TEXAS STATEMAP PROGRAM SUMMARY, FY22 (2022–2023)

by

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ABSTRACT

Nine geologic maps have been completed at 1:24,000 scale in four project areas with support from STATEMAP and the Bureau of Economic Geology's State of Texas Advanced Resource Recovery program (STARR). Four of these maps were on the Texas Coastal Plain, including one (Anahuac quadrangle) on the upper Texas Coastal Plain in the Galveston Bay area and three (Rockport, Tivoli SE, and Tivoli SW quadrangles) on the middle Texas Coastal Plain in the Aransas, Copano, and San Antonio Bay areas. These maps continue efforts to (1) better understand the evolution of the coastal plain in response to sea-level change associated with numerous Quaternary glacial and interglacial cycles and (2) develop more effective methods to map low-relief coastal deposits using high-resolution topographic maps produced from airborne lidar data and near-surface geophysical methods. High-resolution topography and geophysical methods both aid identification of stratal units and distribution in areas where exposures are poor or nonexistent.

Groundwater- and mineral-resource-related mapping produced three maps (Dolan Springs, Monument Mountain SE, and Panther Creek quadrangles) to extend recent mapping of critical groundwater- and mineral-resource areas in central and west Texas. These maps help ensure sustainable development of resources and protection of habitat of threatened species. The detailed maps contribute to a better understanding of the hydrogeologic framework of the areas and help evaluate resource potential.

Mapping in the central Texas urban growth corridor produced one map (Montopolis quadrangle) that extends previous mapping in this critical urban growth and transportation corridor. This map addresses ongoing need for planning and managing groundwater, surface water, land use, and construction projects where rapid population growth and suburban development have caused an increased demand for water and earth resources.

Mapping related to critical mineral resources augmented Earth MRI-sponsored projects in Trans-Pecos with the completion of a 1:24,000-scale map of the Small quadrangle, located in the alkaline igneous belt. Mapping in this area assists in mineral resource exploration, critical mineral identification, and resource development potential.

Major additional STATEMAP tasks included those related to the U.S. GeoFramework Initiative. Activities and deliverables completed in this category included (1) a statewide map (1;1,000,000 scale) and GeMS database showing distribution and elevation of significant subsurface salt deposits in the East Texas Basin, the Coastal Plain, and the Permian Basin; (2) three compilation maps (1:50,000 or 1:62,500 scale) and GeMS databases of portions of the upper Texas Coastal Plain (5 quadrangles), the middle Texas Coastal Plain in the Matagorda Bay area (8 quadrangles), and the southeast Llano Uplift area in central Texas (6 quadrangles); (3) updates to the NGMDB that include corrections of current entries, addition of 40 missing entries in the Geological Circular series, and delivery of high-resolution map images and supporting documents for 253 Bureau publications; and (4) producing an initial inventory of figures from Bureau publications, with the goal of identifying and tagging figures that are amenable to three-dimensional mapping that has resulted in creation of an SQLite database containing entries and images from most of the Bureau's Reports of Investigations and the Oil and Gas Atlas.

INTRODUCTION

Bureau of Economic Geology (Bureau) researchers conducted geologic mapping supported by STATEMAP and by the State of Texas Advanced Resource Recovery (STARR) program in four project areas (fig. 1) during the 2022–2023 project year. Mapping in these areas complements ongoing studies of land, mineral, and water resources and environmental concerns of Texas.

Project 1A continued a multiyear effort begun in 2018 to map areas of general interest on the upper Texas Coastal Plain with mapping of the Anahuac quadrangle, situated on the upper part of Trinity Bay in the Galveston Bay system. This environmentally sensitive area, which includes wetlands associated with the Trinity River delta, is being considered for a major federal engineering project intended to protect infrastructure around Galveston Bay from inundation during future storms.

Project 1B continued a multiyear effort to map low-relief Pleistocene and Holocene strata on the middle Texas Coastal Plain in the San Antonio, Copano, and Aransas Bay area (fig. 1) using high-resolution digital elevation models (DEMs) produced from airborne lidar surveys and near-surface geophysical methods to identify depositional units. Mapping was completed in the Rockport, Tivoli SE, and Tivoli SW quadrangles to address the Holocene and Pleistocene history of the region, including the response of the Texas Coastal Plain to major climatic and sea-level changes accompanying the numerous Quaternary glacial and interglacial cycles.

Mapping for project 2 focused on two areas in central and western Texas (2A and 2B, fig. 1) to support sustainable use of water and mineral resources. Geologic maps of the Monument Mountain SE and Panther Creek quadrangles were completed in area 2A to extend earlier STATEMAP mapping and to support analysis of groundwater resources and potential sand resources. Mapping for the Dolan Springs quadrangle produced the first STATEMAP product in Area 2B, which includes the Devils River State Natural Area.

