | 1,640            | -790     |
| 164                     | 370811               | 0910318                | AMER SMLT P-12                               | T28N R01W 04AAA   | 530                            | 1,173                  | 890                  | -360     | 280       | --                | --       | 0         | 1,170            | -640     |
| 165                     | 370231               | 0910609                | AMER SMLT P-14                               | T28N R01W 31CCD   | 589                            | 1,418                  | 920                  | -331     | 450       | 1,370             | -781     | --        | --               | --       |
| 166                     | 370203               | 0910353                | AMER SMLT                                    | T27N R01W 04CCD   | 580                            | 1,025                  | 790                  | -210     | 190       | 980               | -400     | --        | --               | --       |
| 167                     | 370228               | 0910956                | AMER SMLT                                    | T27N R02W 04AAA   | 770                            | 880                    | 495                  | 275      | --        | --                | --       | --        | --               | --       |
| 168                     | 370654               | 0910613                | AMER SMLT                                    | T28N R01W 06CDB   | 560                            | 1,475                  | 955                  | -395     | 330       | 1,285             | -725     | 180       | 1,465            | -905     |
| 169                     | 370611               | 0910622                | AMER SMLT                                    | T28N R01W 07CCC   | 540                            | 1,425                  | 940                  | -400     | 350       | 1,290             | -750     | 112       | 1,402            | -862     |
| 170                     | 370319               | 0910405                | AMER SMLT                                    | T28N R01W 33BDB   | 510                            | 1,316                  | 1,015                | -505     | 290       | 1,305             | -795     | --        | --               | --       |
| 171                     | 370536               | 0910643                | AMER SMLT                                    | T28N R02W 13ADC   | 600                            | 1,455                  | 1,030                | -430     | 410       | --                | --       | 0         | 1,440            | -840     |
| 172                     | 365105               | 0913905                | AMER SMLT                                    | T25N R06W 07CAA   | 720                            | 3,000                  | 1,550                | -830     | 380       | 1,930             | -1,210   | 270       | 2,200            | -1,480   |
| 173                     | 365622               | 0912012                | AMSELCO PK-42                                | T26N R04W 12ADB   | 915                            | 2,004                  | 1,580                | -665     | 400       | 1,980             | -1,065   | --        | --               | --       |
| 174                     | 365825               | 0912055                | AMSELCO PK-43                                | T27N R04W 25CCC   | 1,025                          | 2,133                  | 1,730                | -705     | --        | --                | --       | --        | --               | --       |
| 175                     | 365838               | 0912054                | AMSELCO PK-44                                | T27N R04W 25CBC   | 1,010                          | 2,135                  | 1,700                | -690     | 420       | 2,120             | -1,110   | --        | --               | --       |
| 176                     | 370215               | 0911929                | ASARCO PK-08                                 | T27N R03W 06CAB   | 1,125                          | 1,260                  | --                   | --       | --        | --                | --       | --        | 1,260            | -135     |
| 177                     | 365828               | 0912059                | ASARCO PK-09                                 | T27N R04W 25CCC   | 1,020                          | 2,124                  | 1,710                | -690     | 390       | 2,100             | -1,080   | --        | --               | --       |
| 178                     | 365254               | 0910755                | ASARCO PK-11                                 | T26N R02W 36BBB   | --                             | 920                    | --                   | --       | --        | --                | --       | --        | --               | --       |
| 179                     | 370209               | 0912006                | ASARCO PK-12                                 | T27N R04W 01DBD   | 1,110                          | 1,976                  | 1,560                | -450     | --        | --                | --       | --        | --               | --       |
| 180                     | 365733               | 0912109                | ASARCO PK-13                                 | T27N R04W 35DDD   | 1,025                          | 2,117                  | 1,710                | -685     | 400       | 2,110             | -1,085   | --        | --               | --       |

Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 181                     | 365618               | 0911655               | ASARCO PK-14                                 | T26N R03W 09ACA   | 1,005                          | 2,164                  | 1,200                 | -195     | 320       | 1,520           | -515     | 200       | 520                                         | --        |
| 182                     | 365602               | 0912000               | ASARCO PK-15                                 | T26N R04W 12DAD   | 950                            | 2,140                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 183                     | 365234               | 0910714               | ASARCO PK-16                                 | T26N R02W 36ACB   | --                             | 2,170                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 184                     | 365603               | 0912034               | ASARCO PK-17                                 | T26N R04W 12CAD   | 990                            | 1,914                  | --                    | --       | --        | 1,390           | -400     | 200       | --                                          | --        |
| 185                     | 365638               | 0912144               | ASARCO PK-18                                 | T26N R04W 11BAB   | 980                            | 1,631                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 186                     | 365344               | 0911715               | ASARCO PK-19                                 | T26N R03W 28BDA   | 925                            | 2,124                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 187                     | 365317               | 0911515               | ASARCO PK-20                                 | T26N R03W 26CDB   | 760                            | 2,015                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 188                     | 365237               | 0911037               | ASARCO PK-21                                 | T26N R02W 33ACC   | 925                            | 2,147                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 189                     | 365701               | 0911402               | ASARCO PK-26                                 | T26N R03W 01BDC   | 970                            | 2,128                  | 1,340                 | -370     | 200       | 1,540           | -570     | 100       | 300                                         | --        |
| 190                     | 365741               | 0912131               | ASARCO PK-27                                 | T27N R04W 35DCB   | 1,000                          | 2,109                  | 1,320                 | -320     | 260       | 1,580           | -580     | 130       | 390                                         | --        |
| 191                     | 370148               | 0912117               | ASARCO PK-28                                 | T27N R04W 11ABA   | 1,050                          | 2,017                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 192                     | 365358               | 0911656               | ASARCO PK-29                                 | T26N R03W 28ABA   | 1,020                          | 1,660                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 193                     | 365753               | 0912054               | ASARCO PK-30                                 | T27N R04W 36CBB   | 1,065                          | 2,161                  | --                    | --       | --        | 1,600           | -535     | 140       | --                                          | --        |
| 194                     | 365709               | 0911945               | ASARCO PK-31                                 | T26N R03W 06BCC   | 990                            | 2,114                  | --                    | --       | --        | 1,540           | -550     | 160       | --                                          | --        |
| 195                     | 365557               | 0911319               | ASARCO PK-32                                 | T26N R02W 07DBB   | 875                            | 2,114                  | 1,350                 | -475     | 160       | 1,510           | -635     | 200       | 360                                         | --        |
| 196                     | 365347               | 0911654               | ASARCO PK-33                                 | T26N R03W 28AAC   | 930                            | 1,760                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 197                     | 365247               | 0911141               | ASARCO PK-34                                 | T26N R02W 32ABC   | 910                            | 2,090                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 198                     | 370140               | 0911926               | ASARCO PK-35                                 | T27N R03W 07BCA   | 995                            | 1,955                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 199                     | 365327               | 0911746               | ASARCO PK-38                                 | T26N R03W 29DAA   | 875                            | 2,172                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 200                     | 365657               | 0911452               | ASARCO PK-40                                 | T26N R03W 02DBB   | 975                            | 2,160                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 201                     | 365552               | 0912035               | ASARCO PK-46                                 | T26N R04W 12CDD   | 1,000                          | 2,035                  | --                    | --       | --        | 1,420           | -420     | --        | --                                          | --        |
| 202                     | 365345               | 0911005               | COMINCO SF-01                                | T26N R02W 28AAA   | 980                            | 2,300                  | --                    | --       | --        | 1,631           | -651     | 114       | --                                          | 17.7      |
| 203                     | 365322               | 0910928               | COMINCO SF-02                                | T26N R02W 27DBB   | 900                            | 2,222                  | 1,460                 | -560     | 140       | 1,600           | -700     | 108       | 248                                         | --        |
| 204                     | 365742               | 0911539               | COMINCO SF-06                                | T27N R03W 34DAC   | 985                            | 2,161                  | 1,410                 | -425     | 150       | 1,560           | -575     | 160       | 310                                         | --        |
| 205                     | 365718               | 0910454               | COMINCO SF-15                                | T26N R01W 05AAB   | 600                            | 2,062                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 206                     | 365643               | 0910915               | COMINCO SF-16                                | T26N R02W 03DBD   | 650                            | 2,008                  | 1,071                 | -421     | 95        | 1,166           | -516     | 125       | 220                                         | 25.7      |
| 207                     | 365634               | 0910717               | COMINCO SF-20                                | T26N R02W 01DCB   | 800                            | 1,944                  | 1,225                 | -425     | 141       | 1,366           | -566     | 120       | 261                                         | 41        |
| 208                     | 365722               | 0910410               | COMINCO SF-21                                | T26N R01W 04BAA   | 620                            | 1,976                  | 1,120                 | -500     | 100       | 1,220           | -600     | 190       | 290                                         | --        |
| 209                     | 365611               | 0910324               | COMINCO SF-22                                | T26N R01W 03CCD   | 840                            | 2,348                  | 1,360                 | -520     | 120       | 1,480           | -640     | 150       | 270                                         | --        |
| 210                     | 370007               | 0911656               | COMINCO SF-25                                | T27N R03W 16DCC   | 950                            | 2,004                  | 1,100                 | -150     | --        | --              | --       | --        | 460                                         | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 181                     | 365618               | 0911655               | ASARCO PK-14                                 | T26N R03W 09ACA   | 1,005                          | 2,164                  | 1,720                | -715     | 440       | 2,160             | -1,155   | --        | --               | --       |
| 182                     | 365602               | 0912000               | ASARCO PK-15                                 | T26N R04W 12DAD   | 950                            | 2,140                  | 1,650                | -700     | 400       | 2,050             | -1,100   | --        | --               | --       |
| 183                     | 365234               | 0910714               | ASARCO PK-16                                 | T26N R02W 36ACB   | --                             | 2,170                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 184                     | 365603               | 0912034               | ASARCO PK-17                                 | T26N R04W 12CAD   | 990                            | 1,914                  | 1,590                | -600     | 320       | --                | --       | 0         | 1,910            | -920     |
| 185                     | 365638               | 0912144               | ASARCO PK-18                                 | T26N R04W 11BAB   | 980                            | 1,631                  | 1,480                | -500     | 150       | --                | --       | 0         | 1,630            | -650     |
| 186                     | 365344               | 0911715               | ASARCO PK-19                                 | T26N R03W 28BDA   | 925                            | 2,124                  | 1,680                | -755     | 430       | 2,110             | -1,185   | --        | --               | --       |
| 187                     | 365317               | 0911515               | ASARCO PK-20                                 | T26N R03W 26CDB   | 760                            | 2,015                  | 1,480                | -720     | --        | --                | --       | --        | --               | --       |
| 188                     | 365237               | 0911037               | ASARCO PK-21                                 | T26N R02W 33ACC   | 925                            | 2,147                  | 1,730                | -805     | --        | --                | --       | --        | --               | --       |
| 189                     | 365701               | 0911402               | ASARCO PK-26                                 | T26N R03W 01BDC   | 970                            | 2,128                  | 1,640                | -670     | 480       | 2,120             | -1,150   | --        | --               | --       |
| 190                     | 365741               | 0912131               | ASARCO PK-27                                 | T27N R04W 35DCB   | 1,000                          | 2,109                  | 1,710                | -710     | 390       | 2,100             | -1,100   | --        | --               | --       |
| 191                     | 370148               | 0912117               | ASARCO PK-28                                 | T27N R04W 11ABA   | 1,050                          | 2,017                  | 1,610                | -560     | 390       | 2,000             | -950     | --        | --               | --       |
| 192                     | 365358               | 0911656               | ASARCO PK-29                                 | T26N R03W 28ABA   | 1,020                          | 1,660                  | 1,520                | -500     | 100       | --                | --       | 0         | 1,620            | -600     |
| 193                     | 365753               | 0912054               | ASARCO PK-30                                 | T27N R04W 36CBB   | 1,065                          | 2,161                  | 1,740                | -675     | 410       | 2,150             | -1,085   | --        | --               | --       |
| 194                     | 365709               | 0911945               | ASARCO PK-31                                 | T26N R03W 06BCC   | 990                            | 2,114                  | 1,700                | -710     | 400       | 2,100             | -1,110   | --        | --               | --       |
| 195                     | 365557               | 0911319               | ASARCO PK-32                                 | T26N R02W 07DBB   | 875                            | 2,114                  | 1,710                | -835     | 400       | 2,110             | -1,235   | --        | --               | --       |
| 196                     | 365347               | 0911654               | ASARCO PK-33                                 | T26N R03W 28AAC   | 930                            | 1,760                  | --                   | --       | --        | --                | --       | --        | 1,720            | -790     |
| 197                     | 365247               | 0911141               | ASARCO PK-34                                 | T26N R02W 32ABC   | 910                            | 2,090                  | 1,570                | -660     | 510       | --                | --       | 0         | 2,080            | -1,170   |
| 198                     | 370140               | 0911926               | ASARCO PK-35                                 | T27N R03W 07BCA   | 995                            | 1,955                  | 1,460                | -465     | 450       | 1,910             | -915     | --        | --               | --       |
| 199                     | 365327               | 0911746               | ASARCO PK-38                                 | T26N R03W 29DAA   | 875                            | 2,172                  | --                   | --       | --        | 2,130             | -1,255   | --        | --               | --       |
| 200                     | 365657               | 0911452               | ASARCO PK-40                                 | T26N R03W 02DBB   | 975                            | 2,160                  | --                   | --       | --        | 2,150             | -1,175   | --        | --               | --       |
| 201                     | 365552               | 0912035               | ASARCO PK-46                                 | T26N R04W 12CDD   | 1,000                          | 2,035                  | --                   | --       | --        | --                | --       | --        | 2,020            | -1,020   |
| 202                     | 365345               | 0911005               | COMINCO SF-01                                | T26N R02W 28AAA   | 980                            | 2,300                  | 1,745                | -765     | 512       | 2,257             | -1,277   | --        | --               | --       |
| 203                     | 365322               | 0910928               | COMINCO SF-02                                | T26N R02W 27DBB   | 900                            | 2,222                  | 1,708                | -808     | 482       | 2,190             | -1,290   | --        | --               | --       |
| 204                     | 365742               | 0911539               | COMINCO SF-06                                | T27N R03W 34DAC   | 985                            | 2,161                  | 1,720                | -735     | 410       | 2,130             | -1,145   | --        | --               | --       |
| 205                     | 365718               | 0910454               | COMINCO SF-15                                | T26N R01W 05AAB   | 600                            | 2,062                  | --                   | --       | --        | --                | -1,408   | --        | --               | --       |
| 206                     | 365643               | 0910915               | COMINCO SF-16                                | T26N R02W 03DBD   | 650                            | 2,008                  | 1,291                | -641     | 531       | 1,822             | -1,172   | 177       | 1,999            | -1,349   |
| 207                     | 365634               | 0910717               | COMINCO SF-20                                | T26N R02W 01DCB   | 800                            | 1,944                  | 1,486                | -686     | 448       | --                | --       | 0         | 1,934            | -1,134   |
| 208                     | 365722               | 0910410               | COMINCO SF-21                                | T26N R01W 04BAA   | 620                            | 1,976                  | 1,410                | -790     | 500       | 1,910             | -1,290   | --        | --               | --       |
| 209                     | 365611               | 0910324               | COMINCO SF-22                                | T26N R01W 03CCD   | 840                            | 2,348                  | 1,630                | -790     | 530       | 2,160             | -1,320   | --        | --               | --       |
| 210                     | 370007               | 0911656               | COMINCO SF-25                                | T27N R03W 16DCC   | 950                            | 2,004                  | 1,560                | -610     | 410       | 1,970             | -1,020   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 211                     | 365603               | 0910215                | COMINCO SF-27                                | T26N R01W 11CBA   | 955                            | 2,488                  | 1,540                 | -585     | 200       | 1,740           | -785     | 50        | 250                                         | --        |
| 212                     | 365630               | 0911232                | COMINCO SF-28                                | T26N R02W 06DCD   | 715                            | 1,932                  | 1,206                 | -491     | 214       | 1,420           | -705     | 99        | 313                                         | 19.5      |
| 213                     | 365557               | 0910257                | COMINCO SF-33                                | T26N R01W 10DBC   | 900                            | 2,354                  | 1,420                 | -520     | 218       | 1,638           | -738     | 54        | 272                                         | 3.3       |
| 214                     | 365611               | 0910309                | COMINCO SF-36                                | T26N R01W 10BDD   | 885                            | 2,267                  | 1,430                 | -545     | 180       | 1,610           | -725     | 70        | 250                                         | --        |
| 215                     | 365626               | 0910544                | COMINCO VB-02                                | T26N R01W 05CCC   | 640                            | 1,840                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 216                     | 365403               | 0910330                | COMINCO VB-03                                | T26N R01W 22CCB   | 915                            | 2,473                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 217                     | 365511               | 0910304                | COMINCO VB-06                                | T26N R01W 15CAA   | 910                            | 2,457                  | --                    | --       | --        | 1,635           | -725     | 100       | --                                          | 13.1      |
| 218                     | 365638               | 0910643                | COMINCO VB-08                                | T26N R01W 06CCA   | 700                            | 2,133                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 219                     | 365620               | 0910448                | COMINCO VB-09                                | T26N R01W 08AAC   | 600                            | 1,962                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 220                     | 365712               | 0910515                | COMINCO VB-10                                | T26N R01W 05ABD   | 540                            | 1,922                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 221                     | 365601               | 0905350                | COMINCO VB-11                                | T26N R01E 01DAD   | 720                            | 2,404                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 222                     | 365723               | 0910844                | COMINCO VB-12                                | T27N R02W 35CCD   | --                             | 1,914                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 223                     | 365421               | 0905700                | COMINCO VB-13                                | T26N R01E 21AAA   | 765                            | 2,357                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 224                     | 365740               | 0911223                | COMINCO VB-14                                | T27N R02W 31DAC   | --                             | 2,106                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 225                     | 365807               | 0910048                | COMINCO VB-16                                | T27N R01W 36CAA   | 720                            | 2,109                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 226                     | 365656               | 0910529                | COMINCO VB-17                                | T26N R01W 05BCD   | 550                            | 1,921                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 227                     | 365602               | 0910301                | COMINCO VB-22                                | T26N R01W 10DBB   | 910                            | 710                    | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 228                     | 365701               | 0910155                | COMINCO VB-23                                | T26N R01W 02ACC   | 580                            | 2,155                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 229                     | 365659               | 0910301                | COMINCO VB-24                                | T26N R01W 03DBB   | 780                            | 2,126                  | --                    | --       | --        | 1,276           | -496     | 289       | --                                          | 1.7       |
| 230                     | 365848               | 0911211                | COMINCO WN-01                                | T27N R02W 30ADA   | --                             | 1,970                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 231                     | 365717               | 0911018                | COMINCO WN-06                                | T26N R02W 04ABA   | 650                            | 2,068                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 232                     | 365601               | 0911120                | COMINCO WN-18                                | T26N R02W 08DAB   | 738                            | 1,976                  | --                    | --       | --        | 1,482           | -744     | 93        | --                                          | 16.1      |
| 233                     | 370145               | 0911902                | COMINCO WN-21                                | T27N R03W 07ABC   | 1,080                          | 1,563                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 234                     | 370150               | 0911832                | COMINCO WN-22                                | T27N R03W 08BBB   | 1,060                          | 1,903                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 235                     | 370127               | 0911821                | COMINCO WN-23                                | T27N R03W 08BCD   | 1,065                          | 1,870                  | 1,160                 | -95      | --        | --              | --       | --        | 350                                         | --        |
| 236                     | 364412               | 0910521                | EXXON CF-01                                  | T24N R01W 17D     | 730                            | 2,615                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 237                     | 364756               | 0910804                | EXXON STH-1                                  | T25N R02W 26DAD   | 920                            | 2,596                  | 1,711                 | -791     | 273       | 1,984           | -1,064   | 110       | 383                                         | 9.4       |
| 238                     | 364830               | 0910714                | EXXON STH-2                                  | T25N R02W 25BAB   | 910                            | 2,751                  | 1,774                 | -864     | 130       | 1,904           | -994     | 194       | 324                                         | 8.7       |
| 239                     | 365003               | 0910758                | HOUSTON 111-A                                | T25N R02W 13BCB   | 804                            | 2,127                  | 1,435                 | -631     | 121       | 1,556           | -752     | 189       | 310                                         | 66.4      |
| 240                     | 365021               | 0910759                | HOUSTON 112-A                                | T25N R02W 11DDD   | 680                            | 1,855                  | --                    | --       | --        | 1,410           | -730     | 200       | --                                          | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 211                     | 365603               | 0910215                | COMINCO SF-27                                | T26N R01W 11CBA   | 955                            | 2,488                  | 1,790                | -835     | 510       | 2,300             | -1,345   | --        | --               | --       |
| 212                     | 365630               | 0911232                | COMINCO SF-28                                | T26N R02W 06DCD   | 715                            | 1,932                  | 1,519                | -804     | 361       | 1,880             | -1,165   | --        | --               | --       |
| 213                     | 365557               | 0910257                | COMINCO SF-33                                | T26N R01W 10DBC   | 900                            | 2,354                  | 1,692                | -792     | 535       | 2,227             | -1,327   | --        | --               | --       |
| 214                     | 365611               | 0910309                | COMINCO SF-36                                | T26N R01W 10BDD   | 885                            | 2,267                  | 1,680                | -795     | 500       | 2,180             | -1,295   | --        | --               | -1,382   |
| 215                     | 365626               | 0910544                | COMINCO VB-02                                | T26N R01W 05CCC   | 640                            | 1,840                  | 1,362                | -722     | --        | --                | --       | --        | --               | --       |
| 216                     | 365403               | 0910330                | COMINCO VB-03                                | T26N R01W 22CCB   | 915                            | 2,473                  | 1,806                | -891     | 564       | 2,370             | -1,455   | --        | --               | --       |
| 217                     | 365511               | 0910304                | COMINCO VB-06                                | T26N R01W 15CAA   | 910                            | 2,457                  | 1,735                | -825     | 692       | 2,427             | -1,517   | --        | --               | --       |
| 218                     | 365638               | 0910643                | COMINCO VB-08                                | T26N R01W 06CCA   | 700                            | 2,133                  | 1,405                | -705     | --        | --                | -1,273   | --        | --               | --       |
| 219                     | 365620               | 0910448                | COMINCO VB-09                                | T26N R01W 08AAC   | 600                            | 1,962                  | 1,440                | -840     | 434       | 1,874             | -1,274   | --        | --               | --       |
| 220                     | 365712               | 0910515                | COMINCO VB-10                                | T26N R01W 05ABD   | 540                            | 1,922                  | 1,203                | -664     | 625       | 1,828             | -1,288   | 84        | 1,912            | -1,372   |
| 221                     | 365601               | 0905350                | COMINCO VB-11                                | T26N R01E 01DAD   | 720                            | 2,404                  | 1,693                | -973     | --        | --                | --       | --        | --               | --       |
| 222                     | 365723               | 0910844                | COMINCO VB-12                                | T27N R02W 35CCD   | --                             | 1,914                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 223                     | 365421               | 0905700                | COMINCO VB-13                                | T26N R01E 21AAA   | 765                            | 2,357                  | 1,674                | -909     | 610       | 2,284             | -1,519   | --        | --               | --       |
| 224                     | 365740               | 0911223                | COMINCO VB-14                                | T27N R02W 31DAC   | --                             | 2,106                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 225                     | 365807               | 0910048                | COMINCO VB-16                                | T27N R01W 36CAA   | 720                            | 2,109                  | 1,496                | -776     | 524       | 2,020             | -1,300   | 80        | 2,100            | -1,380   |
| 226                     | 365656               | 0910529                | COMINCO VB-17                                | T26N R01W 05BCD   | 550                            | 1,921                  | 1,325                | -775     | 573       | 1,898             | -1,348   | --        | --               | --       |
| 227                     | 365602               | 0910301                | COMINCO VB-22                                | T26N R01W 10DBB   | 910                            | 710                    | --                   | --       | --        | --                | --       | --        | --               | --       |
| 228                     | 365701               | 0910155                | COMINCO VB-23                                | T26N R01W 02ACC   | 580                            | 2,155                  | 1,382                | -802     | 519       | 1,901             | -1,321   | 247       | 2,148            | -1,568   |
| 229                     | 365659               | 0910301                | COMINCO VB-24                                | T26N R01W 03DBB   | 780                            | 2,126                  | 1,565                | -785     | 557       | 2,122             | -1,342   | 4         | 2,126            | -1,346   |
| 230                     | 365848               | 0911211                | COMINCO WN-01                                | T27N R02W 30ADA   | --                             | 1,970                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 231                     | 365717               | 0911018                | COMINCO WN-06                                | T26N R02W 04ABA   | 650                            | 2,068                  | 1,304                | -654     | 502       | 1,806             | -1,156   | 237       | 2,043            | -1,393   |
| 232                     | 365601               | 0911120                | COMINCO WN-18                                | T26N R02W 08DAB   | 738                            | 1,976                  | 1,575                | -837     | 385       | 1,960             | -1,222   | --        | --               | --       |
| 233                     | 370145               | 0911902                | COMINCO WN-21                                | T27N R03W 07ABC   | 1,080                          | 1,563                  | 1,360                | -280     | 190       | --                | --       | 0         | 1,550            | -470     |
| 234                     | 370150               | 0911832                | COMINCO WN-22                                | T27N R03W 08BBB   | 1,060                          | 1,903                  | 1,500                | -440     | 340       | --                | --       | 0         | 1,840            | -780     |
| 235                     | 370127               | 0911821                | COMINCO WN-23                                | T27N R03W 08BCD   | 1,065                          | 1,870                  | 1,510                | -445     | 340       | --                | --       | 0         | 1,850            | -785     |
| 236                     | 364412               | 0910521                | EXXON CF-01                                  | T24N R01W 17D     | 730                            | 2,615                  | --                   | --       | --        | --                | --       | --        | --               | --       |
| 237                     | 364756               | 0910804                | EXXON STH-1                                  | T25N R02W 26DAD   | 920                            | 2,596                  | 2,094                | -1,174   | 446       | 2,540             | -1,620   | --        | --               | --       |
| 238                     | 364830               | 0910714                | EXXON STH-2                                  | T25N R02W 25BAB   | 910                            | 2,751                  | 2,098                | -1,188   | 600       | 2,698             | -1,788   | --        | --               | --       |
| 239                     | 365003               | 0910758                | HOUSTON 111-A                                | T25N R02W 13BCB   | 804                            | 2,127                  | 1,745                | -941     | 381       | --                | --       | 0         | 2,126            | -1,322   |
| 240                     | 365021               | 0910759                | HOUSTON 112-A                                | T25N R02W 11DDD   | 680                            | 1,855                  | 1,610                | -930     | 240       | --                | --       | 0         | 1,850            | -1,170   |

Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 241                     | 365043               | 0910758               | HOUSTON 112-B                                | T25N R02W 12CBB   | 845                            | 1,905                  | 1,410                 | -565     | 120       | 1,530           | -685     | 200       | 320                                         | --        |
| 242                     | 365103               | 0910758               | HOUSTON 112-C                                | T25N R02W 12BBC   | 845                            | 2,140                  | 1,400                 | -555     | 200       | 1,600           | -755     | 210       | 410                                         | --        |
| 243                     | 365028               | 0910758               | HOUSTON 112-D                                | T25N R02W 12CCB   | 820                            | 1,978                  | 1,400                 | -580     | 120       | 1,520           | -700     | 220       | 340                                         | --        |
| 244                     | 365049               | 0910758               | HOUSTON 112-E                                | T25N R02W 12BCC   | 700                            | 1,751                  | --                    | --       | --        | 1,360           | -660     | 200       | --                                          | --        |
| 245                     | 365032               | 0910758               | HOUSTON 112-G                                | T25N R02W 12CCB   | 830                            | 1,987                  | 1,400                 | -570     | 140       | 1,540           | -710     | 170       | 310                                         | --        |
| 246                     | 365122               | 0910758               | HOUSTON 113-A                                | T25N R02W 01CCB   | 862                            | 2,030                  | 1,437                 | -575     | 126       | 1,563           | -701     | 108       | 234                                         | 60.4      |
| 247                     | 365038               | 0910926               | HOUSTON 122-A                                | T25N R02W 11DA    | 866                            | 2,290                  | 1,492                 | -626     | 130       | 1,622           | -756     | 124       | 254                                         | 70        |
| 248                     | 365218               | 0911246               | HOUSTON 164-A                                | T26N R02W 31DCB   | --                             | 2,252                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 249                     | 365221               | 0911231               | HOUSTON 164-B                                | T26N R02W 31DA    | --                             | 2,359                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 250                     | 364814               | 0910650               | HOUSTON 312-A                                | T25N R01W 30BC    | 890                            | 2,643                  | 1,837                 | -947     | 185       | 2,022           | -1,132   | 74        | 259                                         | 10.4      |
| 251                     | 365225               | 0911258               | HOUSTON 332-4A                               | T26N R02W 31CAC   | 510                            | 2,990                  | 2,020                 | -1,510   | --        | --              | --       | --        | --                                          | --        |
| 252                     | 370424               | 0910236               | KERR MCGEE VB-01                             | T28N R01W 27ACC   | 500                            | 1,581                  | 680                   | -180     | 155       | 835             | -335     | 170       | 325                                         | --        |
| 253                     | 370540               | 0911700               | MANNMO COPPER RD-01                          | T28N R03W 16CAB   | 1,040                          | 740                    | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 254                     | 370537               | 0911802               | MANNMO COPPER RD-02                          | T28N R03W 17CAC   | 1,080                          | 1,187                  | 1,040                 | 40       | --        | --              | --       | --        | --                                          | --        |
| 255                     | 370606               | 0911604               | MANNMO COPPER RD-03                          | T28N R03W 15BBA   | 1,040                          | 995                    | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| 256                     | 370555               | 0911644               | MANNMO COPPER RD-04                          | T28N R03W 16ACB   | 1,050                          | 1,215                  | --                    | --       | --        | 1,080           | -30      | 15        | --                                          | --        |
| 257                     | 370020               | 0910535               | NEW JERSY ZINC                               | T27N R01W 17CBB   | 700                            | 1,836                  | 955                   | -255     | 145       | 1,100           | -400     | 175       | 320                                         | --        |
| 258                     | 365126               | 0905814               | NORANDA BCN-01                               | T25N R01E 05AD    | 545                            | 2,445                  | 1,477                 | -932     | 119       | 1,596           | -1,051   | 80        | 199                                         | 8.5       |
| 259                     | 370122               | 0911807               | PH DODGE 08-01                               | T27N R03W 08CAA   | 1,056                          | 1,480                  | 1,050                 | 6        | --        | --              | --       | --        | 330                                         | --        |
| 260                     | 370101               | 0911731               | PH DODGE 08-02                               | T27N R03W 08DDD   | 918                            | 1,563                  | 970                   | -52      | 348       | 1,318           | -400     | 80        | 428                                         | --        |
| 261                     | 370208               | 0910106               | PH DODGE 12-01A (PD-29)                      | T27N R01W 17BBB   | 649                            | 1,745                  | 870                   | -221     | 113       | 983             | -334     | 198       | 311                                         | 24.4      |
| 262                     | 370208               | 0910051               | PH DODGE 12-02 (PD-10)                       | T27N R01W 12BAD   | 660                            | 1,661                  | 890                   | -230     | 125       | 1,015           | -355     | 185       | 310                                         | --        |
| 263                     | 370004               | 0911417               | PH DODGE 14-01                               | T27N R03W 14DDD   | 914                            | 1,976                  | 1,150                 | -236     | 290       | 1,440           | -526     | 80        | 370                                         | --        |
| 264                     | 370026               | 0910244               | PH DODGE 15-01 (PD-18)                       | T27N R01W 15DBB   | 706                            | 1,364                  | 837                   | -131     | 187       | 1,024           | -318     | 74        | 261                                         | 22.5      |
| 265                     | 370037               | 0911801               | PH DODGE 17-01                               | T27N R03W 17ACC   | 921                            | 1,917                  | 1,120                 | -199     | 200       | 1,320           | -399     | 90        | 290                                         | --        |
| 266                     | 370220               | 0912019               | PH DODGE 27N4W1-1                            | T27N R04W 01CAA   | 1,030                          | 2,086                  | 1,180                 | -150     | 290       | 1,470           | -440     | 70        | 360                                         | --        |
| 267                     | 370022               | 0910529               | PH DODGE VB-01                               | T27N R01W 17CBB   | 700                            | 1,826                  | 1,002                 | -302     | 93        | 1,095           | -395     | 125       | 218                                         | 37.5      |
| 268                     | 370945               | 0910820               | PH DODGE                                     | T29N R02W 23CAB   | 957                            | 1,700                  | 920                   | 37       | 160       | 1,080           | -123     | 160       | 320                                         | --        |
| 269                     | 365132               | 0910526               | ST JOE 62W82                                 | T25N R01W 05CAB   | 600                            | 2,088                  | 1,301                 | -701     | 314       | 1,615           | -1,015   | 56        | 370                                         | --        |
| 270                     | 370254               | 0912627               | ST JOE 68W44                                 | T28N R05W 36DDB   | 917                            | 1,876                  | 1,230                 | -313     | 120       | 1,350           | -433     | 230       | 350                                         | --        |



