GEOLOGIC FRAMEWORK AND HYDROGEOLOGIC CHARACTERISTICS OF THE EDWARDS AQUIFER OUTCROP, HAYS COUNTY, TEXAS

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 95–4265

Prepared in cooperation with the
EDWARDS UNDERGROUND WATER DISTRICT

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By John A. Hanson and Ted A. Small

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BRUCE BABBITT, Secretary

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District Chief
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Geologic Framework and Hydrogeologic Characteristics of the Edwards Aquifer Outcrop, Hays County, Texas

By John A. Hanson *and* Ted A. Small

Abstract

All of the hydrogeologic subdivisions within the Edwards aquifer outcrop in Hays County have some porosity and permeability. The most porous and permeable appear to be hydrogeologic subdivision VI, the Kirschberg evaporite member of the Kainer Formation; hydrogeologic subdivision III, the leached and collapsed members, undivided; and hydrogeologic subdivision II, the cyclic and marine members, undivided, of the Person Formation. The two types of porosity in the Edwards aquifer outcrop are fabric selective, which is related to depositional or diagenetic elements and typically exists in specific stratigraphic horizons; and not fabric selective, which can exist in any lithostratigraphic horizon. Permeability, the capacity of porous rock to transmit water, depends on the physical properties of the rock such as size, shape, and distribution of pores, and fissuring and dissolution.

Two faults, San Marcos Springs and Mustang Branch, completely, or almost completely, offset the Edwards aquifer by juxtaposing Edwards aquifer limestone against nearly impermeable upper confining units along parts of their traces across Hays County. These faults are thought to be barriers, or partial barriers, to ground-water flow where the beds are juxtaposed.

In Hays County, the Edwards aquifer probably is most vulnerable to surface contamination in the rapidly urbanizing areas on the Edwards aquifer outcrop. Contamination can result from spills or leakage of hazardous materials; or runoff on the intensely faulted and fractured, karstic limestone outcrops characteristic of the recharge zone.

INTRODUCTION

Located in the Lower Cretaceous Kainer and Person Formations of the Edwards Group (Rose, 1972) and the overlying Georgetown Formation, the Edwards aquifer is one of the most permeable and productive carbonate aquifers in the nation. The dissolution-modified, faulted limestone aquifer (Buszka and others, 1990) is the sole source of public water supply for San Antonio and is the major source of water for Hays County.

Most recharge to the Edwards aquifer occurs in counties immediately west of Bexar County (fig. 1). Streams cross Edwards aquifer outcrops (the recharge zone) in the Balcones fault zone and lose much, if not all, of their flow to faults, fractures, sinkholes, and caves in the outcrop. After entering the aquifer, the water moves east to points of discharge in Bexar County (mostly municipal wells) and then northeast, parallel or almost parallel to the northeast-trending Balcones faults into Comal and Hays Counties, where it is discharged by wells and springs.

Additional recharge to the Edwards aquifer is from Edwards aquifer outcrops in the Balcones fault zone in northern Bexar County and southern Comal and Hays Counties. The rugged, scenic limestone hills of the Edwards aquifer outcrops are the site of rapidly encroaching residential and commercial development. Kipp and others (1993, p. 1) report a substantial increase in development activities over the Edwards recharge zone during 1992–93. They also note that increased development brings a greater threat of contamination to the Edwards aquifer. The aquifer could be contaminated from spills or leakage of hazardous materials; or runoff from the rapidly developing urban areas that surround, or are built on, the intensely faulted and fractured, karstic limestone outcrops characteristic of the recharge zone. Furthermore, some of the hydrogeologic subdivisions that compose the Edwards aquifer have greater effective porosity and permeability than