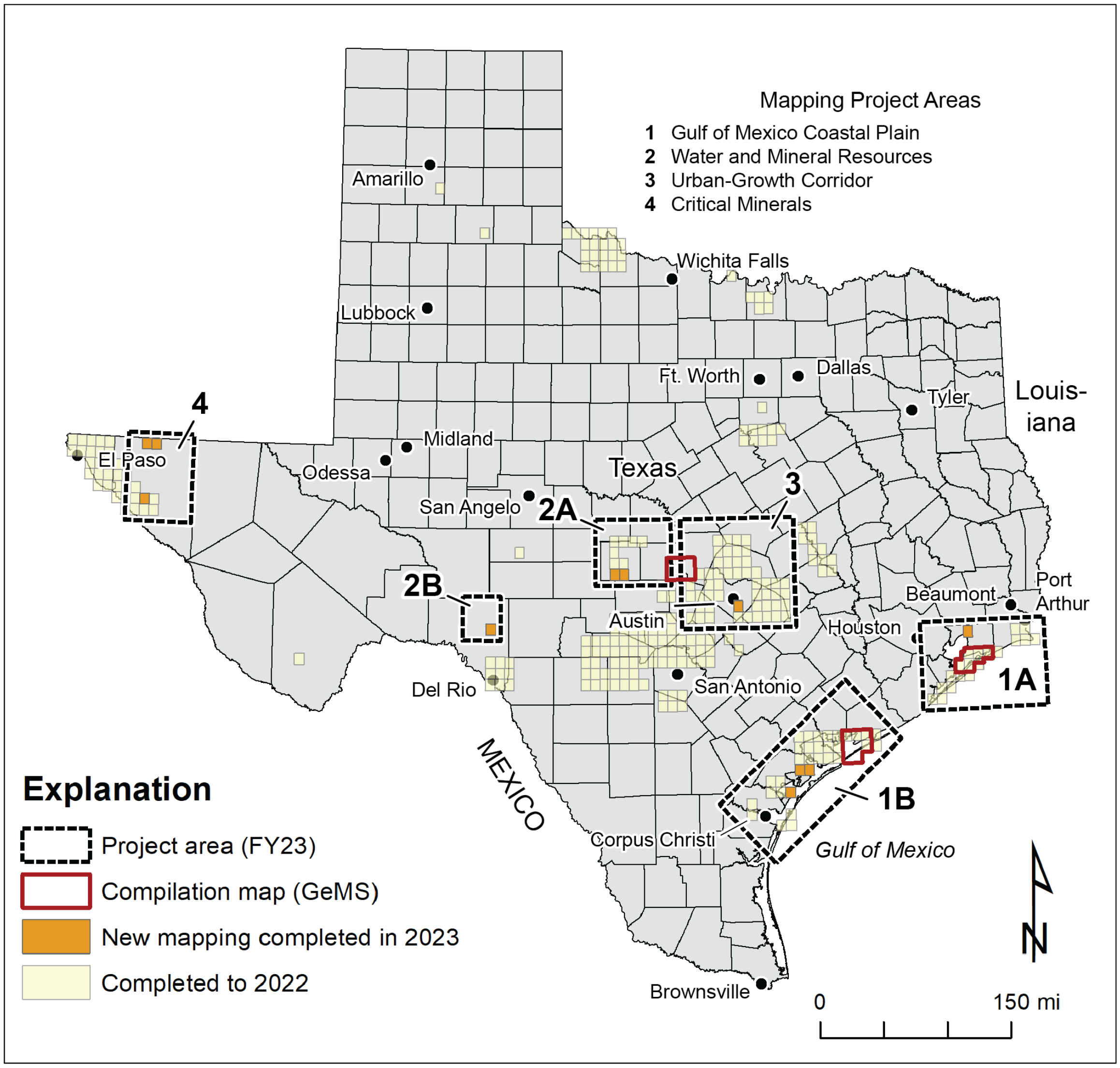

Figure 1. Location of geologic mapping project areas on the upper Texas Coastal Plain (1A), on the middle Texas Coastal Plain (1B), in the central (2A) and western (2B) Texas groundwater- and mineral-resource areas, in the central Texas urban-growth corridor (3), and in the Trans-Pecos critical minerals resource area (4). Also shown are outlines of compilation maps (to GeMS Level 3 compliance) completed in 2023.

Project 3 continued a multiyear effort to extend detailed geologic mapping in the central Texas urban growth corridor to peripheral areas facing increased developmental pressure as urban areas expand. The Montopolis quadrangle, located in the southern part of the growth area, was completed this year. Population growth and suburban development have increased stress on limited water and land resources. Project 3 mapping complements a long-term effort to develop a 56-quadrangle, digital geologic-map data set of the Austin–San Marcos area. This collection will address needs for planning and managing groundwater and surface water, as well as land use and construction projects.

Project 4 resumed STATEMAP-supported geologic mapping in the Trans-Pecos (fig. 1), where heightened national interest in critical mineral resources has led to Earth MRI-sponsored airborne geophysical surveys and related geologic mapping efforts. The Small quadrangle was completed this year, augmenting other maps in the area that were completed for older STATEMAP projects related to potential critical mineral resources as well as the siting of a proposed low-level radioactive waste repository in the 1990s.

Project 5 included U.S. GeoFramework Initiative efforts to create a statewide subsurface salt distribution GeMS database and map, complete three compilation maps at 1:50,000 to 1:100,000 scale as GeMs databases, update NGMDB records to include missing publications in the Geological Circular series, and create a database of figures from Bureau publications amenable to creation of three-dimensional geologic models.

PROJECT 1A: UPPER TEXAS GULF OF MEXICO COASTAL PLAIN MAPPING (ANAHUAC QUADRANGLE, 1:24,000)

Tiffany Caudle and Jeffrey G. Paine

Project 1A mapping focused on Holocene and Pleistocene geology along the upper Texas Gulf of Mexico coast (figs. 1 and 2). The completed map covers the Anahuac quadrangle (Caudle and Paine, 2023a), which encompasses a large portion of the Trinity River delta and is located at the northern reach of Trinity Bay in Chambers County. The quadrangle is east of the city of Houston