**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonnetterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 241                     | 365043               | 0910758               | HOUSTON 112-B                                | T25N R02W 12CBB   | 845                            | 1,905                  | 1,730                 | -885     | 170       | --                | --       | 0         | 1,900            | -1,055   |
| 242                     | 365103               | 0910758               | HOUSTON 112-C                                | T25N R02W 12BBC   | 845                            | 2,140                  | 1,810                 | -965     | --        | --                | --       | --        | --               | --       |
| 243                     | 365028               | 0910758               | HOUSTON 112-D                                | T25N R02W 12CCB   | 820                            | 1,978                  | 1,740                 | -920     | 230       | --                | --       | 0         | 1,970            | -1,150   |
| 244                     | 365049               | 0910758               | HOUSTON 112-E                                | T25N R02W 12BCC   | 700                            | 1,751                  | 1,560                 | -860     | 190       | --                | --       | 0         | 1,750            | -1,050   |
| 245                     | 365032               | 0910758               | HOUSTON 112-G                                | T25N R02W 12CCB   | 830                            | 1,987                  | 1,710                 | -880     | 270       | --                | --       | 0         | 1,980            | -1,150   |
| 246                     | 365122               | 0910758               | HOUSTON 113-A                                | T25N R02W 01CCB   | 862                            | 2,030                  | 1,671                 | -809     | 355       | --                | --       | 0         | 2,026            | -1,164   |
| 247                     | 365038               | 0910926               | HOUSTON 122-A                                | T25N R02W 11DA    | 866                            | 2,290                  | 1,746                 | -880     | 446       | 2,192             | -1,326   | 91        | 2,283            | -1,417   |
| 248                     | 365218               | 0911246               | HOUSTON 164-A                                | T26N R02W 31DCB   | --                             | 2,252                  | --                    | --       | --        | --                | --       | --        | --               | --       |
| 249                     | 365221               | 0911231               | HOUSTON 164-B                                | T26N R02W 31DA    | --                             | 2,359                  | --                    | --       | --        | --                | --       | --        | --               | --       |
| 250                     | 364814               | 0910650               | HOUSTON 312-A                                | T25N R01W 30BC    | 890                            | 2,643                  | 2,096                 | -1,206   | 504       | 2,600             | -1,710   | --        | --               | --       |
| 251                     | 365225               | 0911258               | HOUSTON 332-4A                               | T26N R02W 31CAC   | 510                            | 2,990                  | --                    | --       | --        | --                | --       | --        | --               | --       |
| 252                     | 370424               | 0910236               | KERR MCGEE VB-01                             | T28N R01W 27ACC   | 500                            | 1,581                  | 1,005                 | -505     | 349       | 1,354             | -854     | 224       | 1,578            | -1,078   |
| 253                     | 370540               | 0911700               | MANNMO COPPER RD-01                          | T28N R03W 16CAB   | 1,040                          | 740                    | --                    | --       | --        | --                | --       | --        | --               | --       |
| 254                     | 370537               | 0911802               | MANNMO COPPER RD-02                          | T28N R03W 17CAC   | 1,080                          | 1,187                  | --                    | --       | --        | --                | --       | --        | 1,183            | -103     |
| 255                     | 370606               | 0911604               | MANNMO COPPER RD-03                          | T28N R03W 15BBA   | 1,040                          | 995                    | --                    | --       | --        | --                | --       | --        | 990              | 50       |
| 256                     | 370555               | 0911644               | MANNMO COPPER RD-04                          | T28N R03W 16ACB   | 1,050                          | 1,215                  | 1,095                 | -45      | 108       | --                | --       | 0         | 1,203            | -153     |
| 257                     | 370020               | 0910535               | NEW JERSY ZINC                               | T27N R01W 17CBB   | 700                            | 1,836                  | 1,275                 | -575     | 515       | 1,790             | -1,090   | --        | --               | --       |
| 258                     | 365126               | 0905814               | NORANDA BCN-01                               | T25N R01E 05AD    | 545                            | 2,445                  | 1,676                 | -1,131   | 471       | 2,147             | -1,602   | 290       | 2,437            | -1,892   |
| 259                     | 370122               | 0911807               | PH DODGE 08-01                               | T27N R03W 08CAA   | 1,056                          | 1,480                  | 1,380                 | -324     | 60        | 1,440             | -384     | 30        | 1,470            | -414     |
| 260                     | 370101               | 0911731               | PH DODGE 08-02                               | T27N R03W 08DDD   | 918                            | 1,563                  | 1,398                 | -480     | 159       | --                | --       | 0         | 1,557            | -639     |
| 261                     | 370208               | 0910106               | PH DODGE 12-01A (PD-29)                      | T27N R01W 17BBB   | 649                            | 1,745                  | 1,181                 | -532     | 399       | 1,580             | -931     | 155       | 1,735            | -1,086   |
| 262                     | 370208               | 0910051               | PH DODGE 12-02 (PD-10)                       | T27N R01W 12BAD   | 660                            | 1,661                  | 1,200                 | -540     | 415       | 1,615             | -955     | --        | --               | --       |
| 263                     | 370004               | 0911417               | PH DODGE 14-01                               | T27N R03W 14DDD   | 914                            | 1,976                  | 1,520                 | -606     | 410       | 1,930             | -1,016   | 30        | 1,960            | -1,046   |
| 264                     | 370026               | 0910244               | PH DODGE 15-01 (PD-18)                       | T27N R01W 15DBB   | 706                            | 1,364                  | 1,098                 | -392     | 238       | --                | --       | 0         | 1,336            | -630     |
| 265                     | 370037               | 0911801               | PH DODGE 17-01                               | T27N R03W 17ACC   | 921                            | 1,917                  | 1,410                 | -489     | 450       | 1,860             | -939     | 50        | 1,910            | -989     |
| 266                     | 370220               | 0912019               | PH DODGE 27N4W1-1                            | T27N R04W 01CAA   | 1,030                          | 2,086                  | 1,540                 | -510     | 470       | 2,010             | -980     | --        | --               | --       |
| 267                     | 370022               | 0910529               | PH DODGE VB-01                               | T27N R01W 17CBB   | 700                            | 1,826                  | 1,220                 | -520     | 563       | 1,783             | -1,083   | --        | --               | --       |
| 268                     | 370945               | 0910820               | PH DODGE                                     | T29N R02W 23CAB   | 957                            | 1,700                  | 1,240                 | -283     | 380       | 1,620             | -663     | 60        | 1,680            | -723     |
| 269                     | 365132               | 0910526               | ST JOE 62W82                                 | T25N R01W 05CAB   | 600                            | 2,088                  | 1,671                 | -1,071   | 382       | 2,053             | -1,453   | --        | --               | --       |
| 270                     | 370254               | 0912627               | ST JOE 68W44                                 | T28N R05W 36DDB   | 917                            | 1,876                  | 1,580                 | -663     | 280       | 1,860             | -943     | --        | --               | --       |

Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 271                     | 364953               | 0910106               | ST JOE 76W03                                 | T25N R01W 13BDA   | 481                            | 2,164                  | 1,277                 | -796     | 386       | 1,663           | -1,182   | 24        | 410                                         | --        |
| 272                     | 365612               | 0910810               | ST JOE 76W05                                 | T26N R02W 11AB    | 631                            | 1,948                  | 1,140                 | -509     | 160       | 1,300           | -669     | 210       | 370                                         | --        |
| 273                     | 365559               | 0911037               | ST JOE 76W07                                 | T26N R02W 09CAA   | 760                            | 1,915                  | 1,158                 | -398     | 78        | 1,236           | -476     | 100       | 178                                         | --        |
| 274                     | 365609               | 0910556               | ST JOE 76W10                                 | T26N R01W 07ADB   | 621                            | 1,921                  | 1,134                 | -513     | 147       | 1,281           | -660     | 264       | 411                                         | 73        |
| 275                     | 365446               | 0910707               | ST JOE 76W12                                 | T26N R02W 13DCA   | 671                            | 2,020                  | 1,240                 | -569     | 160       | 1,400           | -729     | 214       | 374                                         | --        |
| 276                     | 365533               | 0910259               | ST JOE 76W15                                 | T26N R01W 15ABB   | 905                            | 2,415                  | 1,679                 | -774     | 117       | 1,796           | -891     | 78        | 195                                         | 9         |
| 277                     | 365637               | 0905520               | ST JOE 76W17                                 | T26N R01E 02ACB   | 493                            | 1,831                  | 1,244                 | -751     | 131       | 1,375           | -882     | 5         | 136                                         | 6         |
| 278                     | 365721               | 0910526               | ST JOE 76W19                                 | T26N R01W 05BAB   | 539                            | 1,810                  | 980                   | -441     | 88        | 1,068           | -529     | 320       | 408                                         | 63        |
| 279                     | 365936               | 0911610               | ST JOE 76W20                                 | T27N R03W 22CA    | 951                            | 1,940                  | 1,260                 | -309     | 180       | 1,440           | -489     | 150       | 330                                         | --        |
| 280                     | 365754               | 0911130               | ST JOE 77W02                                 | T27N R02W 32AC    | 761                            | 1,806                  | 1,390                 | -629     | 120       | 1,510           | -749     | 50        | 170                                         | --        |
| 281                     | 370112               | 0911915               | ST JOE 77W03                                 | T27N R03W 07CC    | 1,023                          | 1,895                  | 1,290                 | -267     | 150       | 1,440           | -417     | 180       | 330                                         | --        |
| 282                     | 365918               | 0911443               | ST JOE 77W05                                 | T27N R03W 23DC    | 808                            | 1,912                  | 1,250                 | -442     | 260       | 1,510           | -702     | 40        | 300                                         | --        |
| 283                     | 365918               | 0911048               | ST JOE 77W06                                 | T27N R02W 21CA    | 731                            | 1,886                  | 1,130                 | -399     | 220       | 1,350           | -619     | 150       | 370                                         | --        |
| 284                     | 370027               | 0912158               | ST JOE 77W07                                 | T27N R04W 14CB    | 1,033                          | 1,999                  | 1,360                 | -327     | 100       | 1,460           | -427     | 260       | 360                                         | --        |
| 285                     | 370247               | 0912044               | ST JOE 77W08                                 | T28N R04W 36CC    | 1,109                          | 1,778                  | 1,220                 | -111     | 170       | 1,390           | -281     | 130       | 300                                         | --        |
| 286                     | 365943               | 0911727               | ST JOE 77W11                                 | T27N R03W 21BC    | 901                            | 1,987                  | 1,340                 | -439     | 110       | 1,450           | -549     | 210       | 320                                         | --        |
| 287                     | 365802               | 0911628               | ST JOE 79W03                                 | T27N R03W 34BC    | 871                            | 2,065                  | 1,360                 | -489     | 60        | 1,420           | -549     | 310       | 370                                         | --        |
| 288                     | 365247               | 0911530               | ST JOE 79W05                                 | T26N R03W 35BC    | 706                            | 2,045                  | 1,270                 | -564     | 60        | 1,330           | -624     | 320       | 380                                         | --        |
| 289                     | 370023               | 0912423               | ST JOE 79W06                                 | T27N R04W 17DA    | 1,081                          | 2,156                  | 1,400                 | -319     | 160       | 1,560           | -479     | 270       | 430                                         | --        |
| 290                     | 370125               | 0912242               | ST JOE 79W08                                 | T27N R04W 10CA    | 1,106                          | 2,158                  | 1,450                 | -344     | 160       | 1,610           | -504     | 230       | 390                                         | --        |
| 291                     | 364303               | 0910716               | ST JOE 79W10                                 | T24N R02W 24DDD   | 756                            | 2,545                  | --                    | --       | --        | 1,750           | -994     | 238       | --                                          | --        |
| 292                     | 370248               | 0912000               | ST JOE 81W09                                 | T28N R04W 36DD    | 1,115                          | 1,794                  | 1,230                 | -115     | 140       | 1,370           | -255     | 170       | 310                                         | 24        |
| 293                     | 364627               | 0911008               | ST JOE 81W15                                 | T24N R02W 03BDB   | 806                            | 2,436                  | 1,648                 | -842     | 139       | 1,787           | -981     | 148       | --                                          | --        |
| 294                     | 364509               | 0910708               | ST JOE 81W29                                 | T24N R01W 07CBB   | 760                            | 2,486                  | 1,346                 | -586     | 420       | 1,766           | -1,006   | 156       | 576                                         | --        |
| 295                     | 365207               | 0911958               | ST JOE 82W03                                 | T25N R03W 06BB    | 960                            | 2,290                  | 1,528                 | -568     | 91        | 1,619           | -659     | 232       | 323                                         | 139       |
| 296                     | 365205               | 0912310               | ST JOE 82W07                                 | T25N R04W 03BB    | 745                            | 2,022                  | 1,266                 | -521     | 87        | 1,353           | -608     | 265       | 352                                         | --        |
| 297                     | 365359               | 0911815               | ST JOE 82W11                                 | T26N R03W 29ABB   | 920                            | 2,179                  | --                    | --       | --        | 1,520           | -600     | 200       | --                                          | --        |
| 298                     | 365358               | 0911459               | ST JOE 82W19                                 | T26N R03W 23CDD   | 790                            | 2,248                  | --                    | --       | --        | 1,370           | -580     | 180       | --                                          | 83        |
| 299                     | 365404               | 0911632               | ST JOE 82W21                                 | T26N R03W 22CCC   | 970                            | 1,528                  | --                    | --       | --        | 1,460           | -490     | 0         | --                                          | --        |
| 300                     | 365430               | 0911632               | ST JOE 82W25                                 | T26N R03W 22BCC   | 965                            | 2,171                  | --                    | --       | --        | 1,540           | -575     | 200       | --                                          | --        |

