Geologic Map Compilation of the Upper Seco Creek Area, Medina and Uvalde Counties, south-central Texas

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INTRODUCTION

The Edwards aquifer of south-central Texas lies within and adjacent to the Balcones fault zone and is considered one of the most complex and productive carbonate aquifers in the United States. Many agencies have worked together toward gaining a better understanding of the geologic and hydrogeologic characteristics controlling the productivity and sustainability of this prolific ground-water resource. The Edwards aquifer in the upper Seco Creek area lies within the Devils River Formation, a predominant unit within the Devils River reef-trend facies of the Edwards Group (see map inset showing facies distribution). The Devils River Formation contains approximately 600 feet of highly porous and permeable limestone deposited on a carbonate platform along the presently defined Balcones fault zone and Edwards Plateau. The stratigraphy of the area ranges from the Lower Cretaceous Glen Rose Limestone (oldest) to the Quaternary alluvium (youngest). Edwards Group lithostratigraphic units in the mapped area contain the Devils River and Fort Terrett Formations, the latter being equivalent to the lower part of the Devils River Formation.

The network of overlapping Balcones faults has a significant impact on the hydrogeology of the Edwards aquifer throughout south-central Texas by controlling regional ground-water flowpaths in a general southwest to northeast direction (Maclay

and Small, 1976). The general trend of the flowpaths parallels the major faults in the area. The fault control on the major ground-water flowpaths highlights the need for more accurate digital mapping and compilations of geologic data for use in hydrogeologic assessments of the Edwards aquifer region.

The impetus for compiling the geology of four 7.5 degree quadrangles (Comanche Waterhole, Flatrock Crossing, Sabinal NE, and Texas Mountain) at a scale of 1:50,000 was to provide a digital geologic map database for a helicopter electromagnetic (HEM) survey flown in 2002 (Smith and others, 2003) as well as ongoing 3-D EarthVision modeling of the Edwards/Trinity aquifer boundary in the north Seco Creek area. The majority of the geology contained within these four quadrangles is from the mapping of Collins (1997, 1998, 1999a, and 1999b). Earlier mapping in this area included the efforts of Holt (1959) and Welder and Reeves (1962), and parts of their geology are included in the Collins' reports. More recent mapping by Small and Clark (2000) and Clark (2003) reveal a number of additional faults in the upper Seco Creek area not recognized by Collins. However, this map compilation represents the original mapping by Collins (1997, 1998, 1999a, and 1999b) and subsequent mapping by Blome and Faith in FY-03 and FY-04. Also, new structural data will be included in upcoming 3-D geophysical and structural models as needed but only after each fault is field checked.

Geologic Setting

The lithostratigraphic units of the upper Seco Creek area are provided on the map explanation and are described in detail below. The oldest lithology in the study area is the Lower Cretaceous Glen Rose Limestone, which represents the upper part of the

Trinity Group. The Devils River Formation is commonly divided into informal upper (about 250 feet thick) and lower (about 350 feet thick) units (Collins, 2000). The upper and lower parts of the Devils River Formation are also equivalent to the Segovia and Fort Terrett Formations, respectively, in the Edwards Plateau area to the north. According to Collins' mapping of the Flatrock Crossing and Texas Mountain 7.5 quadrangles, lithologic changes between the Devils River and Fort Terrett deposits are gradational and are related to minor facies variations. The Georgetown Formation, comprised of limestone and marl, typically overlies the Edwards Group lithologies in much of the region (Small and Clark, 2000) but is absent in the study area.

The Upper Cretaceous lithologic units consist of several formations, including (from oldest to youngest), the Del Rio Clay, Buda Formation, Eagle Ford Formation, Austin Group, Anacacho Limestone, Escondido Formation, and isolated, mafic intrusive rocks. The Del Rio Clay directly overlies the Edwards Group due to the absence of the Georgetown Formation in the upper Seco Creek area.

Although the precise age of the Uvalde gravel is not known, it is considered late Tertiary and Quaternary in age. The Leona Formation consists of fine silt to coarse gravel and, along with the Uvalde Gravel, terrace deposits, and unconsolidated alluvium, comprise the Quaternary stratigraphy. The gravel and alluvial deposits occur abundantly and conceal a large portion of the underlying geology and structural features in the study area.