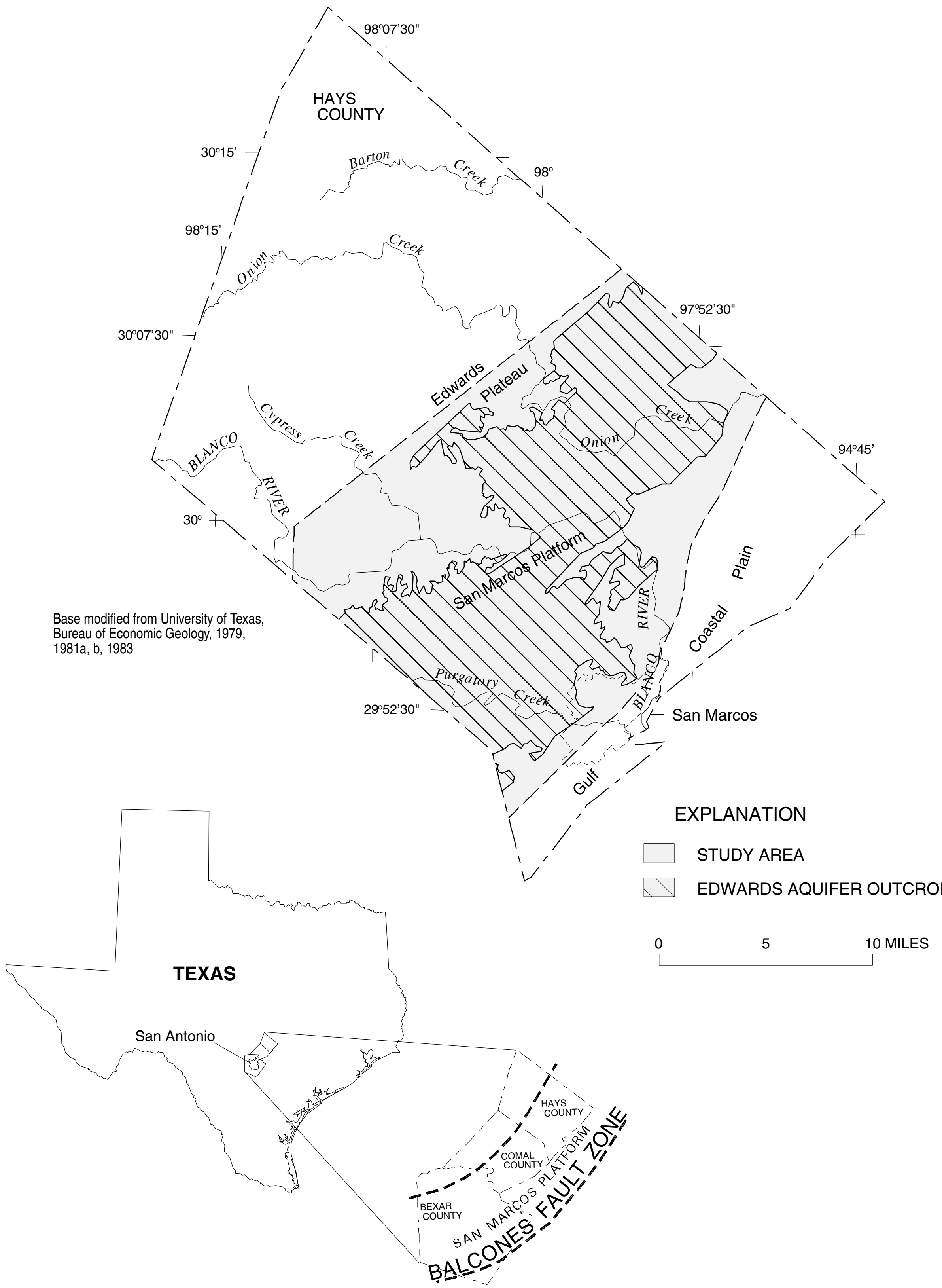

Figure 1. Location of the study area.

others, and in areas where they crop out, might provide efficient avenues for contaminants to enter the aquifer. According to Buszka (1987, p. 2), "Carbonate aquifers such as the Edwards are readily susceptible to ground-water contamination where the presence of pollutants coincides with the outcrop of the aquifer." In Hays County, the Edwards aquifer probably is most vulnerable to surface contamination in the rapidly urbanizing areas on the Edwards aquifer outcrop.

The U.S. Geological Survey, in cooperation with the Edwards Underground Water District, mapped the Edwards aquifer outcrop and described its hydrogeologic characteristics (porosity and permeability) to document conditions pertinent to movement and contamination of ground water. This report describes the geologic framework and hydrogeologic characteristics of the Edwards aquifer outcrop in Hays County. This information will help to provide a better understanding of the processes controlling the spatial distribution of recharge and the flow of water into the aquifer. The information also will help determine the areas of the recharge zone that are most susceptible to potential contamination from land-use practices.

Methods of Investigation

The hydrogeologic subdivisions (table 1) modified from Maclay and Small (1976) were used to map the Edwards aquifer outcrop. The stratigraphic nomenclature and descriptions of Rose (1972) were used in mapping the geologic units for the San Marcos platform (fig. 1). The carbonate-rock classification system of Dunham (1962) was used for the lithologic descriptions. Member, hydrogeologic subdivision, and porosity/permeability type were determined at the outcrop. The porosity type follows the sedimentary carbonate classification system of Choquette and Pray (1970). The hydrogeologic subdivisions of the Edwards aquifer outcrop in Hays County are shown on plate 1.

Recent aerial photographs were used to locate roads and excavations that could provide outcrop exposures for field examination and for orientation in the morphologically similar Edwards aquifer outcrops. In addition, stratigraphic information was ascertained by inspection of surficial expressions and features as indicated by the following examples. The basal nodular member of the Kainer Formation supports a dense growth of juniper and oak trees and can be recognized on aerial photographs by the dark trace that encircles the hills of the overlying dolomitic member. The dolomitic member of the Kainer Formation, which caps several hills in southwestern, north-central, and northeastern Hays County, can be identified on aerial photographs by a pattern of concentric rings of sparse vegetation growing on the differentially weathered limestone. The regional dense member of the Person Formation can be recognized on aerial photographs as small, light-to-almost-white areas.

Well logs and geologic map data were compiled and used in mapping the hydrogeologic subdivisions of the Edwards aquifer in the study area. The thicknesses of the hydrogeologic subdivisions that compose the Edwards aquifer were determined from well logs in and adjacent to the aquifer outcrop in Hays County. The upper member of the Lower Cretaceous Glen Rose Limestone, the lower confining unit (table 1), was mapped adjacent to the Edwards aquifer outcrop along the northwestern boundary of the study area (pl. 1). The upper confining units, which include the Upper Cretaceous Del Rio Clay, Buda Limestone, Eagle Ford Group, Austin Group, and the Navarro and Taylor Groups, undivided, were mapped along the eastern and southeastern boundary of the study area.

Faults were identified in the field by stratigraphic displacement and characteristics related to faulting, such as zones of fault gouge composed of soils that greatly resemble caliche, or relatively thick, vein-like masses of subhedral to anhedral calcite crystals. Steeply inclined strata, uncommon in the relatively flat-lying Edwards aquifer outcrop, typically represent drag-folding related to faulting. The presence of cedar elm trees, which tend to grow along faults, perhaps as a result of enhanced downward movement of water along the fault planes, also was used to indicate faults.