**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 271                     | 364953               | 0910106                | ST JOE 76W03                                 | T25N R01W 13BDA   | 481                            | 2,164                  | 1,687                | -1,206   | 401       | 2,088             | -1,607   | --        | --               | --       |
| 272                     | 365612               | 0910810                | ST JOE 76W05                                 | T26N R02W 11AB    | 631                            | 1,948                  | 1,510                | -879     | 300       | 1,810             | -1,179   | --        | --               | --       |
| 273                     | 365559               | 0911037                | ST JOE 76W07                                 | T26N R02W 09CAA   | 760                            | 1,915                  | 1,336                | -576     | 541       | 1,877             | -1,117   | --        | --               | --       |
| 274                     | 365609               | 0910556                | ST JOE 76W10                                 | T26N R01W 07ADB   | 621                            | 1,921                  | 1,545                | -924     | 316       | 1,861             | -1,240   | --        | --               | --       |
| 275                     | 365446               | 0910707                | ST JOE 76W12                                 | T26N R02W 13DCA   | 671                            | 2,020                  | 1,614                | -943     | 373       | 1,987             | -1,316   | --        | --               | --       |
| 276                     | 365533               | 0910259                | ST JOE 76W15                                 | T26N R01W 15ABB   | 905                            | 2,415                  | 1,874                | -969     | 309       | 2,183             | -1,278   | 214       | 2,397            | -1,492   |
| 277                     | 365637               | 0905520                | ST JOE 76W17                                 | T26N R01E 02ACB   | 493                            | 1,831                  | 1,380                | -887     | 435       | --                | --       | 0         | 1,815            | -1,322   |
| 278                     | 365721               | 0910526                | ST JOE 76W19                                 | T26N R01W 05BAB   | 539                            | 1,810                  | 1,388                | -849     | --        | --                | --       | --        | --               | --       |
| 279                     | 365936               | 0911610                | ST JOE 76W20                                 | T27N R03W 22CA    | 951                            | 1,940                  | 1,590                | -639     | 320       | 1,910             | -959     | --        | --               | --       |
| 280                     | 365754               | 0911130                | ST JOE 77W02                                 | T27N R02W 32AC    | 761                            | 1,806                  | 1,560                | -799     | --        | --                | --       | --        | --               | --       |
| 281                     | 370112               | 0911915                | ST JOE 77W03                                 | T27N R03W 07CC    | 1,023                          | 1,895                  | 1,620                | -597     | 230       | 1,850             | -827     | --        | --               | --       |
| 282                     | 365918               | 0911443                | ST JOE 77W05                                 | T27N R03W 23DC    | 808                            | 1,912                  | 1,550                | -742     | 330       | 1,880             | -1,072   | --        | --               | --       |
| 283                     | 365918               | 0911048                | ST JOE 77W06                                 | T27N R02W 21CA    | 731                            | 1,886                  | 1,500                | -769     | 370       | 1,870             | -1,139   | --        | --               | --       |
| 284                     | 370027               | 0912158                | ST JOE 77W07                                 | T27N R04W 14CB    | 1,033                          | 1,999                  | 1,720                | -687     | 260       | 1,980             | -947     | --        | --               | --       |
| 285                     | 370247               | 0912044                | ST JOE 77W08                                 | T28N R04W 36CC    | 1,109                          | 1,778                  | 1,520                | -411     | 240       | 1,760             | -651     | 10        | 1,770            | -661     |
| 286                     | 365943               | 0911727                | ST JOE 77W11                                 | T27N R03W 21BC    | 901                            | 1,987                  | 1,660                | -759     | 310       | 1,970             | -1,069   | --        | --               | --       |
| 287                     | 365802               | 0911628                | ST JOE 79W03                                 | T27N R03W 34BC    | 871                            | 2,065                  | 1,730                | -859     | 330       | 2,060             | -1,189   | --        | --               | --       |
| 288                     | 365247               | 0911530                | ST JOE 79W05                                 | T26N R03W 35BC    | 706                            | 2,045                  | 1,650                | -944     | 380       | 2,030             | -1,324   | --        | --               | --       |
| 289                     | 370023               | 0912423                | ST JOE 79W06                                 | T27N R04W 17DA    | 1,081                          | 2,156                  | 1,830                | -749     | 310       | 2,140             | -1,059   | --        | --               | --       |
| 290                     | 370125               | 0912242                | ST JOE 79W08                                 | T27N R04W 10CA    | 1,106                          | 2,158                  | 1,840                | -734     | 300       | 2,140             | -1,034   | --        | --               | --       |
| 291                     | 364303               | 0910716                | ST JOE 79W10                                 | T24N R02W 24DDD   | 756                            | 2,545                  | 1,988                | -1,232   | 538       | 2,526             | -1,770   | --        | --               | --       |
| 292                     | 370248               | 0912000                | ST JOE 81W09                                 | T28N R04W 36DD    | 1,115                          | 1,794                  | 1,540                | -425     | --        | --                | --       | --        | --               | --       |
| 293                     | 364627               | 0911008                | ST JOE 81W15                                 | T24N R02W 03BDB   | 806                            | 2,436                  | 1,935                | -1,129   | --        | --                | --       | --        | --               | --       |
| 294                     | 364509               | 0910708                | ST JOE 81W29                                 | T24N R01W 07CBB   | 760                            | 2,486                  | 1,922                | -1,162   | 520       | 2,442             | -1,682   | --        | --               | --       |
| 295                     | 365207               | 0911958                | ST JOE 82W03                                 | T25N R03W 06BB    | 960                            | 2,290                  | 1,851                | -891     | 421       | 2,272             | -1,312   | --        | --               | --       |
| 296                     | 365205               | 0912310                | ST JOE 82W07                                 | T25N R04W 03BB    | 745                            | 2,022                  | 1,618                | -873     | 385       | 2,003             | -1,258   | --        | --               | --       |
| 297                     | 365359               | 0911815                | ST JOE 82W11                                 | T26N R03W 29ABB   | 920                            | 2,179                  | 1,720                | -800     | 390       | 2,110             | -1,190   | --        | --               | --       |
| 298                     | 365358               | 0911459                | ST JOE 82W19                                 | T26N R03W 23CDD   | 790                            | 2,248                  | 1,550                | -760     | 410       | 1,960             | -1,170   | --        | --               | --       |
| 299                     | 365404               | 0911632                | ST JOE 82W21                                 | T26N R03W 22CCC   | 970                            | 1,528                  | 1,460                | -490     | 60        | --                | --       | 0         | 1,520            | -550     |
| 300                     | 365430               | 0911632                | ST JOE 82W25                                 | T26N R03W 22BCC   | 965                            | 2,171                  | 1,740                | -775     | 400       | 2,140             | -1,175   | --        | --               | --       |



Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 301                     | 365339               | 0911823               | ST JOE 82W27                                 | T26N R03W 29BDD   | 870                            | 2,155                  | --                    | --       | --        | 1,500           | -630     | 200       | --                                          | 100       |
| 302                     | 364753               | 0911619               | ST JOE 82W31                                 | T25N R03W 27CDD   | 540                            | 1,945                  | 1,150                 | -610     | 70        | 1,220           | -680     | 240       | 310                                         | 145       |
| 303                     | 364724               | 0911324               | ST JOE 82W34                                 | T25N R02W 31BCC   | --                             | 2,435                  | --                    | --       | --        | --              | --       | --        | --                                          | 89        |
| 304                     | 370054               | 0911819               | ST JOE 83W06                                 | T27N R03W 17BBA   | 985                            | 1,982                  | 1,310                 | -325     | 120       | 1,430           | -445     | 170       | 290                                         | 27        |
| 305                     | 370405               | 0912202               | ST JOE 83W09                                 | T28N R04W 27ADC   | 1,050                          | 1,598                  | 1,060                 | -10      | 190       | 1,250           | -200     | 150       | 340                                         | --        |
| 306                     | 365128               | 0912248               | ST JOE 83W12                                 | T25N R04W 03CD    | 925                            | 2,224                  | 1,250                 | -325     | 300       | 1,550           | -625     | 270       | 570                                         | --        |
| 307                     | 365419               | 0911632               | ST JOE 83W14                                 | T26N R03W 22CBB   | 985                            | 1,549                  | 1,280                 | -295     | 60        | 1,340           | -355     | 140       | 200                                         | 75        |
| 308                     | 365359               | 0911612               | ST JOE 83W15                                 | T26N R03W 22CDD   | 785                            | 1,960                  | 1,170                 | -385     | 100       | 1,270           | -485     | 180       | 280                                         | --        |
| 309                     | 365036               | 0912220               | ST JOE 83W17                                 | T25N R04W 10DDD   | 918                            | 2,242                  | 1,420                 | -502     | 130       | 1,550           | -632     | 280       | 410                                         | 117       |
| 310                     | 364645               | 0911523               | ST JOE 83W25                                 | T24N R03W 02ABC   | 860                            | 2,406                  | 1,540                 | -680     | 140       | 1,680           | -820     | 260       | 400                                         | 148       |
| 311                     | 365209               | 0912417               | ST JOE 83W30                                 | T25N R04W 04BCC   | 930                            | 2,196                  | 1,260                 | -330     | 240       | 1,500           | -570     | 340       | 580                                         | 156       |
| 312                     | 365254               | 0912350               | ST JOE 83W34                                 | T26N R04W 33BDA   | 960                            | 2,206                  | 1,180                 | -220     | 380       | 1,560           | -600     | 270       | 650                                         | 129       |
| 313                     | 365135               | 0912310               | ST JOE 83W35                                 | T25N R04W 03CCB   | 735                            | 1,987                  | 1,030                 | -295     | 320       | 1,350           | -615     | 250       | 570                                         | --        |
| 314                     | 370404               | 0912225               | ST JOE 83W44                                 | T28N R04W 27BDD   | 1,040                          | 1,786                  | 1,020                 | 20       | 240       | 1,260           | -220     | 240       | 480                                         | --        |
| 315                     | 364701               | 0911545               | ST JOE 84W43                                 | T25N R03W 34DDD   | 860                            | 2,386                  | 1,550                 | -690     | 130       | 1,680           | -820     | 230       | 360                                         | 97        |
| 316                     | 364658               | 0911536               | ST JOE 84W44                                 | T24N R03W 02BAA   | 805                            | 2,337                  | --                    | --       | --        | 1,600           | -795     | 250       | --                                          | --        |
| 317                     | 365002               | 0912138               | ST JOE 85W09                                 | T25N R04W 14DB    | 912                            | 2,265                  | --                    | --       | --        | 1,550           | -638     | 280       | --                                          | --        |
| 318                     | 365021               | 0912137               | ST JOE 85W11                                 | T25N R04W 14AB    | 919                            | 2,236                  | --                    | --       | --        | 1,540           | -621     | 320       | --                                          | --        |
| 319                     | 365001               | 0912124               | ST JOE 85W15                                 | T25N R04W 14DAB   | 887                            | 2,196                  | --                    | --       | --        | 1,510           | -623     | 290       | --                                          | 102       |
| 320                     | 365004               | 0912109               | ST JOE 85W31                                 | T25N R04W 14DA    | 644                            | 1,957                  | --                    | --       | --        | 1,270           | -626     | 310       | --                                          | --        |
| 321                     | 365655               | 0912156               | ST JOE 85W35                                 | T26N R04W 02CBD   | 890                            | 1,946                  | 1,270                 | -380     | 50        | 1,320           | -430     | 320       | 370                                         | 96        |
| 322                     | 365838               | 0912100               | ST JOE 85W37                                 | T27N R04W 26DAD   | 997                            | 2,080                  | 1,400                 | -403     | 50        | 1,450           | -453     | 290       | 340                                         | 58        |
| 323                     | 365001               | 0912131               | ST JOE 86W02                                 | T25N R04W 14DB    | 874                            | 2,183                  | 1,450                 | -576     | 90        | 1,540           | -666     | 260       | 350                                         | --        |
| 324                     | 364622               | 0911434               | ST JOE 88W03                                 | T24N R03W 01BDC   | 810                            | 2,400                  | 1,600                 | -790     | 90        | 1,690           | -880     | 250       | 340                                         | --        |
| 325                     | 364859               | 0912007               | ST JOE 88W04                                 | T25N R04W 24DD    | 920                            | 2,321                  | 1,540                 | -620     | 110       | 1,650           | -730     | 310       | 420                                         | 159       |
| 326                     | 364849               | 0912020               | ST JOE 88W05                                 | T25N R04W 24DD    | 870                            | 2,244                  | --                    | --       | --        | 1,520           | -650     | 310       | --                                          | --        |
| 327                     | 365013               | 0912140               | ST JOE 88W06                                 | T25N R04W 14AC    | 910                            | 2,223                  | 1,500                 | -590     | 20        | 1,520           | -610     | 320       | 340                                         | --        |
| 328                     | 364816               | 0911946               | ST JOE 88W09                                 | T25N R03W 30CAB   | 890                            | 2,315                  | 1,520                 | -630     | 100       | 1,620           | -730     | 290       | 390                                         | --        |
| 329                     | 364812               | 0911915               | ST JOE 88W10                                 | T25N R03W 30DBD   | 890                            | 2,324                  | 1,500                 | -610     | 90        | 1,590           | -700     | 320       | 410                                         | --        |
| 330                     | 364557               | 0911424               | ST JOE 88W11                                 | T24N R03W 01DBC   | 750                            | 2,400                  | 1,630                 | -880     | 60        | 1,690           | -940     | 310       | 370                                         | --        |