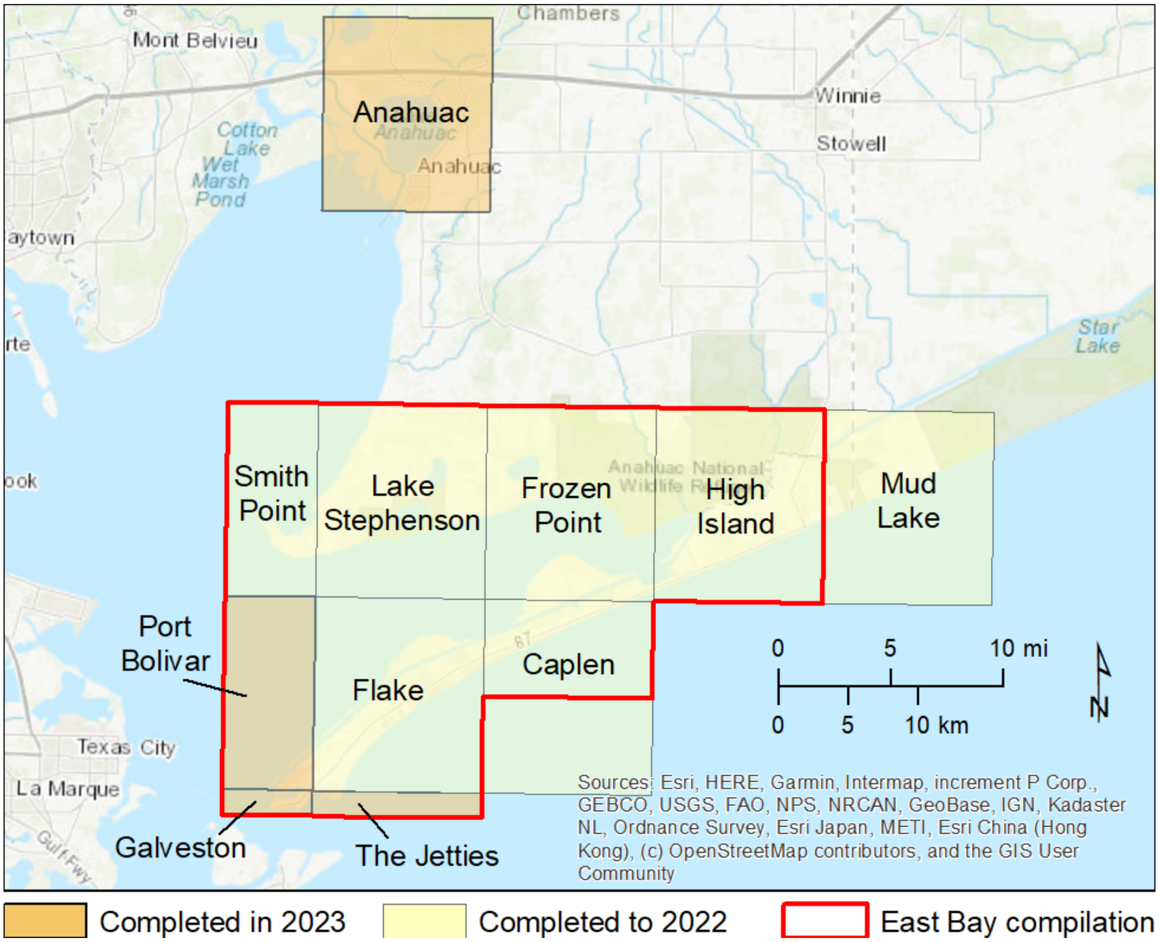

Figure 2. Status of geologic mapping along the upper Texas coastal plain (project area 1A), including the Anahuac quadrangle mapped in 2023. Also shown is the map area for the 1:50,000 compilation GeMS database that encompasses Galveston's East Bay (project 5).

and north of the city of Galveston. Lake Anahuac, in the central part of the quadrangle, was called Turtle Bay before the construction of an earthen embankment across the mouth of the bay. In the early 1900s, Turtle Bay was used for local irrigation that depleted freshwater in the bay and led to encroachment of salt water. The current embankment was completed in 1954 (TWDB, 2006). Lake Anahuac receives freshwater from a diversion channel from the Trinity River (Big Hog Bayou) and the Turtle Bayou watershed. The main channel of the Trinity River has formed the modern delta between Lake Anahuac and Trinity Bay.

The Anahuac map addresses geologic framework needs for planning and management of land use for sensitive coastal environments, evaluating depositional history and environments, identifying potential erosion issues, supporting permitting activities, and studies related to resource development and educating the public. This map is a continuation of coastal plain mapping on the upper Texas Gulf of Mexico coast that includes the Flake, Lake Stephenson, Frozen Point, Caplen, High Island, and Mud Lake quadrangles (Caudle and Paine, 2019, 2020, 2021, 2022 and Caudle and others, 2022). Previous regional maps that cover this area and guided interpretations of the depositional environments include the 1:250,000-scale Geologic Atlas of Texas, Houston Sheet (Aronow and others, 1968 [revised 1982]), the 1:125,000-scale Environmental Geologic Atlas, Galveston-Houston Area (Fisher and others, 1972) and Beaumont-Port Arthur Area (Fisher and others, 1973), and the 1:125,000-scale map of Distribution of Wetlands and Benthic Macroinvertebrates (White and others, 1985, 1987).

Mapping procedures included (1) compiling available data, (2) mapping geologic units and features using lidar-derived elevations and aerial photographs, (3) making field observations of geologic units, and (4) producing final maps. Photography used in the study was 0.6- and 1.0-m resolution, natural color, NAIP digital imagery photographed in 2020 and 2022. Photography was supplemented by a 35-cm cell size DEM constructed from 2017 topographic lidar data and a 50-cm cell size DEM constructed from 2018 lidar data. The 2017 airborne lidar survey was flown by Sanborn Mapping Company and the 2018 survey was flown by Fugro USA Land, Inc. for the Texas Strategic Mapping (StratMap) Program (https://tnris.org/stratmap/). Soil data from the Soil Survey Geographic (SSURGO) database distributed by the U.S. Department of Agriculture, Natural Resources Conservation Service; wetland data from the National Wetlands Inventory distributed by the U.S. Fish & Wildlife Service; State of Texas well reports downloaded from the Texas Water Development Board's (TWDB) Groundwater Database; and 1956 Tobin aerial photography were used to assist in feature interpretation.

Strata in the Anahuac quadrangle are dominated by Pleistocene Beaumont Formation fluvial-deltaic deposits and modern Trinity River floodplain and delta deposits (fig. 3) surrounding Lake Anahuac. Holocene to Pleistocene-aged Deweyville terrace deposits lie between the modern

Figure 3. Transition from the modern, low lying delta plain to Pleistocene Beaumont Formation near Anahuac, Texas.

alluvial-deltaic plain and the upland surface of the Beaumont Formation. By using high-resolution lidar and imagery data, three distinct terraces were mapped, distinguishing abandoned channels on the fluvial terraces and meander scars. The map displays Holocene units consisting primarily of delta and floodplain deposits with minor areas of tidal flat and bay-margin marsh deposits. The Pleistocene Beaumont Formation fluvial-deltaic, distributary, and interdistributary deposits include sandy muds deposited in channel complexes, floodplain and delta-plain deposits in interchannel areas, and abandoned stream channel deposits. A previously unknown growth fault was identified in the lower southeastern corner of the quadrangle using high-resolution lidar data.