Acknowledgments

Special thanks are extended to Dean Word, Dean Word Industries, Joe Rogers, and Centex Industries for access to their quarries. Also, thanks are extended to Dr. P.R. Rose and Dr. Charles Woodruff, Jr., for their helpful comments during a visit to two quarries near San Marcos, and to the many property owners who granted permission to enter their property, supplied information, and aided in collecting the field data.

Table 1. Summary of the lithologic and hydrologic properties of the hydrogeologic subdivisions of the Edwards aquifer outcrop, Hays County, Texas

[Hydrogeologic subdivisions modified from Maclay and Small (1976); groups, formations, and members modified from Rose (1972); lithology modified from Dunham (1962); and porosity type modified from Choquette and Pray (1970). CU, confining unit; AQ, aquifer]

Hydrogeologic subdivision	Group, formation, or member	Hydrologic function	Thickness (feet)	Lithology	Field identification	Cavern development	Porosity/ permeability type
Upper Cretaceous; Upper confining units	Navarro and Taylor Groups, undivided	CU	600	Clay; chalky limestone	Gray-brown clay; marly limestone	None	Low porosity/ low permeability
Upper Cretaceous; Upper confining units	Austin Group	CU; rarely AQ	130 – 150	White to gray limestone	White, chalky limestone; *Gryphaea aucella*	None	Low porosity/ low permeability; rare water production from fractures
Upper Cretaceous; Upper confining units	Eagle Ford Group	CU	30 – 50	Brown, flaggy, sandy shale and argillaceous limestone	Thin flagstones; petroliferous	None	Primary porosity lost/ low permeability
Upper Cretaceous; Upper confining units	Buda Limestone	CU	40 – 50	Buff, light gray, dense mudstone	Porcelaneous limestone	Minor surface karst	Low porosity/ low permeability
Upper Cretaceous; Upper confining units	Del Rio Clay	CU	40 – 50	Blue-green to yellow-brown clay	Fossiliferous; *Ilymatogyra arietina*	None	None; primary upper confining unit
Lower Cretaceous; Edwards aquifer; I	Georgetown Formation	CU	10 – 40	Gray to light tan marly limestone	Marker fossil: *Waconella wacoensis*	None	Low porosity/ low permeability
Lower Cretaceous; Edwards aquifer; II	Edwards Group; Person Formation; Cyclic and marine members, undivided	AQ	80 – 100	Mudstone to packstone; *miliolid* grainstone; chert	Boxwork vugs; light tan, massive; some *Toucasia* and *Caprinid*	Many caves; might be associated with earlier karst development	Laterally extensive; both fabric and not fabric/one of the more porous and permeable of the subdivisions
Lower Cretaceous; Edwards aquifer; III	Edwards Group; Person Formation; Leached and collapsed members, undivided	AQ	80 – 100	Crystalline limestone; mudstone to grainstone; chert; collapsed breccia	Bioturbated iron-stained beds separated by massive limestone beds; *Montastrea (?)* sp.	Extensive lateral development; large rooms	Majority not fabric/ probably the most permeable of the subdivisions
Lower Cretaceous; Edwards aquifer; IV	Edwards Group; Person Formation; Regional dense member	CU	20 – 24	Dense, argillaceous mudstone	Wispy iron-oxide stains	None; only vertical fracture enlargement	Not fabric/ low permeability; vertical barrier
Lower Cretaceous; Edwards aquifer; V	Edwards Group; Kainer Formation; Grainstone member	AQ	50 – 60	*Miliolid* grainstone; mudstone to wackestone; chert	White crossbedded grainstone; *Toucasia* and *Turritella*	Few caves	Not fabric/ recrystallization reduces permeability
Lower Cretaceous; Edwards aquifer; VI	Edwards Group; Kainer Formation; Kirschberg evaporite member	AQ	50 – 60	Crystalline limestone; chalky mudstone; chert	Boxwork voids, with neospar and travertine frame	Probably extensive cave development	Majority fabric/one of the more porous and permeable of the subdivisions
Lower Cretaceous; Edwards aquifer; VII	Edwards Group; Kainer Formation; Dolomitic member	AQ	110 – 130	Mudstone to grainstone; crystalline limestone; chert	Massively bedded light gray, *Toucasia* abundant	Caves related to structure or bedding planes	Mostly not fabric; some bedding-plane fabric/ locally permeable
Lower Cretaceous; Edwards aquifer; VIII	Edwards Group; Kainer Formation; Basal nodular member	Karst AQ; not karst CU	50 – 60	Shaly, nodular limestone; mudstone and *miliolid* grainstone	Massive, nodular and mottled, *Exogyra texana*	Few caves	Fabric/low permeability
Lower Cretaceous; Lower confining unit	Upper member of the Glen Rose Limestone	CU; evaporite beds AQ	350 – 500	Yellowish tan, thinly bedded limestone and marl	Stair-step topography; alternating limestone and marl	Some surface cave development	Some water production at evaporite beds/ relatively impermeable

GEOLOGIC FRAMEWORK

General Features

A regional dip of about 20 feet per mile (ft/mi) to the southeast for Cretaceous strata on the Edwards Plateau (fig. 1) in northwestern Hays County was reported by DeCook (1963, p. 43). According to DeCook (1963, p. 43), the Comal/Hays County line lies along the approximate axis of the San Marcos platform; however, Rose (1972, fig. 16) places the axis in Comal County. Northeast-trending faults of the Balcones fault zone cross the entire county, but are more numerous in the southeastern part of the county. According to DeCook (1963), the San Marcos Springs fault (pl. 1) forms a prominent part of the escarpment separating the Gulf Coastal Plain from the Edwards Plateau (fig. 1).