**Table 1.** Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonnetterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |
| 301                     | 365339               | 0911823               | ST JOE 82W27                                 | T26N R03W 29BDD   | 870                            | 2,155                  | 1,700                 | -830     | 400       | 2,100             | -1,230   | --        | --               | --       |
| 302                     | 364753               | 0911619               | ST JOE 82W31                                 | T25N R03W 27CDD   | 540                            | 1,945                  | 1,460                 | -920     | 450       | 1,910             | -1,370   | --        | --               | --       |
| 303                     | 364724               | 0911324               | ST JOE 82W34                                 | T25N R02W 31BCC   | --                             | 2,435                  | --                    | --       | --        | --                | --       | --        | --               | --       |
| 304                     | 370054               | 0911819               | ST JOE 83W06                                 | T27N R03W 17BBA   | 985                            | 1,982                  | 1,600                 | -615     | 290       | 1,890             | -905     | 60        | 1,950            | -965     |
| 305                     | 370405               | 0912202               | ST JOE 83W09                                 | T28N R04W 27ADC   | 1,050                          | 1,598                  | 1,400                 | -350     | 150       | 1,550             | -500     | 40        | 1,590            | -540     |
| 306                     | 365128               | 0912248               | ST JOE 83W12                                 | T25N R04W 03CD    | 925                            | 2,224                  | 1,820                 | -895     | 380       | 2,200             | -1,275   | --        | --               | --       |
| 307                     | 365419               | 0911632               | ST JOE 83W14                                 | T26N R03W 22CBB   | 985                            | 1,549                  | 1,480                 | -495     | 70        | --                | --       | 0         | 1,550            | -565     |
| 308                     | 365359               | 0911612               | ST JOE 83W15                                 | T26N R03W 22CDD   | 785                            | 1,960                  | 1,450                 | -665     | 490       | --                | --       | 0         | 1,940            | -1,155   |
| 309                     | 365036               | 0912220               | ST JOE 83W17                                 | T25N R04W 10DDD   | 918                            | 2,242                  | 1,830                 | -912     | 350       | 2,180             | -1,262   | --        | --               | --       |
| 310                     | 364645               | 0911523               | ST JOE 83W25                                 | T24N R03W 02ABC   | 860                            | 2,406                  | 1,940                 | -1,080   | 460       | 2,400             | -1,540   | --        | --               | --       |
| 311                     | 365209               | 0912417               | ST JOE 83W30                                 | T25N R04W 04BCC   | 930                            | 2,196                  | 1,840                 | -910     | 350       | 2,190             | -1,260   | --        | --               | --       |
| 312                     | 365254               | 0912350               | ST JOE 83W34                                 | T26N R04W 33BDA   | 960                            | 2,206                  | 1,830                 | -870     | 300       | 2,130             | -1,170   | --        | --               | --       |
| 313                     | 365135               | 0912310               | ST JOE 83W35                                 | T25N R04W 03CCB   | 735                            | 1,987                  | 1,600                 | -865     | 380       | 1,980             | -1,245   | --        | --               | --       |
| 314                     | 370404               | 0912225               | ST JOE 83W44                                 | T28N R04W 27BDD   | 1,040                          | 1,786                  | 1,500                 | -460     | 210       | 1,710             | -670     | 40        | 1,750            | -710     |
| 315                     | 364701               | 0911545               | ST JOE 84W43                                 | T25N R03W 34DDD   | 860                            | 2,386                  | 1,910                 | -1,050   | 470       | 2,380             | -1,520   | --        | --               | --       |
| 316                     | 364658               | 0911536               | ST JOE 84W44                                 | T24N R03W 02BAA   | 805                            | 2,337                  | 1,850                 | -1,045   | 470       | 2,320             | -1,515   | --        | --               | --       |
| 317                     | 365002               | 0912138               | ST JOE 85W09                                 | T25N R04W 14DB    | 912                            | 2,265                  | 1,830                 | -918     | 420       | 2,250             | -1,338   | --        | --               | --       |
| 318                     | 365021               | 0912137               | ST JOE 85W11                                 | T25N R04W 14AB    | 919                            | 2,236                  | 1,860                 | -941     | 360       | 2,220             | -1,301   | --        | --               | --       |
| 319                     | 365001               | 0912124               | ST JOE 85W15                                 | T25N R04W 14DAB   | 887                            | 2,196                  | 1,800                 | -913     | 390       | 2,190             | -1,303   | --        | --               | --       |
| 320                     | 365004               | 0912109               | ST JOE 85W31                                 | T25N R04W 14DA    | 644                            | 1,957                  | 1,580                 | -936     | 370       | 1,950             | -1,306   | --        | --               | --       |
| 321                     | 365655               | 0912156               | ST JOE 85W35                                 | T26N R04W 02CBD   | 890                            | 1,946                  | 1,640                 | -750     | 280       | 1,920             | -1,030   | --        | --               | --       |
| 322                     | 365838               | 0912100               | ST JOE 85W37                                 | T27N R04W 26DAD   | 997                            | 2,080                  | 1,740                 | -743     | 280       | 2,020             | -1,023   | --        | --               | --       |
| 323                     | 365001               | 0912131               | ST JOE 86W02                                 | T25N R04W 14DB    | 874                            | 2,183                  | 1,800                 | -926     | --        | --                | --       | --        | --               | --       |
| 324                     | 364622               | 0911434               | ST JOE 88W03                                 | T24N R03W 01BDC   | 810                            | 2,400                  | 1,940                 | -1,130   | 440       | 2,380             | -1,570   | --        | --               | --       |
| 325                     | 364859               | 0912007               | ST JOE 88W04                                 | T25N R04W 24DD    | 920                            | 2,321                  | 1,960                 | -1,040   | --        | --                | --       | --        | --               | --       |
| 326                     | 364849               | 0912020               | ST JOE 88W05                                 | T25N R04W 24DD    | 870                            | 2,244                  | 1,830                 | -960     | 400       | 2,230             | -1,360   | --        | --               | --       |
| 327                     | 365013               | 0912140               | ST JOE 88W06                                 | T25N R04W 14AC    | 910                            | 2,223                  | 1,840                 | -930     | 380       | 2,220             | -1,310   | --        | --               | --       |
| 328                     | 364816               | 0911946               | ST JOE 88W09                                 | T25N R03W 30CAB   | 890                            | 2,315                  | 1,910                 | -1,020   | 390       | 2,300             | -1,410   | --        | --               | --       |
| 329                     | 364812               | 0911915               | ST JOE 88W10                                 | T25N R03W 30DBD   | 890                            | 2,324                  | 1,910                 | -1,020   | 400       | 2,310             | -1,420   | --        | --               | --       |
| 330                     | 364557               | 0911424               | ST JOE 88W11                                 | T24N R03W 01DBC   | 750                            | 2,400                  | 2,000                 | -1,250   | 400       | 2,400             | -1,650   | --        | --               | --       |

Table 1. Core log analysis data—Continued

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Derby-Doerun Dolomite |          |           | Davis Formation |          |           | Thickness of St. Francois<br>confining unit |           |
|-------------------------|----------------------|-----------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|-----------------------|----------|-----------|-----------------|----------|-----------|---------------------------------------------|-----------|
|                         |                      |                       |                                              |                   |                                |                        | Depth                 | Altitude | Thickness | Depth           | Altitude | Thickness | Total                                       | Net shale |
| 331                     | 364853               | 0912103               | ST JOE 89W01                                 | T25N R04W 24CCC   | 551                            | 1,935                  | --                    | --       | --        | 1,250           | -699     | 280       | --                                          | 131       |
| 332                     | 364905               | 0911943               | ST JOE 89W02                                 | T25N R03W 19CAC   | 901                            | 2,264                  | --                    | --       | --        | 1,000           | -99      | 310       | --                                          | 130       |
| 333                     | 364628               | 0911356               | ST JOE 89W22                                 | T24N R03W 01ADD   | --                             | 2,590                  | --                    | --       | --        | --              | --       | --        | --                                          | 124       |
| 334                     | 364621               | 0911315               | ST JOE 90W03                                 | T24N R02W 06BDD   | 850                            | 2,505                  | 1,590                 | -740     | 100       | 1,690           | -840     | 310       | 410                                         | 100       |
| 335                     | 365116               | 0912153               | ST JOE 93W08                                 | T25N R04W 11BAC   | 965                            | 2,285                  | 1,500                 | -535     | 110       | 1,610           | -645     | 280       | 390                                         | --        |
| 336                     | 365102               | 0912147               | ST JOE 93W13                                 | T25N R04W 11BDD   | 925                            | 2,265                  | --                    | --       | --        | 1,550           | -625     | 300       | --                                          | 115       |
| 337                     | 365041               | 0912148               | ST JOE 93W16                                 | T25N R04W 11CD    | 865                            | 2,225                  | 1,490                 | -625     | 80        | 1,570           | -705     | 260       | 340                                         | --        |
| 338                     | 365120               | 0912204               | ST JOE 93W18                                 | T25N R04W 11BBB   | 930                            | 2,262                  | 1,500                 | -570     | 80        | 1,580           | -650     | 270       | 350                                         | --        |
| 339                     | 365901               | 0910045               | VAN BUREN WELL 2                             | T27N R01W 25BDD   | 540                            | 815                    | 800                   | -260     | --        | --              | --       | --        | --                                          | --        |
| 340                     | 365757               | 0905821               | PD-19                                        | T27N R01E 32BDD   | 924                            | 1,095                  | --                    | --       | --        | --              | --       | --        | --                                          | --        |
| Minimum                 |                      |                       |                                              |                   | 481                            | 710                    | 495                   | -1,510   | 20        | 620             | -1,182   | 0         | 136                                         | 1.7       |
| Maximum                 |                      |                       |                                              |                   | 1,125                          | 3,000                  | 2,020                 | 85       | 420       | 2,022           | -30      | 340       | 650                                         | 162       |