PROJECT 1B: MIDDLE TEXAS GULF OF MEXICO COASTAL PLAIN MAPPING (ROCKPORT, TIVOLI SE, AND TIVOLI SW QUADRANGLES, 1:24,000)

Jeffrey G. Paine, Benjamin A. Grunau, and Jennifer N. Morris

Project 1B geologic mapping focused on Pleistocene and Holocene geologic units along the middle Texas Gulf of Mexico coast (figs. 1, 4, and 5). The completed maps include the Rockport quadrangle (Paine, Morris and Grunau, 2023a) in the Copano and Aransas Bay area and the Tivoli SE (Paine, Morris, and Grunau, 2023b) and Tivoli SW (Paine, Grunau, and Morris, 2023a) quadrangles in the Aransas National Wildlife Refuge area on the western margin of San Antonio Bay (figs. 4 and 5). These maps extend a multiyear effort to complete 1:24,000-scale geologic mapping between Corpus Christi Bay and Matagorda Bay, where the principal focus is to better

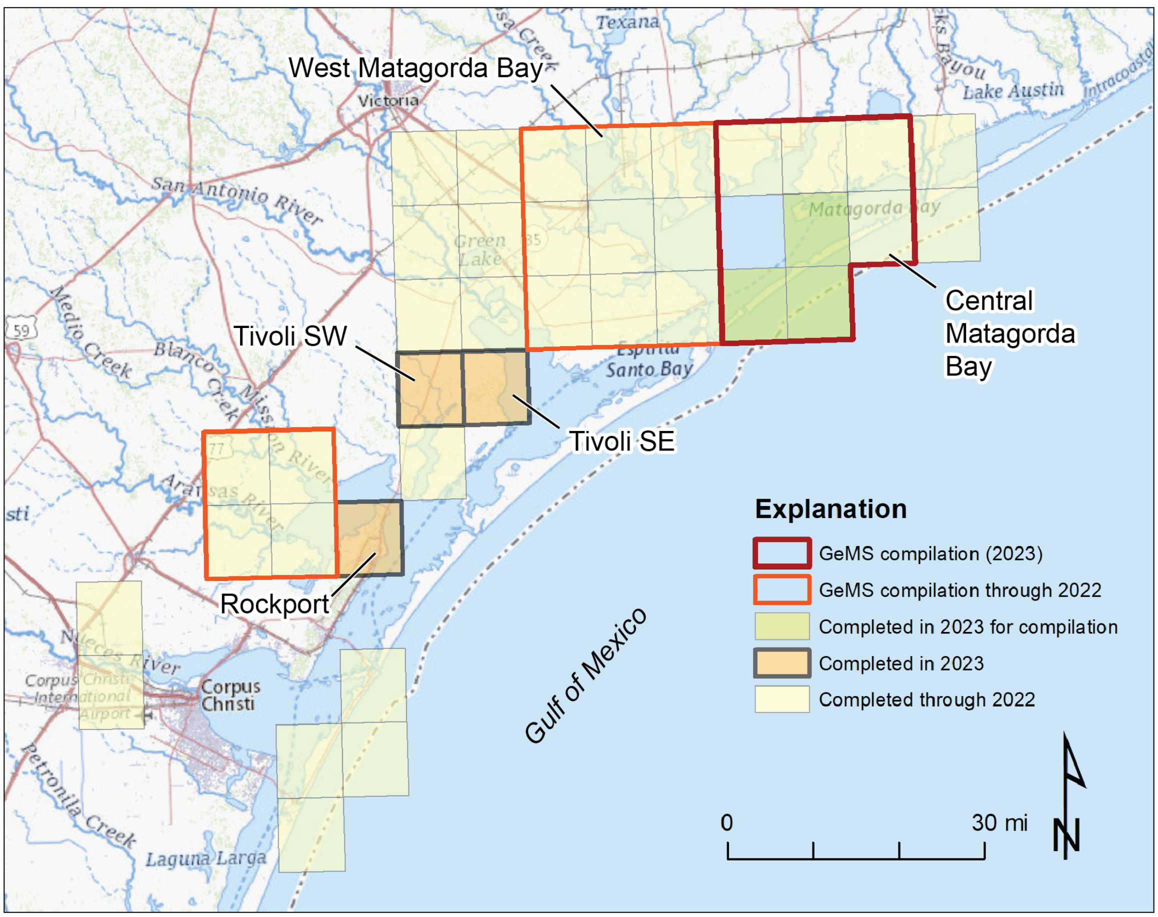

Figure 4. Status of geologic mapping along the middle Texas Coastal Plain (project area 1B), including the Rockport, Tivoli SE, and Tivoli SW quadrangles mapped in 2023. Also shown are map areas for the central Matagorda Bay compilation map (1:62,500) and GeMS database completed in 2023 and previously completed compilation maps.