Tectonic and Hydrologic Setting

Uplift of the Edwards Plateau and subsidence of the Gulf of Mexico during the Miocene created the Balcones fault zone in south-central Texas. The network of overlapping *en echelon* normal faults trend, on average, to the northeast, is downthrown to the southeast, and is linked by scattered cross faults trending southeast (see map insert showing facies distribution). Relay ramps often form between overlapping faults with varying lateral displacement gradients to accommodate the deformation occurring in their bounding hanging wall and footwall blocks. Continued displacement of the bounding faults and the subsequent increasing extension parallel to them produce cross faults that link the major faults and breach the relay ramp. On the surface, Seco Creek and other drainages in the area flow south, nearly perpendicular to the major faults, with the exception of the area just south of the Woodard Cave Sinkhole where Seco Creek intersects a series of cross faults, and its path is abruptly redirected to the southeast. These cross faults breach a southwest-dipping, large-scale relay ramp observed in the Comanche Waterhole and Sabinal NE quadrangles.

The Edwards aquifer in Medina and Uvalde Counties is contained in the Edwards Group rocks and overlying Georgetown Formation. Faults in a carbonate aquifer commonly affect the ground-water flowpaths by: 1) acting as a pathway for flow through increased porosity and permeability parallel to the faults, or 2) acting as a flow barrier and preventing hydrologic communication across the fault. In either situation, when the displacement of hydrostratigraphic units is minor, faults may not significantly affect the flow of ground water. Regional ground-water flowpaths in the Edwards aquifer,

including those in the four-quadrangle study area, tend to follow regional fault trends regardless of whether the water is flowing within or adjacent to the fault planes.

DESCRIPTION OF MAP UNITS

QUATERNARY AND UPPER TERTIARY STRATIGRAPHY

Qal **Alluvium (Quaternary)—**The alluvium is comprised of unconsolidated gravel, sand, silt, and clay along streams and rivers that are inundated regularly. The gravel contains mostly limestone and chert. Low terrace deposits found along minor drainages include some local outcrops that cannot be subdivided

Qu **Undivided terrace, slope-wash deposits, and fan deposits (Quaternary)—**This undivided unit contains gravel to mud

Qt **Terrace deposits (Quaternary)—**Terraces in the mapped area contain unconsolidated gravel, sand, silt, and clay along streams and rivers. They occur mostly above flood level. Deposits of adjacent terraces exposed along different elevations have been mapped separately

Qle **Leona Formation (Pleistocene)—**The Leona Formation ranges in thickness from a few feet to 80 feet and is composed of lenticular beds of sand, gravel,

silt, and clay. The pebbles and cobbles in the Leona predominantly contain limestone with some chert. Coarser gravels are present near the base of the formation with silt increasing upwards. The Leona is locally a prolific ground-water source and has rare cavern development and variable (low to high) porosity due to the poor sorting in the gravels. Locally, silt and clay cement significantly reduces the permeability. In general, the formation is thickest near the stream channels or older abandoned meander channels

QTu Uvalde Gravel, older alluvium (Quaternary and upper Tertiary)—The Uvalde Gravel contains mostly gravel and sand with some silt and clay. Well-rounded, pebble- to cobble-sized gravel are common, few boulders. The unit contains mostly chert and limestone, commonly cemented by caliche. The Uvalde deposits typically cap topographically high areas. The precise age of the unit is unknown but has been estimated to be approximately Quaternary to late Tertiary in age. Thickness of the unit ranges from several feet of gravel lag to more than 10 feet

UPPER CRETACEOUS STRATIGRAPHY

Ki Mafic intrusive rocks—The igneous exposures generally are not well exposed. Welder and Reeves (1962) first mapped and located many of the intrusive

exposures. However, some small outcrops noted by Holt (1959) in Medina County are not shown.

The igneous rocks consist of fine- to course-grained ultramafic and hyabyssal rocks that occur either as surface exposures or in the subsurface as dikes, plugs, and shallow intrusions. The ultramafic field is centered in Ulvalde County and extends to the west into Kinney County. The igneous rocks are represented by five rocks types, which include alkali basalt, melilite-olivine nephelinite, olivine nephelinite, nepheline basinite, and phonolite (Miggins and others, 2004).

A high-resolution aeromagnetic survey flown in 2001 (Smith and others, 2002) revealed over 200 shallow (in the subsurface) igneous intrusive bodies whereas fewer than 30 had been mapped (Fisher, 1983). A $^{40}Ar/^{39}Ar$ geochronologic study (Miggins and others, 2004) shows that there have been at least two distinct phases of magmatic activity in Uvalde County. The first phase of intrusive activity occurred approximately 82-80 m.y. ago whereas the younger intrusive rocks (phonolites) were emplaced 74-72 m.y. ago

Kes **Escondido Formation—**The Escondido Formation contains mudstone, siltstone, sandstone, and silty limestone. The map unit also includes a thin (as much as ~30 feet) lower marl and mudstone unit called the Corsicana Marl.