**Table 1. Core log analysis data—Continued**

[DDMMSS, degrees, minutes, seconds; all units for depth and thickness are in feet; units for altitude are in feet above sea level; depth and altitude refer to the formation top; --, no data]

| Site<br>number<br>(fig. 4) | Latitude<br>(DDMMSS) | Longitude<br>(DDDMMSS) | Mining company<br>borehole<br>identification | Local well number | Altitude<br>of land<br>surface | Bore-<br>hole<br>depth | Bonneterre Formation |          |           | Lamotte Sandstone |          |           | Precambrian rock |          |        |
|----------------------------|----------------------|------------------------|----------------------------------------------|-------------------|--------------------------------|------------------------|----------------------|----------|-----------|-------------------|----------|-----------|------------------|----------|--------|
|                            |                      |                        |                                              |                   |                                |                        | Depth                | Altitude | Thickness | Depth             | Altitude | Thickness | Depth            | Altitude |        |
| 331                        | 364853               | 0912103                | ST JOE 89W01                                 | T25N R04W 24CCC   | 551                            | 1,935                  | 1,530                | -979     | 390       | 1,920             | -1,369   | --        | --               | --       |        |
| 332                        | 364905               | 0911943                | ST JOE 89W02                                 | T25N R03W 19CAC   | 901                            | 2,264                  | 1,310                | -409     | 380       | 1,690             | -789     | --        | --               | --       |        |
| 333                        | 364628               | 0911356                | ST JOE 89W22                                 | T24N R03W 01ADD   | --                             | 2,590                  | --                   | --       | --        | --                | --       | --        | --               | --       |        |
| 334                        | 364621               | 0911315                | ST JOE 90W03                                 | T24N R02W 06BDD   | 850                            | 2,505                  | 2,000                | -1,150   | 450       | 2,450             | -1,600   | --        | --               | --       |        |
| 335                        | 365116               | 0912153                | ST JOE 93W08                                 | T25N R04W 11BAC   | 965                            | 2,285                  | 1,890                | -925     | 370       | 2,260             | -1,295   | --        | --               | --       |        |
| 336                        | 365102               | 0912147                | ST JOE 93W13                                 | T25N R04W 11BDD   | 925                            | 2,265                  | 1,850                | -925     | 400       | 2,250             | -1,325   | --        | --               | --       |        |
| 337                        | 365041               | 0912148                | ST JOE 93W16                                 | T25N R04W 11CD    | 865                            | 2,225                  | 1,830                | -965     | 380       | 2,210             | -1,345   | --        | --               | --       |        |
| 338                        | 365120               | 0912204                | ST JOE 93W18                                 | T25N R04W 11BBB   | 930                            | 2,262                  | 1,850                | -920     | 390       | 2,240             | -1,310   | --        | --               | --       |        |
| 339                        | 365901               | 0910045                | VAN BUREN WELL 2                             | T27N R01W 25BDD   | 540                            | 815                    | --                   | --       | --        | --                | --       | --        | --               | --       |        |
| 340                        | 365757               | 0905821                | PD-19                                        | T27N R01E 32BDD   | 924                            | 1,095                  | --                   | --       | --        | --                | --       | --        | --               | --       |        |
|                            |                      |                        |                                              |                   | Minimum                        | 481                    | 710                  | 495      | -1,250    | 60                | 980      | -1,788    | 0                | 870      | -1,892 |
|                            |                      |                        |                                              |                   | Maximum                        | 1,125                  | 3,000                | 2,098    | 275       | 692               | 2,698    | -384      | 290              | 2,437    | 50     |

**Table 2.** Porosity, vertical permeability, and vertical hydraulic conductivity data

[DDR, Derby-Doerun Dolomite; DVS, Davis Formation; BNT, Bonneterre Formation; LMT, Lamotte Sandstone; C, carbonate rock; B, both carbonate rock and shale; Q, sandstone; S, shale]

| Sample number   | Mining company borehole identification | Formation | Sample depth, in feet | Porosity, in percent | Density, in grams per cubic centimeter | Vertical permeability, in millidarcies | Vertical hydraulic conductivity, in feet per second | Lithology |
|-----------------|----------------------------------------|-----------|-----------------------|----------------------|----------------------------------------|----------------------------------------|-----------------------------------------------------|-----------|
| Study area      |                                        |           |                       |                      |                                        |                                        |                                                     |           |
| 1               | AMAX 801-018                           | DDR       | 1,362                 | 2.40                 | 2.81                                   | 0.000186                               | 5.51E-13                                            | C         |
| 2               | AMAX 801-018                           | DVS       | 1,427                 | 2.20                 | 2.84                                   | .000428                                | 1.27E-12                                            | C         |
| 3               | AMAX 801-018                           | BNT       | 1,794                 | 2.80                 | 2.83                                   | .000142                                | 4.20E-13                                            | B         |
| 4               | AMAX 801-026                           | DDR       | 1,442                 | 1.20                 | 2.84                                   | .000323                                | 9.59E-13                                            | C         |
| 5               | AMAX 801-026                           | DVS       | 1,549                 | .90                  | 2.75                                   | .001043                                | 3.09E-12                                            | C         |
| 6               | COMINCO SF-01                          | DDR       | 1,620                 | 3.10                 | 2.83                                   | .002486                                | 7.37E-12                                            | C         |
| 7               | COMINCO SF-01                          | DVS       | 1,725                 | 2.90                 | 2.82                                   | .002967                                | 8.80E-12                                            | B         |
| 8               | COMINCO SF-02                          | BNT       | 1,964                 | 1.30                 | 2.71                                   | .000015                                | 4.50E-14                                            | B         |
| 9               | COMINCO SF-20                          | DDR       | 1,283                 | 1.70                 | 2.83                                   | .000226                                | 6.71E-13                                            | B         |
| 10              | COMINCO SF-20                          | DVS       | 1,430                 | .50                  | 2.84                                   | .000203                                | 6.03E-13                                            | C         |
| 11              | COMINCO SF-21                          | DVS       | 1,375                 | 2.19                 | 2.81                                   | .000135                                | 4.02E-13                                            | B         |
| 12              | COMINCO SF-28                          | LMT       | 1,912                 | 4.10                 | 2.76                                   | .285602                                | 8.47E-10                                            | Q         |
| 13              | COMINCO SF-33                          | LMT       | 2,230                 | 9.10                 | 2.66                                   | .254374                                | 7.55E-10                                            | Q         |
| 14              | COMINCO VB-06                          | DDR       | 1,592                 | 3.00                 | 2.83                                   | .000423                                | 1.25E-12                                            | C         |
| 15              | COMINCO VB-06                          | DVS       | 1,682                 | 2.80                 | 2.82                                   | .001429                                | 4.24E-12                                            | C         |
| 16              | COMINCO VB-16                          | DVS       | 1,441                 | 5.00                 | 2.84                                   | .000509                                | 1.51E-12                                            | C         |
| 17              | COMINCO VB-16                          | BNT       | 1,693                 | .50                  | 2.82                                   | .000097                                | 2.86E-13                                            | C         |
| 18              | COMINCO VB-24                          | DDR       | 1,255                 | 1.90                 | 2.83                                   | .000752                                | 2.23E-12                                            | C         |
| 19              | COMINCO VB-24                          | DVS       | 1,360                 | 4.80                 | 2.83                                   | .000167                                | 4.96E-13                                            | C         |
| 20              | EXXON CF-01                            | DVS       | 1,701                 | 3.37                 | 2.83                                   | .000229                                | 6.79E-13                                            | C         |
| 21              | EXXON STH-01                           | LMT       | 2,555                 | 6.10                 | 2.67                                   | .834568                                | 2.48E-09                                            | Q         |
| 22              | EXXON STH-02                           | DDR       | 1,839                 | 1.50                 | 2.82                                   | .069957                                | 2.08E-10                                            | C         |
| 23              | EXXON STH-02                           | DVS       | 1,978                 | 4.20                 | 2.82                                   | .000965                                | 2.86E-12                                            | C         |
| 24              | EXXON STH-02                           | BNT       | 2,421                 | 1.00                 | 2.81                                   | .006891                                | 2.04E-11                                            | B         |
| 25              | HOUSTON 122-A                          | DDR       | 1,523                 | 2.50                 | 2.84                                   | .000459                                | 1.36E-12                                            | C         |
| 26              | HOUSTON 122-A                          | DVS       | 1,666                 | .50                  | 2.72                                   | .000034                                | 1.01E-13                                            | C         |
| <sup>a</sup> 27 | HOUSTON 122-A                          | BNT       | 1,768                 | 3.10                 | 2.82                                   | .002164                                | 6.42E-12                                            | B         |
| 28              | NORANDA BCN-01                         | DDR       | 1,525                 | 2.60                 | 2.83                                   | .000719                                | 2.13E-12                                            | C         |

**Table 2.** Porosity, vertical permeability, and vertical hydraulic conductivity data—Continued

[DDR, Derby-Doerun Dolomite; DVS, Davis Formation; BNT, Bonnetterre Formation; LMT, Lamotte Sandstone; C, carbonate rock; B, both carbonate rock and shale; Q, sandstone; S, shale]

| Sample number        | Mining company borehole identification | Formation | Sample depth, in feet | Porosity, in percent | Density, in grams per cubic centimeter | Vertical permeability, in millidarcies | Vertical hydraulic conductivity, in feet per second | Lithology |
|----------------------|----------------------------------------|-----------|-----------------------|----------------------|----------------------------------------|----------------------------------------|-----------------------------------------------------|-----------|
| Study area—Continued |                                        |           |                       |                      |                                        |                                        |                                                     |           |
| 29                   | PH DODGE 12-01A                        | DDR       | 941                   | 6.40                 | 2.84                                   | 0.007430                               | 2.20E-11                                            | C         |
| 30                   | PH DODGE 12-01A                        | DVS       | 1,054                 | 3.20                 | 2.71                                   | .000003                                | 7.65E-15                                            | C         |
| 31                   | PH DODGE 12-01A                        | BNT       | 1,371                 | 1.10                 | 2.85                                   | .000006                                | 1.83E-14                                            | C         |
| 32                   | ST JOE 76W10                           | DVS       | 1,287                 | 2.77                 | 2.79                                   | .000035                                | 1.05E-13                                            | B         |
| 33                   | ST JOE 76W10                           | DVS       | 1,333                 | 5.13                 | 2.76                                   | .000055                                | 1.64E-13                                            | S         |
| 34                   | ST JOE 76W15                           | DDR       | 1,728                 | 1.56                 | 2.85                                   | .000012                                | 3.66E-14                                            | C         |
| 35                   | ST JOE 76W15                           | DDR       | 1,762                 | 1.35                 | 2.83                                   | .000093                                | 2.75E-13                                            | C         |
| 36                   | ST JOE 76W15                           | DVS       | 1,832                 | 1.82                 | 2.83                                   | .000004                                | 1.06E-14                                            | C         |
| 37                   | ST JOE 76W15                           | DVS       | 1,855                 | 1.30                 | 2.84                                   | .000125                                | 3.72E-13                                            | C         |
| 38                   | ST JOE 76W17                           | DDR       | 1,301                 | 1.71                 | 2.84                                   | .000055                                | 1.62E-13                                            | C         |
| 39                   | ST JOE 76W17                           | DVS       | 1,377                 | 1.96                 | 2.74                                   | .000120                                | 3.57E-13                                            | B         |
| 40                   | ST JOE 76W17                           | BNT       | 1,402                 | 1.90                 | 2.85                                   | .000008                                | 2.29E-14                                            | C         |
| 41                   | ST JOE 76W19                           | DVS       | 1,104                 | 3.60                 | 2.83                                   | .000078                                | 2.31E-13                                            | C         |
| 42                   | ST JOE 76W19                           | DVS       | 1,198                 | 6.23                 | 2.74                                   | .000262                                | 7.78E-13                                            | S         |
| 43                   | ST JOE 76W19                           | DVS       | 1,237                 | 3.84                 | 2.79                                   | .000013                                | 3.76E-14                                            | B         |
| Prospecting area     |                                        |           |                       |                      |                                        |                                        |                                                     |           |
| 1                    | AMAX 801-002                           | DDR       | 1,479                 | 3.54                 | 2.84                                   | 0.000004                               | 1.27E-13                                            | C         |
| 2                    | AMAX 801-002                           | DVS       | 1,508                 | 1.73                 | 2.76                                   | .000001                                | 3.17E-14                                            | C         |
| 3                    | AMAX 801-002                           | DVS       | 1,521                 | .73                  | 2.71                                   | .000010                                | 3.17E-13                                            | C         |
| 4                    | AMAX 801-002                           | DVS       | 1,544                 | 4.02                 | 2.68                                   | .000022                                | 6.97E-13                                            | B         |
| 5                    | AMAX 801-002                           | DVS       | 1,578                 | .88                  | 2.75                                   | .000001                                | 3.17E-14                                            | C         |
| 6                    | AMAX 801-009                           | DDR       | 1,409                 | 4.57                 | 2.85                                   | .011813                                | 3.74E-10                                            | C         |
| 7                    | AMAX 801-009                           | DVS       | 1,435                 | 2.31                 | 2.84                                   | .000025                                | 7.83E-13                                            | C         |
| 8                    | AMAX 801-009                           | DVS       | 1,457                 | 2.59                 | 2.64                                   | .000021                                | 6.56E-13                                            | S         |
| 9                    | AMAX 801-009                           | DVS       | 1,485                 | 2.61                 | 2.70                                   | .000043                                | 1.37E-12                                            | C         |
| 10                   | AMAX 801-009                           | DVS       | 1,512                 | 4.49                 | 2.66                                   | .000001                                | 3.17E-14                                            | S         |
| 11                   | AMAX 801-009                           | DVS       | 1,535                 | 2.15                 | 2.70                                   | .000019                                | 5.86E-13                                            | B         |
| 12                   | AMAX 801-010                           | DDR       | 1,492                 | 2.69                 | 2.84                                   | .000015                                | 4.82E-13                                            | C         |