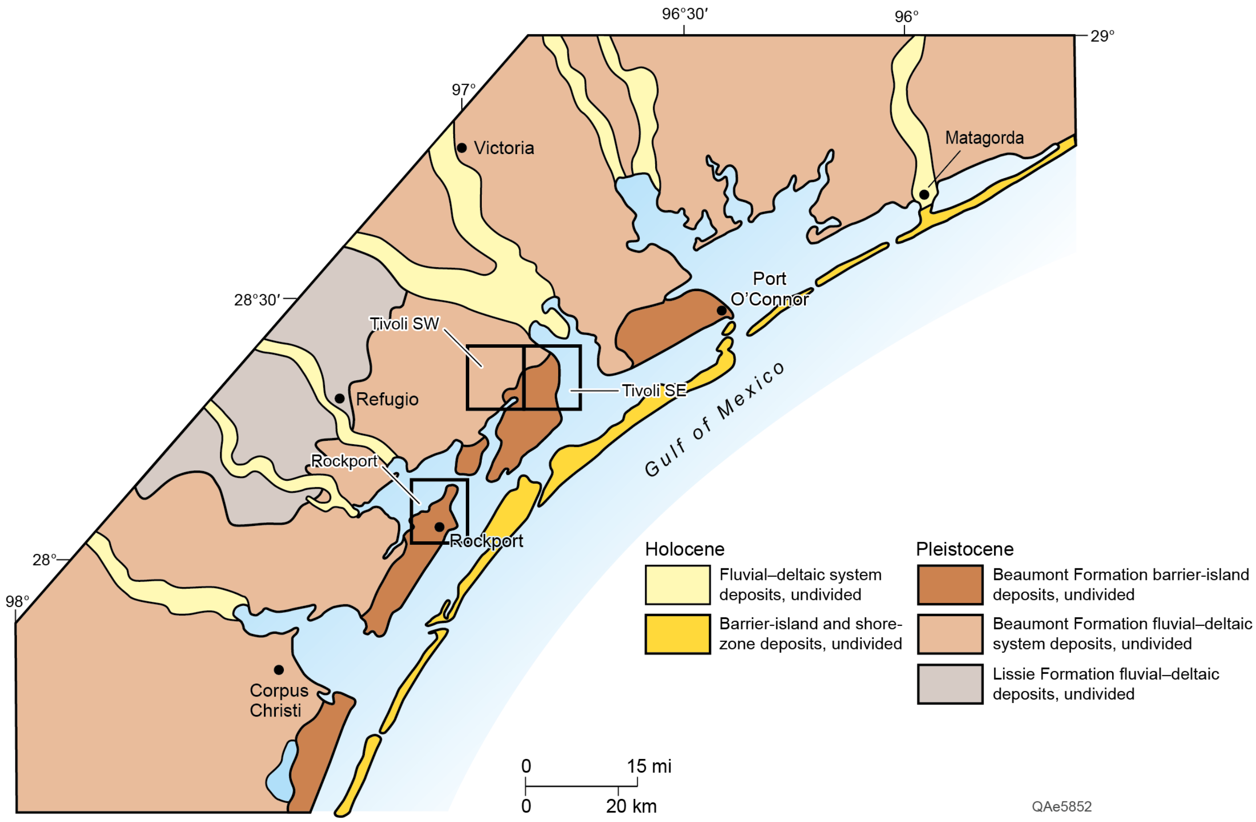

Figure 5. Generalized geologic map of the middle Texas Coastal Plain (project area 1B), including the Rockport, Tivoli SE, and Tivoli SW quadrangles mapped in 2023.

understand the distribution of Pleistocene and Holocene barrier-island, bay, lagoon, deltaic, and fluvial depositional units comprising the Pleistocene Beaumont Formation and younger fluvial, deltaic, estuarine, and marine deposits of sand, silt, and clay. Generally, these strata have aggraded during Quaternary interglacial periods of relatively high sea level and have undergone soil formation, erosion, and incision during glacial periods of relatively low sea level. Previous mapping efforts that guided depositional environment interpretations include the Beeville–Bay City sheet of the Geologic Atlas of Texas at 1:250,000-scale (Aronow and others, 1975 [revised 1987]) and maps in the Port Lavaca and Bay City–Freeport volumes of the Environmental Geologic Atlas of the Texas Coastal Zone at 1:125,000 scale (McGowen and others, 1976a, b) and the Submerged Lands of Texas, also at 1;125,000 scale (White and others, 1988, 1989).

Goals of the project are to augment aerial imagery with high-resolution DEMs acquired during airborne lidar surveys to allow detailed mapping of previously unrecognized depositional features such as channel complexes, paleochannels, levees, crevasse splays, floodplains, alluvial terraces, and marine-margin deposits within Quaternary strata. Geophysical measurements conducted as a part of the mapping effort supplemented lidar data and aerial imagery by measuring lateral and vertical distribution of electrical conductivity using surface and borehole geophysical instruments. These measurements can serve as a proxy for clay content, a critical discriminator in determining depositional environment in low-energy coastal-plain systems. This mapping approach for use on low-relief coastal plains was developed during STATEMAP efforts along the middle Texas coastal plain over several years (Paine and Collins, 2016a; Paine and others, 2017; Paine and others, 2018a; Paine and others, 2019). Geologic maps completed previously include the Tivoli quadrangle (Collins and Paine, 2013) in the western San Antonio Bay area, the Mission Bay, Bayside, Rincon Bend, and Woodsboro quadrangles in the Copano Bay area (Paine and Collins, 2014a, b; Paine and others, 2015a, b) and the St. Charles Bay quadrangle (Paine and Collins, 2016b) in the Aransas Bay area.

New geologic mapping in the Rockport, Tivoli SE, and Tivoli SW quadrangles was based on 0.6- and 1.0-m resolution aerial imagery acquired in 2020 and 2022 and lidar-derived DEMs at 1-m cell size obtained from airborne lidar surveys flown by the U.S. Geological Survey in 2018. Field investigations by Bureau researchers included three time-domain electromagnetic induction (TDEM) soundings in the Rockport and Tivoli SE quadrangles (fig. 6) and ground-conductivity measurements at 19 sites using Geonics EM31 and EM38 frequency-domain electromagnetic induction (FDEM) ground conductivity meters (McNeill, 1980a, b).