Balcones faults are en echelon, high-angle, normal, and mostly downthrown to the southeast (down-to-the-Gulf Coast); however, a few faults are downthrown to the northwest. Sellards and Baker (1934, p. 56–57) described the zone of faults consisting principally of the Comal Springs and San Marcos Springs faults as "* * * a highly complicated zone of faulting characterized by numerous faults, some of which are of large throw. * * * The individual faults have in the main the same trend, although there are many faults of divergent trend, resulting in numerous small and irregularly shaped fault blocks, so that the fault pattern as a whole is very complex." DeCook (1963, p. 47) noted that dips of the faults were not easily obtained and where the dips have been observed, they commonly exceed 60 degrees and their steepness is indicated further by the generally straight traces of faults across uneven land surfaces. Grimshaw and Woodruff (1986, p. 72) stated, "The fact that fault traces are not at all influenced by topography indicates that all faults are vertical or nearly so."

DeCook (1963, p. 44) reported that at least seven major faults in Hays County are traceable for many miles and have relatively great displacements. DeCook (1963, p. 44) further noted at least 70 more faults of lesser length with generally less displacement. The seven major faults are Comal Springs, San Marcos Springs, Kyle, Mustang Branch, Hidden Valley, Wimberley, and Tom Creek (pl. 1). At least three other faults—Academy, Mountain City, and Bat Cave (pl. 1)—probably could be included in the list of major faults. Two faults, San Marcos Springs and Mustang Branch, completely, or almost completely, offset the Edwards aquifer by juxtaposing Edwards aquifer limestone against nearly impermeable upper confining units along parts of their traces across Hays County. These faults are thought to be barriers, or partial barriers, to ground-water flow where the beds are juxtaposed.

Geomorphic expression of faulting on the upthrown fault blocks is indicated on topographic maps by the branching of subsequent valleys normal to the consequent valleys, forming a "T-square" morphology of the valleys. The formation of the consequent valleys resulted from the drop in base level of the downthrown block, which initiated headward erosion on the escarpment. The development of the subsequent valleys possibly is the result of faults structurally weakening the consequent valley slopes creating the T-square pattern normal to the natural course of headward erosion (Thornbury, 1962).

Stratigraphy

The Edwards Group (table 1) is about 440 to 534 feet (ft) thick in Hays County. The Edwards Limestone of DeCook (1963) is roughly equivalent to the Edwards Group of Rose (1972). DeCook (1963, p. 27) reported a thickness in the Edwards Limestone of about 350 ft in a well in San Marcos and a thickness of about 400 ft in a well in northeast Hays County. In 1990, the Edwards Underground Water District reported a thickness of about 480 ft in the Edwards Group in wells drilled near San Marcos Springs (pl. 1). According to DeCook (1963), the Edwards Limestone in Hays County primarily consists of "***light-gray, brittle, thick-bedded to massive limestone, commonly dolomitic, containing minor beds of argillaceous or siliceous limestone and calcareous shale. Bedded or nodular chert and flint characterize much of the formation." This is useful information when mapping the outcrop of the Edwards Group. Massive, nodular limestone beds at the lower part of the Kainer Formation overlie the alternating marl and limestone beds of the upper member of the Glen Rose Limestone in Hays County (DeCook, 1963). The upper member of the Glen Rose Limestone is identified by its characteristic stair-step topography caused by the differential weathering of the nonresistant marl and resistant limestone and dolomite beds (Stricklin and others, 1971, p. 23).

The major formal lithostratigraphic units of the Edwards aquifer are the Kainer, Person, and Georgetown Formations. The Kainer and Person Formations of the Edwards Group were divided into seven informal members by Rose (1972). Maclay and Small (1976) combined Rose's seven members with the Georgetown Formation to form the group of eight informal hydrogeologic subdivisions of the Edwards aquifer identified on plate 1. The Georgetown Formation is not known to yield water in the study area. However, because well drillers historically have relied on the Georgetown Formation to indicate the top of the Edwards aquifer, the formation is considered part of the aquifer. Except for the Georgetown Formation, the strata that compose the Edwards aquifer were deposited in shallow to very shallow marine water (Rose, 1972) and reflect depositional environments resulting from slight changes in water level, water chemistry, temperature, and circulation. These factors caused subtle to not-so-subtle variations in the overall lithology of the various members and some variations within the individual members.

The Kainer Formation (Rose, 1972, p. 19) is about 260 to 310 ft thick in Hays County (table 1). The lithology of the Kainer Formation ranges from mudstone to *miliolid* grainstone to crystalline limestone. The lowermost unit, the basal nodular member, is 50 to 60 ft thick and generally is a dense, shaly, fossiliferous, nodular limestone, mudstone, and some *miliolid* grainstone. The fossil oyster *Exogyra texana* is scattered erratically throughout the member and is abundant locally. The tan-yellow clay layer at the base of the basal nodular member might be equivalent to the Walnut Clay described by DeCook (1963).

The next higher member, the 110- to 130-ft-thick dolomitic member, is mostly dense crystalline limestone with occasional zones of grainstone and layers of variably burrowed, and occasionally strongly dissolutioned mudstone. Chert nodules and thin discontinuous beds of chert are scattered throughout the member. Rudists, typically *Toucasia*, are common locally near the top of the member. *Chondrodonta*, a thick-shelled pelecypod, also is found near the top of the dolomitic member, but is not common.