**Table 2.** Porosity, vertical permeability, and vertical hydraulic conductivity data—Continued

[DDR, Derby-Doerun Dolomite; DVS, Davis Formation; BNT, Bonneterre Formation; LMT, Lamotte Sandstone; C, carbonate rock; B, both carbonate rock and shale; Q, sandstone; S, shale]

| Sample number              | Mining company borehole identification | Formation | Sample depth, in feet | Porosity, in percent | Density, in grams per cubic centimeter | Vertical permeability, in millidarcies | Vertical hydraulic conductivity, in feet per second | Lithology |
|----------------------------|----------------------------------------|-----------|-----------------------|----------------------|----------------------------------------|----------------------------------------|-----------------------------------------------------|-----------|
| Prospecting area—Continued |                                        |           |                       |                      |                                        |                                        |                                                     |           |
| 13                         | AMAX 801-010                           | DVS       | 1,512                 | 5.14                 | 2.85                                   | 0.002307                               | 7.31E-11                                            | C         |
| 14                         | AMAX 801-010                           | DVS       | 1,536                 | 7.38                 | 2.70                                   | .000080                                | 2.52E-12                                            | C         |
| 15                         | AMAX 801-010                           | DVS       | 1,564                 | 2.65                 | 2.70                                   | .000016                                | 5.10E-13                                            | B         |
| 16                         | AMAX 801-010                           | DVS       | 1,585                 | 4.52                 | 2.67                                   | .000001                                | 3.17E-14                                            | S         |
| 17                         | AMAX 801-010                           | DVS       | 1,608                 | .82                  | 2.72                                   | .000016                                | 5.17E-13                                            | B         |
| 18                         | AMAX 801-016                           | DDR       | 1,528                 | 1.23                 | 2.84                                   | .000016                                | 4.91E-13                                            | C         |
| 19                         | AMAX 801-016                           | DDR       | 1,560                 | .71                  | 2.80                                   | .000005                                | 1.65E-13                                            | S         |
| 20                         | AMAX 801-016                           | DVS       | 1,602                 | 3.13                 | 2.72                                   | .000001                                | 3.17E-14                                            | B         |
| 21                         | AMAX 801-016                           | DVS       | 1,630                 | 2.39                 | 2.66                                   | .000001                                | 3.17E-14                                            | S         |
| 22                         | AMAX 801-016                           | DVS       | 1,649                 | 2.51                 | 2.69                                   | .000001                                | 3.17E-14                                            | B         |
| 23                         | AMAX 801-016                           | DVS       | 1,689                 | 2.98                 | 2.69                                   | .000005                                | 1.65E-13                                            | B         |
| 24                         | AMAX 801-031                           | DDR       | 1,478                 | 1.40                 | 2.84                                   | .000001                                | 3.17E-14                                            | C         |
| 25                         | AMAX 801-031                           | DDR       | 1,523                 | 2.19                 | 2.87                                   | .000001                                | 3.17E-14                                            | C         |
| 26                         | AMAX 801-031                           | DVS       | 1,554                 | .66                  | 2.85                                   | .000001                                | 3.17E-14                                            | C         |
| 27                         | AMAX 801-031                           | DVS       | 1,579                 | 2.12                 | 2.68                                   | .000001                                | 3.17E-14                                            | S         |
| 28                         | AMAX 801-031                           | DVS       | 1,606                 | 2.04                 | 2.66                                   | .000014                                | 4.44E-13                                            | S         |
| 29                         | AMAX 801-031                           | DVS       | 1,640                 | .96                  | 2.69                                   | .000001                                | 3.17E-14                                            | C         |
| 30                         | ST JOE 82W03                           | DDR       | 1,564                 | .61                  | 2.83                                   | .000001                                | 3.17E-14                                            | C         |
| 31                         | ST JOE 82W03                           | DDR       | 1,581                 | .80                  | 2.82                                   | .000001                                | 3.17E-14                                            | C         |
| 32                         | ST JOE 82W03                           | DVS       | 1,624                 | 2.37                 | 2.82                                   | .000035                                | 1.11E-12                                            | C         |
| 33                         | ST JOE 82W03                           | DVS       | 1,692                 | 3.49                 | 2.68                                   | .000001                                | 3.17E-14                                            | S         |
| 34                         | ST JOE 82W03                           | DVS       | 1,841                 | 4.93                 | 2.75                                   | .000098                                | 3.11E-12                                            | S         |
| 35                         | ST JOE 82W27                           | DDR       | 1,445                 | 1.08                 | 2.83                                   | .000001                                | 3.17E-14                                            | C         |
| 36                         | ST JOE 82W27                           | DDR       | 1,479                 | 1.16                 | 2.81                                   | .000001                                | 3.17E-14                                            | C         |
| 37                         | ST JOE 82W27                           | DVS       | 1,522                 | 5.00                 | 2.68                                   | .000019                                | 6.15E-13                                            | S         |
| 38                         | ST JOE 82W27                           | DVS       | 1,597                 | 3.23                 | 2.72                                   | .000001                                | 3.17E-14                                            | B         |
| 39                         | ST JOE 82W27                           | DVS       | 1,679                 | 6.70                 | 2.78                                   | .000036                                | 1.14E-12                                            | S         |
| 40                         | ST JOE 83W17                           | DDR       | 1,493                 | 2.95                 | 2.84                                   | .206553                                | 6.55E-09                                            | C         |
| 41                         | ST JOE 83W17                           | DDR       | 1,542                 | 4.06                 | 2.85                                   | .000001                                | 6.14E-12                                            | C         |

**Table 2.** Porosity, vertical permeability, and vertical hydraulic conductivity data—Continued

[DDR, Derby-Doerun Dolomite; DVS, Davis Formation; BNT, Bonneterre Formation; LMT, Lamotte Sandstone; C, carbonate rock; B, both carbonate rock and shale; Q, sandstone; S, shale]

| Sample number              | Mining company borehole identification | Formation | Sample depth, in feet | Porosity, in percent | Density, in grams per cubic centimeter | Vertical permeability, in millidarcies | Vertical hydraulic conductivity, in feet per second | Lithology |
|----------------------------|----------------------------------------|-----------|-----------------------|----------------------|----------------------------------------|----------------------------------------|-----------------------------------------------------|-----------|
| Prospecting area—Continued |                                        |           |                       |                      |                                        |                                        |                                                     |           |
| 42                         | ST JOE 83W17                           | DVS       | 1,615                 | 5.64                 | 2.73                                   | 0.000001                               | 3.17E-14                                            | S         |
| 43                         | ST JOE 83W17                           | DVS       | 1,692                 | 1.40                 | 2.70                                   | .000001                                | 3.17E-14                                            | C         |
| 44                         | ST JOE 83W17                           | DVS       | 1,762                 | 3.12                 | 2.73                                   | .000001                                | 3.17E-14                                            | B         |
| <sup>b</sup> 45            | ST JOE 83W30                           | DDR       | 1,445                 | 17.6                 | 2.83                                   | 3.988473                               | 1.18E-08                                            | C         |
| <sup>b</sup> 46            | ST JOE 83W30                           | DDR       | 1,445                 | 17.47                | 2.83                                   | 2.743155                               | 8.70E-08                                            | C         |
| 47                         | ST JOE 83W30                           | DDR       | 1,494                 | 1.99                 | 2.83                                   | .000012                                | 3.90E-13                                            | C         |
| 48                         | ST JOE 83W30                           | DVS       | 1,591                 | 4.47                 | 2.72                                   | .000026                                | 8.24E-13                                            | B         |
| 49                         | ST JOE 83W30                           | DVS       | 1,727                 | .46                  | 2.70                                   | .000001                                | 3.17E-14                                            | C         |
| 50                         | ST JOE 83W30                           | DVS       | 1,796                 | 5.74                 | 2.78                                   | .000021                                | 6.66E-13                                            | S         |
| <sup>b</sup> 51            | ST JOE 83W34                           | DDR       | 1,511                 | 11.6                 | 2.85                                   | .472414                                | 1.40E-09                                            | C         |
| <sup>b</sup> 52            | ST JOE 83W34                           | DDR       | 1,511                 | 11.76                | 2.84                                   | .584585                                | 1.85E-08                                            | C         |
| 53                         | ST JOE 83W34                           | DVS       | 1,573                 | 1.93                 | 2.75                                   | .000001                                | 3.17E-14                                            | C         |
| 54                         | ST JOE 83W34                           | DVS       | 1,685                 | 5.32                 | 2.69                                   | .000054                                | 1.71E-12                                            | S         |
| 55                         | ST JOE 83W34                           | DVS       | 1,725                 | 5.61                 | 2.72                                   | .000051                                | 1.62E-12                                            | S         |
| 56                         | ST JOE 83W34                           | DVS       | 1,785                 | 3.28                 | 2.80                                   | .000001                                | 3.17E-14                                            | C         |
| 57                         | ST JOE 83W34                           | DVS       | 1,791                 | 5.99                 | 2.75                                   | .000001                                | 3.17E-14                                            | B         |
| 58                         | ST JOE 83W35                           | DDR       | 1,333                 | 2.37                 | 2.80                                   | .000001                                | 3.17E-14                                            | C         |
| 59                         | ST JOE 83W35                           | DDR       | 1,350                 | 4.49                 | 2.84                                   | .000729                                | 2.31E-11                                            | C         |
| 60                         | ST JOE 83W35                           | DVS       | 1,475                 | 4.27                 | 2.72                                   | .000007                                | 2.22E-13                                            | B         |
| 61                         | ST JOE 83W35                           | DVS       | 1,495                 | 5.18                 | 2.72                                   | .000005                                | 1.59E-13                                            | S         |
| 62                         | ST JOE 83W35                           | DVS       | 1,516                 | 2.46                 | 2.71                                   | .008150                                | 2.58E-10                                            | B         |
| 63                         | ST JOE 83W35                           | DVS       | 1,597                 | 3.88                 | 2.75                                   | .000001                                | 3.17E-14                                            | B         |

<sup>a</sup> Bonneterre Formation sample from above the False Davis, sample included in Davis Formation data set.<sup>b</sup> Duplicate sample.

**KLEESCHULTE and SEEGER—Stratigraphy and Vertical Hydraulic Conductivity of the St. Francois Confining Unit—USGS WRIR 01-4270  
in Townships 25-27 N. and Ranges 01-02 W., Southeastern Missouri**