The Tivoli SE and SW quadrangles are on the western margin of San Antonio Bay. They are dominated on the west by Pleistocene Beaumont Formation fluvial, deltaic, and estuarine units (fig. 5) that include sandy muds deposited in southerly trending channel complexes and floodplain, delta-plain, and estuarine mud deposited in interchannel areas. These units transition

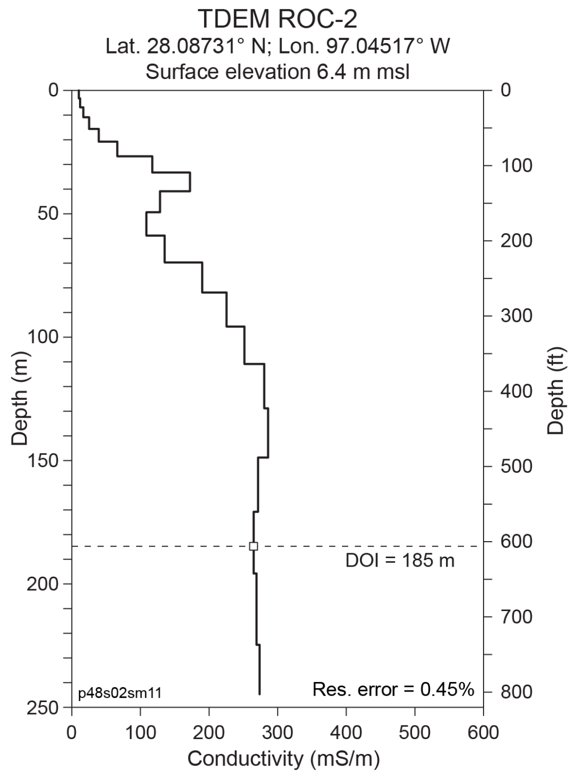

Figure 6. Subsurface electrical conductivity profile from a time-domain electromagnetic induction sounding that shows a low-conductivity zone from the surface to about 20-m depth that likely represents the thickness of sandy deposits associated with the Ingleside barrier island. This sounding was acquired at the Aransas County Airport, Rockport, Texas in September 2023.

eastward into barrier island and estuarine or lagoonal deposits of the marine-influenced Ingleside member of the Beaumont Formation (fig. 7). These deposits yielded a mammoth molar from an exposure in the Tivoli SE quadrangle along San Antonio Bay (fig. 7). Common Holocene units mapped in the area include fluvial flood-plain deposits along minor streams, clay dune deposits, and bay margin berm, marsh, spit, and tidal-flat deposits. Two previously unknown growth faults were identified in the southern part of the Tivoli SW quadrangle using high-resolution lidar and imagery data.

The Rockport quadrangle covers the northern end of a continuous segment of the Ingleside barrier-island system (fig. 5) that, with other correlative segments, extends from south of Corpus Christi Bay to Matagorda Bay. Detailed stratigraphic studies of the Ingleside in this area have been published by Shideler (1986). Ingleside strata within the Rockport quadrangle are

Figure 7. (left) Exposure of the Ingleside Member of the Beaumont Formation along San Antonio Bay in the Tivoli SE quadrangle. Thick Holocene windblown sand and silt overlie muddy sand deposits associated with the late Pleistocene (~100 ka) Ingleside barrier island. B. Grunau is pointing to the in-place mammoth molar (right) found within Ingleside strata.

dominantly sandy with a strong eolian expression on the northern part of the Pleistocene barrier island. Prominent southeast–northwest topographic texture across the Rockport peninsula has obscured progradational ridge-and-swale topography evident on Ingleside segments farther north, reflecting likely eolian and storm overwash effects. Ingleside sands grade westward into back-barrier or lagoonal facies deposits with higher mud content, abundant burrows, and strong pedogenic development. TDEM soundings at the Aransas County Airport (fig. 6) along the axis of the barrier island suggest a sand thickness of at least 12 m with decreasing sand content downward.

PROJECT 2A: WATER- AND MINERAL-RESOURCE MAPPING, CENTRAL TEXAS (PANTHER CREEK AND MONUMENT MOUNTAIN SE QUADRANGLES, 1:24,000)

Brian B. Hunt

Two new geologic quadrangle maps were completed in project area 2A (fig. 1) that relate to groundwater and mineral resources in Mason County in central Texas. The quadrangles are located within the western portion of the Llano Uplift geologic province, south of the town of Mason and adjacent to two recently mapped quadrangles (Hunt and others, 2022a, b). The Llano and James Rivers are prominent hydrologic features of the Panther Creek and Monument Mountain SE quadrangles (Hunt, 2023a, b), respectively.

The Panther Creek quadrangle includes Mesoproterozoic metamorphic units of the Packsaddle Schist Supersuite (formerly Packsaddle Schist Domain) and are variably deformed and contain multiple generations of ductile fabrics and structures (fig. 8; Mosher, 1998). Metamorphic rocks

Figure 8. Folded Mesoproterozoic marbles of the Packsaddle Schist Supersuite within the Panther Creek quadrangle.

are intruded by late syn-to post-tectonic granite plutons, which are regionally associated with the Town Mountain and associated granites (Barnes, 1981). Mesoproterozoic units make up the core of the Llano Uplift with Paleozoic sediments unconformably on top of, and radiating away from, the core of the Llano Uplift. Precambrian bedrock found within the Panther Creek quadrangle forms a localized fractured and weathered crystalline rock aquifer (Setlur and others, 2019; Hunt, 2008).

The two quadrangles contain much of the Paleozoic section units found in central Texas and include the Cambrian Moore Hollow Group (fig. 9; Barnes and Bell, 1977; Barnes, 1981; Lehrmann and others, 2020), and the Ordovician Ellenberger Group (Cloud and Barnes, 1946; Barnes, 1981). All the bedrock units are faulted and fractured by northeast-trending, late Paleozoic normal faults that form a variety of horst and graben structures that strongly influence the landscape of the map area; the grabens often form topographic highs due to

Figure 9. Photograph of stromatolite reef cluster along Salt Creek within Monument Mountain SE quadrangle. The unit is late Cambrian Point Peak Member of the Wilburn Formation of the Moore Hollow Group.

differential erosion. The Paleozoic units comprise several aquifers in the region. The Hickory and Ellenberger–San Saba aquifers serve domestic and agricultural needs in the map area (George and others, 2011). Detailed mapping of this and previous studies and evaluation of wells in the Texas Water Development Board database has revealed the importance of the Welge Sandstone (Wilburns Formation, Moore Hollow Group) as a local water supply. Remnants of the Edwards Plateau, formed by the Cretaceous Edwards and associated sediments, overlie the Paleozoic units of the map area. These flat-lying limestone units are eroded and dissected, forming hills with highest elevations along the southern extent of the map area. Quaternary alluvium and multiple terrace deposits along streams discontinuously overlie all units (Barnes, 1981).