The Kirschberg evaporite member is 50 to 60 ft thick and consists mostly of crystalline limestone and chalky mudstone with chert nodules and lenses. This member lacks the collapse features common to the Kirschberg evaporite on the Edwards Plateau, which might indicate that less evaporite was deposited on the San Marcos platform. However, boxwork structure thought to represent dissolution of evaporites is evident in thinly layered beds of crystalline limestone in the western part of the county.

The grainstone member overlies the Kirschberg evaporite member and is the uppermost member of the Kainer Formation. The grainstone member is 50 to 60 ft thick and primarily is dense, *miliolid* grainstone cemented with calcite spar; however, patches of mudstone to wackestone are scattered throughout (table 1). Chert nodules generally are rare in this member. Locally, *Toucasia*s and stubby spar-filled *turritella* gastropods are common near the top of the member. *Chondrodonta* is found in approximately the same stratigraphic interval as *Toucasia*, but is not common.

The Person Formation (Rose, 1972, p. 19) is about 180 to 224 ft thick in Hays County (table 1). The lithology of the Person Formation ranges from mudstone to layers of locally intensely burrowed mudstone to grainstone to crystalline limestone. The regional dense member is the lowermost member of the Person Formation and consists of dense, argillaceous mudstone, with distinctive wispy shale partings. The combination of the grainstone member (Kainer Formation) and the regional dense member (Person Formation) forms a very distinctive mapping horizon.

The leached and collapsed members, undivided, overlie the regional dense member and were mapped as one unit because they could not be distinguished as separate members. The lithology of the leached and collapsed members, undivided, ranges from variably burrowed mudstone to grainstone with intervals of crystalline limestone; chert lenses are common as well. The collapsed zones common in this member were caused by the collapse of the overlying limestone into the voids created by early dissolution of the thin evaporite layers and lenses (Rose, 1972, p. 55).

The cyclic and marine members, undivided, also were mapped as one unit. According to Rose (1972, p. 71), the cyclic member and much of the marine member were eroded from the axis of the San Marcos platform before deposition of the Georgetown Formation. The remaining part of the marine member consists of medium thick to thick beds of variably honeycombed mudstone and fossiliferous packstone and lenses of *miliolid* grainstone and chert nodules. DeCook (1963) reported that in an area northwest of San Marcos the uppermost part of the Edwards limestone is characterized by massive honeycombed rudistid-bearing biostromes. Rocks of this description were identified in a quarry about 2 miles (mi) north of San Marcos where there is an excellent exposure near the contact of the marine member with the overlying Georgetown Formation. Locally, the marine member is bored at the contact. About 5 ft below this contact is a honeycombed zone. Some of the vugs in this honeycombed zone have a semi-rectangular outline, similar to those shown by Stricklin and others (1971, p. 54), as boxwork structures. P.R. Rose (Geologist, oral commun., 1994) suggests that these boxwork vugs might represent preferential dissolution of clasts of collapse breccia formed by the collapse of overlying layers into voids left by the dissolution of underlying evaporites. *Caprinids* (a type of fossil rudistid), some of which are larger than those generally seen on the San Marcos platform, locally are common in the rudist biostrome just below the honeycomb zone. *Toucasia*s locally are common near the contact of the marine member with the Georgetown Formation.

The Georgetown Formation, which overlies the Edwards Group, was deposited on the eroded surface of the Person Formation in deeper water than was characteristic for most of the Edwards Group deposition (Rose, 1972, p. 71). The Georgetown Formation generally is a marly, fossiliferous limestone, usually containing ammonites, oyster-like clams, and the brachiopod *Waconella wacoensis*, formerly *Kingena wacoensis* (Roemer), which is an excellent marker fossil for the Georgetown Formation (table 1). Exposures of the Georgetown Formation are common and range from 10 to 40 ft thick.

The Upper Cretaceous Del Rio Clay, Buda Limestone, Eagle Ford Group, Austin Group, and Navarro and Taylor Groups, undivided, overlie the Georgetown Formation (table 1). The Del Rio Clay is a dark blue-green to yellow-brown, variably gypsiferous clay commonly containing pecten-type fossil clams and an abundance of the fossil oyster *Ilymatogyra arietina*, formerly *Exogyra arietina* (Roemer). These fossil oysters are known locally as "rams horns." The Buda Limestone consists of dense, variably nodular, sublithographic or "porcelaneous" limestone (Sellards and others, 1933, p. 397); and buff, light-gray mudstone, commonly containing calcispheres and tiny calcite-filled fractures. The Eagle Ford Group overlies the Buda Limestone and consists of thin flagstones of brown, flaggy sandy shale and argillaceous limestone. Some of the freshly fractured flagstones (thin brittle slabs) emit a petroliferous odor. Because the Eagle Ford Group is dark brown in the subsurface, local water-well drillers commonly refer to this shale as lignite. The Austin Group overlies the Eagle Ford Group and consists of chalky, variably marly, generally fossiliferous limestone, commonly containing the fossil oyster *Gryphaea aucella*. The Navarro and Taylor Groups, undivided, are Upper Cretaceous rocks that overlie the Austin Group, and are mostly calcareous clayey chalky limestone.