Outcrops are not common. Thickness of the Escondido ranges between 550 and 900 feet

Kan **Anacacho Limestone—**Unit contains limestone and marl. Grain-rich limestone is common. The Anacacho is light gray to white in outcrop view, thin- to thick-bedded, glauconitic, and contains fossil fragments. Thickness of the unit ranges from 240 to 500 feet

Kan+Kau **Anacacho Limestone and Austin Group, undivided—**In areas of poor exposure, the Anacacho Limestone and Austin Group cannot be differentiated

Kau **Austin Group—**The Austin Group, commonly called the Austin Chalk, contains massive to slightly nodular, gray to white, chalky to marly, fossiliferous mudstone ranging from 135 to 200 feet thick. It is identified in the field as white, chalky limestone (microgranular calcite) containing the fossil oyster *Gryphaea aucella*, abundant *Inoceramus* prisms, minor foraminifera and ostracode tests as well as echinoid debris. The chalky mudstone forms ledges and alternates with marl and locally with bentonitic seams. Glauconitic pyrite nodules partly weathered to limonite are also found. Thick caliche is common on the surfaces of most outcrops.

The Austin Group is generally referred to as an aquifer-confining unit. However, there is local occurrence of ground water associated with fractures. The Austin Group has scarce cavern development and low porosity and permeability. The unit forms thick black soil with juniper and live oak in low-relief areas

Kef **Eagle Ford Formation—**This unit is typified by brown, flaggy and sandy shale, siltstone, and argillaceous limestone, 15 to 30 feet thick. The upper part of the unit contains limestone and shale and is dark gray in color. Limestone is generally light, yellowish brown, flaggy, and occurs in beds as much as 4 feet thick. The lower part of the unit contains silty, medium-brown, laminated siltstone and weathers easily, forming flat to gently rolling topography. The unit also is known as lignite by local drillers.

No cavern development is evident and the primary porosity has been lost, thereby reducing permeability. Outcrops are rare in the mapped area and are generally covered with dark-brown soil. Strata at slope break of the Eagle Ford/Buda contact are commonly fossiliferous with oysters, ostracodes, foraminifers, fish bones, teeth, and *Inoceramus* prisms present

Kbu **Buda Formation (Upper Cretaceous)—**The unit contains poorly bedded to nodular, hard to chalky, mudstone, 40 to 56 feet thick. The mudstone commonly contains calcite-filled veins and is glauconitic and locally

fossiliferous with abundant shell fragments. Coloration is light gray to pale orange; weathers dark gray to brown. Unit is thinner bedded and argillaceous near its upper contact. The upper contact with the Eagle Ford Formation is disconformable, sharp, and conspicuous, and outcrops as resistant caps on hills. Lower part of formation contains soft, chalky limestone.

The Buda Formation weathers to form thin, red-brown soil containing rounded cobbles of limestone, and is less glauconitic and less iron-oxide-stained than the underlying Georgetown Formation (present outside the map area; Collins, 1997, 1998, 1999a, 1999b). The Buda also contains more fossil gastropods than the Austin Group in addition to burrows filled with chalky marl. The Buda fossils include abundant pelecypods, foraminifers, ostracodes, serpulids, echinoid spines, and bryozoans. Locally, solitary corals and green algae are also found. The unit has minor karst features with low porosity and regionally is considered a confining unit for both the Edwards and Trinity aquifer systems

Kdr **Del Rio Clay—**This unit is 15 to 50 feet thick and contains gypsiferous and calcareous, poorly indurated, dark gray to olive brown clay with abundant pelecypods. Minor, thin lenticular beds of highly calcareous siltstone also may occur. The Del Rio becomes less calcareous and more gypsiferous up section and weathers light gray to yellowish gray. The unit is slope

forming or under hanging where slumped below the overlying Buda Formation. Upper and lower contacts with the Buda Formation and upper Devils River Formation, respectively, are gradational.

The unit contains highly expansive soil, has no significant porosity or permeability or recognized cavern development and is the primary upper confining unit of the Edwards aquifer system. Unweathered Del Rio Clay is composed of kaolinite, illite, and lesser amounts of montmorillonite (Collins, 2000). Water tanks for livestock are commonly found on outcrops. Marine megafossils include abundant *Ilymatogyra arietina* (formerly *Exogyra arietina*) in addition to other pelecypods (Young, 1967)