Field observations and mapping by the author was integrated with historic maps and remote sensing data (Hunt and others, 2021). The use of lidar data (USGS, 2018) was particularly important to the final map. A compilation of historic maps includes numerous university geology theses (generally 1:20,000 scale) produced from the 1950s through the 1990s. Those theses were done primarily through Texas A&M University (Grote, 1954; Miller, 1957; Sliger, 1957; Dannemiller, 1957; Wilson, 1957; Harwood, 1959; Ammer, 1959; Coughran, 1959; Marshall, 1959; Fisher, 1960; Pool, 1960; White, 1961), and at the University of Texas Permian Basin (Spencer, 1988). Unpublished geologic mapping on aerial photographs and topographic quadrangle maps (ca. 1970s) by Virgil Barnes within the archives of the Bureau of Economic Geology was also used in the mapping. Barnes (1981) later integrated many of these maps into the Geologic Atlas of Texas, Llano Sheet (1:250,000). An unpublished geologic map by Mutis-Duplat (2023) of the Panther Creek quadrangle was also used in the mapping compilation.

The geologic map and database for the Panther Creek and Monument Mountain SE were developed according to GeMS (USGS, 2020) standards. Results of the new geologic maps and map databases provide detailed geologic information important for groundwater and other resource evaluations.

PROJECT 2B: WATER- AND MINERAL-RESOURCE MAPPING, WEST TEXAS (DOLAN SPRINGS QUADRANGLE, 1:24,000)

Brian B. Hunt, John R. Andrews, and Jeffrey G. Paine

The Dolan Springs quadrangle (Hunt and others, 2023) is located within the Edwards Plateau physiographic and geologic province of west Texas, in Val Verde County. The quadrangle contains most of the Texas Parks and Wildlife's Devils River State Natural Area (Del Norte). The new map provides important detailed geologic information about the geology and is a critical start to understanding the aquifer framework and surface and groundwater interactions of the Edwards–Trinity Plateau aquifer. Dolan Creek, portions of the Dry Devils and Devils River, and major springs such as Finnegan Springs (fig. 10) are the critical hydrologic features of the map area.

The Edwards–Trinity Plateau Aquifer is a major aquifer of Texas and serves as a sole-source supply for domestic, public supply, livestock, and irrigation needs in the region. The aquifer in the map area also has significant springs that provide perennial baseflow to the Devils River and

Figure 10. Photograph of Finnegan Spring in the Devils River State Natural Area that issues from the upper Fort Terrett Formation. Photo courtesy of the Devils River Conservancy.

ultimately the Rio Grande. The springs sustain habitats in the Devils River that are home to the federally threatened Devils River Minnow (*Dionda diaboli*) and federally endangered Texas Hornshell mussel (*Popenaias popeii*) (Caldwell and others, 2020).

Bedrock geology in the area includes Fort Terrett and Fort Lancaster formations of the Edwards Group (Waechter and others, 1977; Smith, 1964; Smith and others, 2000). Quaternary surficial deposits, including multiple generations of terraces, are found along the deeply incised Devils River and its tributaries. Other prominent features mapped include fractures, faults, significant springs, and karst features. The Geologic Atlas of Texas, Del Rio sheet at a scale of 1:250,000 (Waechter and others, 1977) covers the proposed map area. A geologic map at a scale of 1:96,000 (planimetric) by Webster (1982) covers part of the quadrangle.

Field observations and mapping by the author was integrated with the historic maps and remote sensing data (Hunt and others, 2021). Hydrogeologic data (Hunt and others, 2022) from recent studies were also integrated into the map and database. The use of historic theses and measured sections was critical to the understanding of the lithostratigraphy of the area (Calvert, 1928; Spice, 1954; Smith, 1964; Smith and others, 2000) and mapping. In addition, drone photogrammetry, borehole geophysics, and passive seismic data were all collected and important for lithostratigraphic mapping. The use of lidar data (USGS, 2018) and aerial photographs were particularly important to the final map. Karst features and closed depressions were mapped using GIS and lidar data with some field validation. Mapping these features is important for hydrogeologic understanding of the aquifer.

The geologic map and database was developed according to GeMS (USGS, 2020) standards. Results include a new geologic map and map databases that provide detailed geologic information important for groundwater and other resource evaluations for the Edwards–Trinity Plateau Aquifer and the Devils River.

PROJECT 3: URBAN GROWTH-CORRIDOR MAPPING, CENTRAL TEXAS (MONTOPOLIS QUADRANGLE, 1:24,000)

Charles M. Woodruff, Jr. and Jennifer N. Morris

The Montopolis 7.5-minute quadrangle map (Woodruff and Morris, 2023) extends previous mapping in the Lytton Springs and Creedmoor quadrangles (Woodruff and Costard, 2021, 2022). It lies wholly within Travis County and takes in the southeastern part of the Austin city limits (figs. 1 and 11). This map includes Austin-Bergstrom International Airport, whose passenger terminal lies approximately 7 miles southeast of the Texas Capitol building. Other important man-made features include several major roadways: Interstate Highway 35 (IH-35) traversing the northwest quadrant of this map, and the intersection of that freeway with State Highway 71