Field identification of the various members in the Kainer and Person Formations was based on their characteristic lithologies and fossils (table 1). Red clay soil that resembles the "terra rossa" of Pleistocene age, described by Young (1986, p. 63) as a diagenetically altered paleosol, commonly is evident in outcrops of the Edwards Group, but rarely in the Glen Rose Limestone or in the clays, marls, or limestones of the upper confining units. According to Young (1986, p. 65), the red clay soil indicates that lithology was important in the development of central Texas terra rossa. Red clay soil was observed more often in the Person Formation than in the Kainer Formation, but locally it is common in the dolomitic member and Kirschberg evaporite member, and has been reported in core and drill cuttings in the Kainer Formation. Large accumulations of terra rossa relative to the volume of pore space in the limestone decrease the effective porosity and thereby decrease the permeability.

Young (1986, p. 65) observed that karstification of the Person Formation was more thorough than karstification of the Kainer Formation on the San Marcos platform. Because of the lithologic similarities between the leached and collapsed members, undivided, and the cyclic and marine members, undivided, of the Person Formation, the contact between the two sometimes is difficult to determine. In such areas, the approximate stratigraphic thickness was used to identify the unit and locate the approximate contact. A unique colonial coral, identified as *Montastrea* sp. (Finsley, 1989), was observed in the lower to middle part of the leached and collapsed members, undivided, and could serve as a guide fossil.

HYDROGEOLOGIC CHARACTERISTICS

General Features

Major factors controlling porosity and permeability in the Edwards aquifer outcrop are faulting, stratification, and karstification—a form of diagenesis resulting from extensive dissolution of limestone. Zones of faulted, fractured, and dissolutioned limestone, along with layers of burrowed, honeycombed, and occasionally cavernous limestone, are common in the Edwards aquifer outcrop.

The karst features of the Edwards Group rocks in Hays County are characterized by resistant terrain of dense limestone, sparsely dotted with sinkholes and caves, which can greatly enhance porosity and permeability. Although not necessarily representative of previous geologic times, the present-day dry-subhumid climate (Thornthwaite, 1952) (rainfall 33.79 inches per year [in/yr]; Bader and others, 1993, table 3.1) is not favorable for rapid karst development.

Porosity and Permeability

According to Choquette and Pray (1970, p. 212), porosity in sedimentary carbonates is either fabric selective or not fabric selective. Fabric selective porosity is related directly to the depositional or diagenetic fabric elements of a sediment and typically is controlled by lithostratigraphic horizon. Not fabric selective porosity is not related to depositional or diagenetic fabric elements of a sediment and can exist in any lithostratigraphic horizon.

Choquette and Pray (1970, p. 222) designated seven types of carbonate porosity that are "extremely common and volumetrically important." Five of these (interparticle, intraparticle, intercrystalline, moldic, and fenestral) generally are fabric selective, and two (fracture and vuggy) are not fabric selective. According to Choquette and Pray (1970, p. 223–224), breccia porosity is a type of interparticle porosity and can be either fabric selective or not fabric selective. Other types of porosity in the Edwards aquifer outcrop are channel and cavern, both of which are not fabric selective; and burrow, which can be either fabric selective or not fabric selective. Choquette and Pray (1970, p. 250) noted that vugs and channels are similar in that neither is fabric selective. Vugs and channels differ in shape; "vug" is used to describe the more equidimensional pores; whereas, "channel" is used to describe markedly elongated pores or irregular openings with a marked elongation in one or two dimensions.

Permeability is the capacity of a porous rock to transmit water. According to Ford and Williams (1989, p. 130), permeability depends on the physical properties of the rock, particularly pore size, shape, and distribution. Ford and Williams (1989, p. 150) further state that, "As a consequence of the effects of fissuring and differential solution, permeability may be greater in some directions than in others, as well as in certain preferred stratigraphic horizons." The eight hydrogeologic subdivisions of the Edwards aquifer, the names of the corresponding members, and the type of porosity and permeability observed in the field within the subdivisions are discussed in ascending order.

Hydrogeologic subdivision VIII (basal nodular member) has interparticle porosity but little permeability in the *miliolid* grainstone and nodular limestone beds. Cavern porosity and permeability associated with caves in this subdivision characterize several caves in a small area in Comal County, but these properties were not seen in Hays County. This subdivision is locally, but not regionally, porous or permeable.

Hydrogeologic subdivision VII (dolomitic member) has little visible porosity or permeability in the dense crystalline limestone. Interparticle (breccia) porosity and permeability and fracture porosity and permeability associated with faulting are common locally. Vuggy porosity and permeability also are common locally in the burrowed zones.

Hydrogeologic subdivision VI (Kirschberg evaporite member) generally has common to abundant intercrystalline porosity in the chalky mudstone, and locally abundant vuggy porosity and permeability probably associated with faulting and evaporite dissolution (Maclay and Small, 1976). This subdivision has both fabric selective and not fabric selective porosity, and appears to be the most porous and permeable subdivision in the Kainer Formation.

Hydrogeologic subdivision V (grainstone member) has widely separated interparticle and intraparticle porosity and little permeability in the dense, tightly cemented *miliolid* grainstone; and local fracture porosity and permeability associated with faulting. Otherwise, this subdivision has little porosity or permeability.

Hydrogeologic subdivision IV (regional dense member) has little porosity or permeability except for some fracture porosity and permeability associated with faulting. This subdivision probably is the least porous or permeable subdivision and locally might be a confining unit within the Edwards aquifer.

Hydrogeologic subdivision III (leached and collapsed members, undivided) has vuggy and burrow porosity and permeability associated with burrowed zones; breccia and cavern porosity and permeability associated with collapsed zones resulting from dissolution of evaporites; and fracture porosity and permeability associated with faulting. This subdivision probably is the most porous and permeable of the subdivisions and, thus, the most susceptible to contamination from surface sources.