LOWER CRETACEOUS STRATIGRAPHY

The lithostratigraphy of the Edwards aquifer varies from northeast to southwest due to the three fluctuating depositional environments, the San Marcos Platform, the Devils River Trend, and the Maverick Basin (see map inset). The Edwards Group of the San Marcos Platform, formed in shallow marine waters, is divided into seven informal hydrostratigraphic members (from youngest to oldest): cyclic and marine, leached and collapsed, regional dense, grainstone, kirschberg evaporite, dolomitic, and basal nodular (Maclay and Small, 1976). The overlying Georgetown Formation represents an eighth hydrostratigraphic member. The San Marcos Platform facies grades abruptly into the Devils River Trend facies in northern Medina County. The central portion of the Edwards aquifer, represented by reefal facies of the Devils River Trend (see map inset),

is comprised of the upper and lower Devils River Formation (historically interpreted as one unit by the U.S. Geological Survey) and overlying Georgetown Formation. However, the lateral transition from the Devils River Formation to the deeper-water West Nueces, McKnight, and Salmon Peak Formations (Maverick Basin facies) is highly gradational and variable along their assumed boundaries (Clark, 2003)

Kdvru upper Devils River Formation—The upper Devils River Formation contains limestone and dolomitic limestone deposited in shallow, subtidal to tidal-flat depositional environments. Some rudistid mounds are also found. The unit is generally 200-250 feet thick in the mapped area. The upper Devils River is comprised of miliolid, shell-fragment wackestones and grainstones containing rudists as well as abundant caprinids, monopleurids, and requieniids. The unit also displays extensive cavern development and is classified as having fabric-selective porosity, which grades downward into more nonfabric-selective porosity near the base

Kdvrl lower Devils River Formation—The lower Devils River is typified by 350 to 400 feet of limestone and dolomitic limestone formed in shallow subtidal to tidal-flat depositional environments. The unit contains some leached evaporitic rocks and breccias. The lower 20 to 50 feet of the unit contains nodular limestone, and the basal part (100 to 200 feet) of the Devils River Formation contains sparry limestone and nodular, burrowed mudstone to wackestone containing gastropods, *miliolids,* and the pelecypod *Exogyra*

texana. Solution-enlarged fractures are present in the lowermost part of the formation.

The Texas Bureau of Economic Geology geologic maps and this study show the Devils River Formation as subdivided into upper and lower units whereas USGS mapping to date depicted the Devils River Formation as a single undifferentiated unit. A helicopter electromagnetic survey flown in the Seco Creek area in Medina and Uvalde Counties (Smith and others, 2003) clearly shows the Devils River as two separate units based on contrasts in resistivity.

In his mapping of Uvalde County, Clark (2003) demonstrated that the Edwards basal nodular (informal) member could be traced from the San Marcos Platform into the Maverick Basin. Recent fieldwork by a number of authors (Clark, Blome, and Faith) also shows that at least the informal basal nodular and dolomitic members (Kainer Formation) can be traced laterally from the San Marcos Platform into the Devils River Trend and even into the deeper-water Maverick Basin (see map inset). This lateral continuity of the lowermost units was first observed by Rose (1972) and later revisited by Miller (1983, 1984). Nevertheless, local aquifer researchers have not, to date, accepted the informal hydrostratigraphic subdivisions through the Edwards Group. Hydrostratigraphic mapping of the lower part of the Devils River Formation in Medina and Uvalde

Counties and mapping of Maverick Basin lithologies in Kinney County are planned for FY 2005

Kft **Fort Terrett Formation—**This unit contains limestone, dolomitic limestone, and marl that originally formed in shallow subtidal to tidal-flat depositional environments. The upper part of the unit contains leached evaporitic rocks and breccias, and the lower 20 to 40 feet of the unit contains subtidal limestone

Kgru **upper Glen Rose Limestone—**The formation contains alternating beds of light gray to yellowish-brown limestone, dolomitic limestone, and argillaceous limestone and marl. Carbonate textural fabrics include wackestone, packstone, and grainstone. The upper Glen Rose Limestone is about 400 feet thick in the study area, contains minor evaporite layers, and originally formed in shallow subtidal to tidal-flat depositional environments; upward-shoaling cycles are common. Some intervals of disturbed bedding and collapse breccia are also present and possibly were created by evaporite dissolution. The upper Glen Rose unconformably underlies the Devils River Formation in the Devils River Trend (Miller, 1984) and forms the lower confining unit of the Edwards aquifer system.

Field identification of the Glen Rose Limestone is commonly associated with stair-step topography that forms through differential erosion of the

alternating limestone and marl beds. The Glen Rose is locally burrowed and produces honeycomb porosity in some areas. Fossil evidence includes sparse casts of marine faunas, specifically molluscan steinkerns (*Protocardia texana* and others), rudistids, oysters, echinoids, gastropods (*Tylostoma* sp., *Turitella* sp.), the foraminifera *Orbitolina minuta*, as well as local dinosaur tracks.

Surface cavern development associated with faults and fractures and some water production at evaporite beds have been noted but are considered a rare occurrence. The unit is classified hydrologically as having mostly nonfabric-selective porosity and generally low permeability (Small and Clark, 2000; Clark, 2003)

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