Hydrogeologic subdivision II (cyclic and marine members, undivided) has moldic and vuggy porosity and permeability associated with fossiliferous zones and dissolution of evaporites, and fracture porosity and permeability associated with faulting. San Marcos Springs issue from openings believed to be in this subdivision along the San Marcos Springs fault (William F. Guyton and Associates, 1979). Field observations indicate that this subdivision has only slightly less porosity and permeability than subdivision III.

Hydrogeologic subdivision I (Georgetown Formation) has almost no visible porosity or permeability. According to DeCook (1963, p. 40), the shale, marl, and compact limestones of the Georgetown Formation are relatively impermeable, and the formation acts as an upper confining unit for water in the Edwards limestone.

SUMMARY

The Edwards aquifer, sole source of public water supply for San Antonio, is the major source of water for Hays County. The aquifer primarily consists of dissolution-modified, faulted limestone. The Edwards aquifer is recharged in its outcrop area in the Balcones fault zone.

In Hays County, the Edwards aquifer probably is most vulnerable to surface contamination in the rapidly urbanizing areas on the Edwards aquifer outcrop. Contamination can result from spills or leakage of hazardous materials; or runoff on the intensely faulted and fractured, karstic limestone outcrops characteristic of the recharge zone.

Northeast-trending faults of the Balcones fault zone cross Hays County, but are more numerous in the southeastern part of the county. San Marcos Springs fault forms a part of the escarpment separating the Gulf Coastal Plain from the Edwards Plateau. San Marcos Springs fault and Mustang Branch fault completely, or almost completely, offset the Edwards aquifer by juxtaposing Edwards aquifer limestone against nearly impermeable upper confining units along parts of their traces across Hays County. These faults are thought to be barriers, or partial barriers, to ground-water flow where the beds are juxtaposed.

The Kainer and Person Formations of the Edwards Group and the overlying Georgetown Formation compose the Edwards aquifer. The Kainer and the Person Formations consist of seven informal members. These members, together with the overlying Georgetown Formation, form the eight informal hydrogeologic subdivisions of the aquifer. Some formation members are similar in lithology and appearance, whereas others are more distinctive.

The major factors controlling porosity and permeability in the Edwards aquifer outcrop are faulting, stratification, and karstification. Karst features in the outcrop, which can greatly enhance porosity and permeability, include sinkholes and caves. The two types of porosity in the Edwards aquifer outcrop are fabric selective, which is related to depositional or diagenetic elements and typically exists in specific stratigraphic horizons; and not fabric selective, which can exist in any lithostratigraphic horizon. Permeability, the capacity of porous rock to transmit water, depends on the physical properties of the rock such as size, shape, and distribution of pores, and fissuring and dissolution. The Edwards aquifer hydrogeologic subdivisions VI (Kirschberg evaporite member of the Kainer Formation), III (leached and collapsed members, undivided, of the Person Formation), and II (cyclic and marine members, undivided, of the Person Formation) appear to be the most porous and permeable. Hydrogeologic subdivision III probably is the most susceptible to contamination from surface sources.

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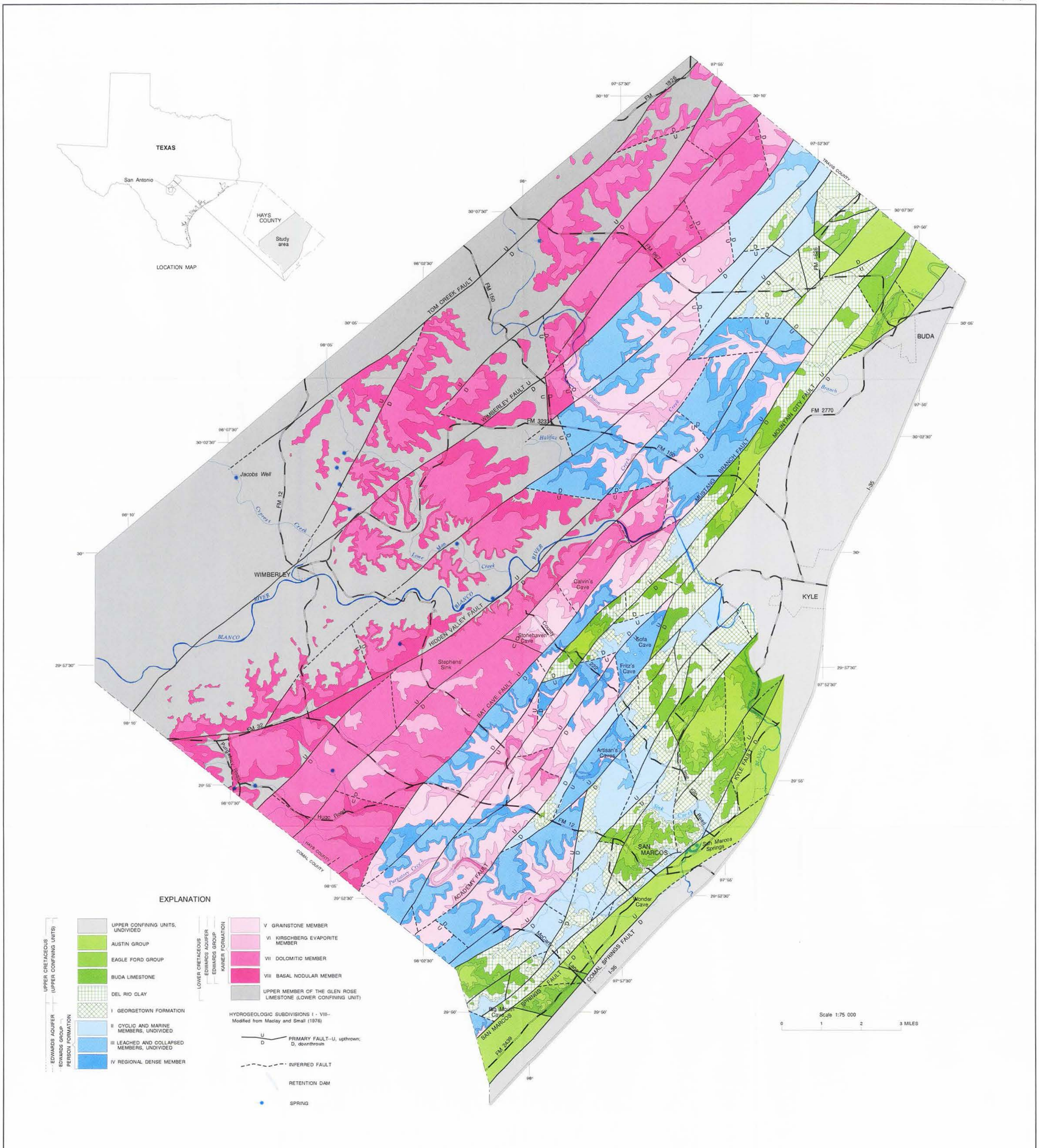
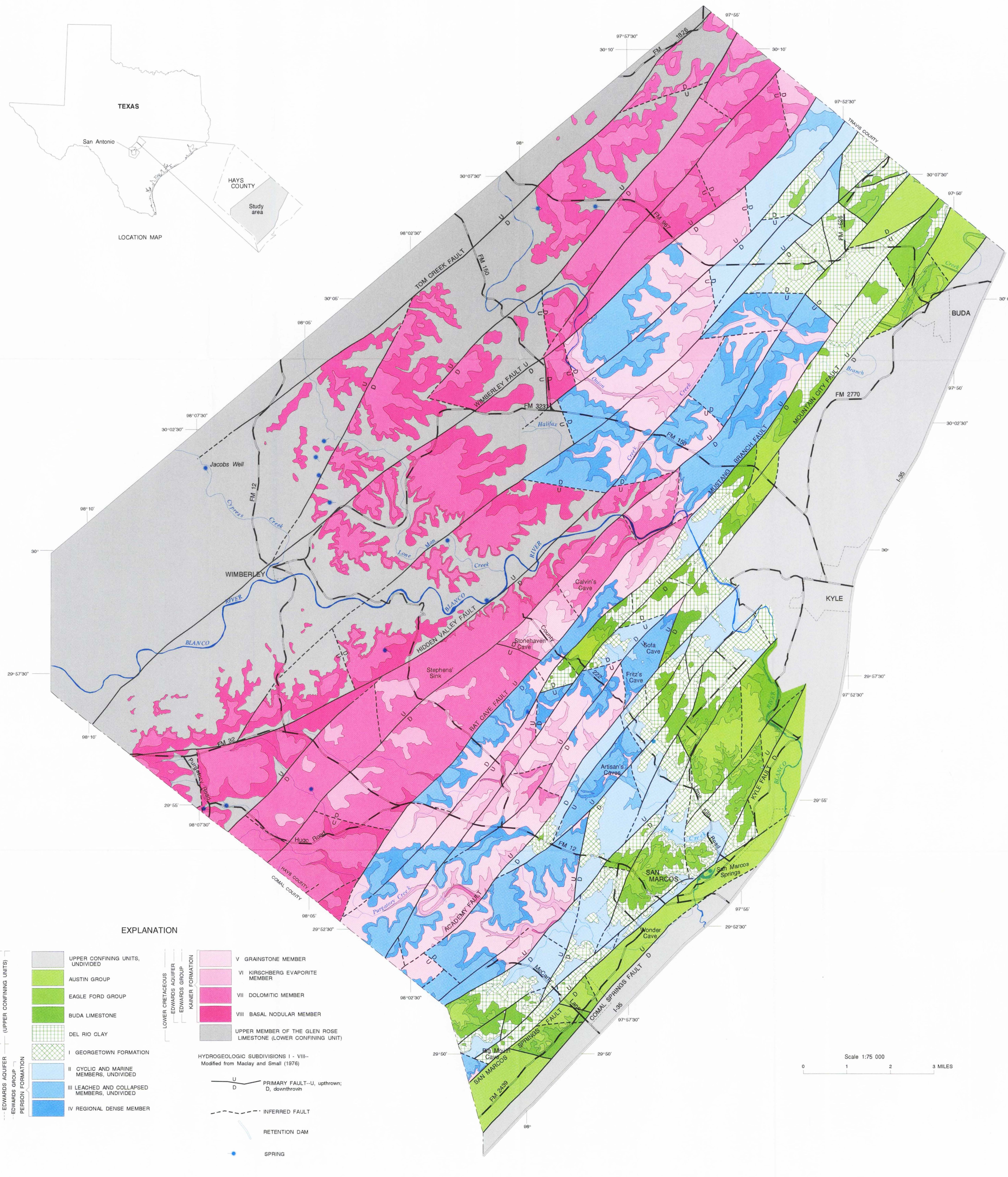


Base modified from U.S. Geological Survey 1:24,000 quadrangles
Universal Transverse Mercator Projection, zone 14

MAP SHOWING HYDROGEOLOGIC SUBDIVISIONS OF THE EDWARDS AQUIFER OUTCROP, HAYS COUNTY, TEXAS

By
John A. Hanson and Ted A. Small

1995



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