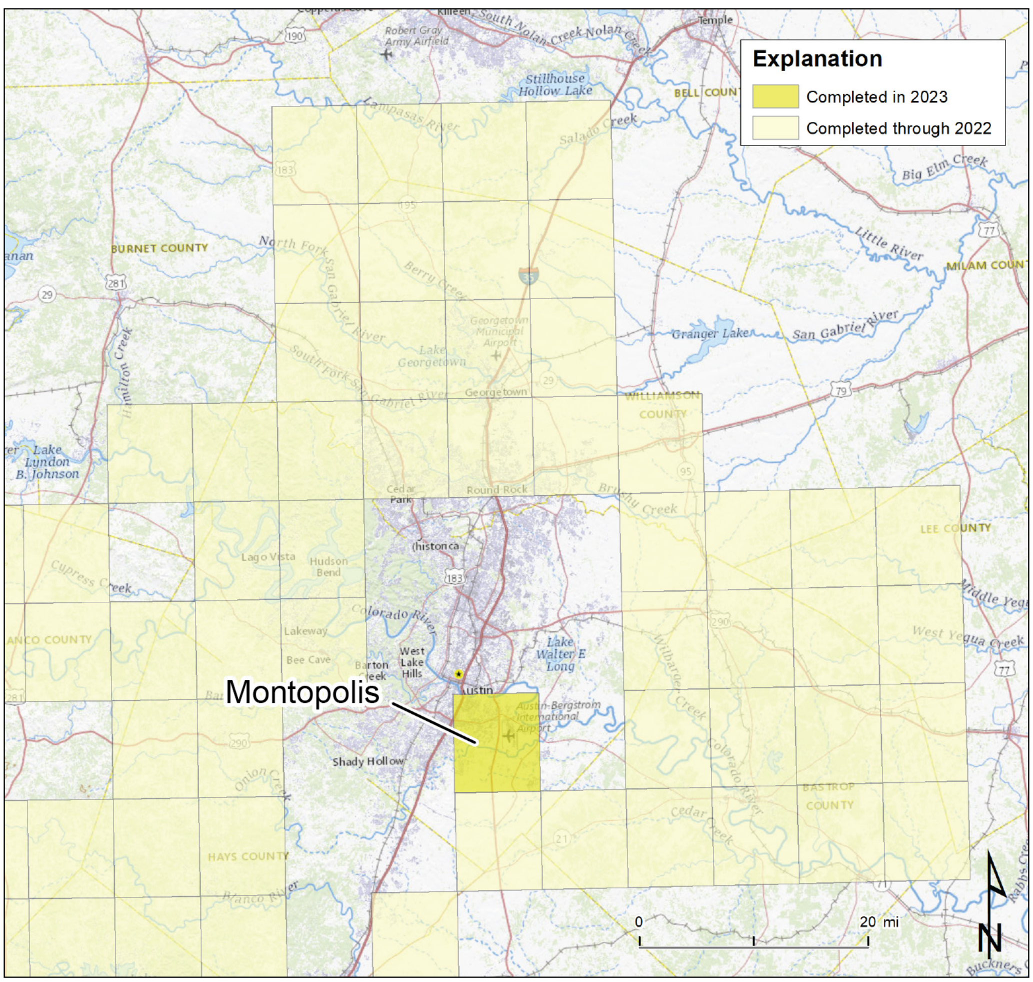

Figure 11. Map of the central Texas urban growth corridor (project area 3, fig. 1). Also shown are quadrangles completed through 2022 and the quadrangle mapped this year (Montopolis).

(SH-71) extending just off the western boundary of the Montopolis map. Moreover, the map is bisected by the north–south route of U.S. Highway 183, which crosses the Colorado River near the pioneer river town of Montopolis that was established in 1839—the same year in which Austin was incorporated. The Montopolis Bridge is the site of the first stream gage for the Colorado River in Austin and is still in use. This gage provides data on stream flow for the river's watershed that encompasses roughly 39,000 mi^2. Farther east, SH-71 intersects SH-130, a toll road that provides a north–south bypass route around Austin and the traffic congestion along IH-35. The intersection of this toll road with SH-71 lies immediately east of the map's eastern edge.

This map encompasses several notable geographic features, including the meandering course of the Colorado River and the downstream limit of Lady Bird Lake, which is impounded by Longhorn Dam, the right abutment of which occurs along the northern edge of the map. Prominent meander bends (Hornsby Bend and Montopolis Bend) include many large sand and gravel pits, as well as other sites denoted as "disturbed land" that include abandoned landfill sites, wastewater-treatment facilities (both active and inactive), and locations that have been used for extraction of sod and "soil" for landscaping purposes. Most of the northern half of the map is covered by Quaternary deposits at various elevations (hence, of diverse ages).

Cretaceous bedrock units include faulted terrain, where Austin Chalk interbedded with weathered volcanic rock occurs. South of Onion Creek, bedrock comprises claystone deposits of Late-Cretaceous age, mapped here as combined Taylor and Navarro Groups (Barnes, 1974). These clay deposits are weathered to deep, highly fertile soils that produce crops having great value for food, forage, and fiber. This terrain composes part of the Blackland Prairies of Central Texas (Ferguson, 1986), and the dark-brown to black, clay-rich soils give the Blackland Prairies their name. One of the characteristic soils mapped on this quadrangle by scientists of the U.S. Department of Agriculture is designated the Houston Black Clay (Werchan and others, 1974); the Texas legislature recognized the economic value of these croplands, and they designated the "Houston Black" soil series as the "State Soil of Texas." Besides high value as cropland, soils and substrates in this map area exhibit other attributes that affect human use of the land. They also pose engineering problems, owing to their low bearing strength, high plasticity, low slope stability, and high corrosion potential. High plasticity causes the soils to shrink when dry and swell when wet, and this produces great stresses on man-made structures. It also promotes slope failures–either along excavated exposures or areas cut by streams.

One of the highest topographic elevations on the Montopolis quadrangle is a landform known as Pilot Knob, which stands at 711 ft above mean sea level. This hill marks the site of an extinct marine volcano that erupted during the Late Cretaceous (roughly 80 Ma). This volcano complex contains hard, black volcanic rock, and widespread occurrences of weathered volcanic ash. The weathered ash deposits occur interbedded with limestone strata to form waterfalls along Onion Creek, which are key sites of McKinney Falls State Park.

PROJECT 4: CRITICAL MINERALS MAPPING, TRANS-PECOS (SMALL QUADRANGLE, 1:24,000)

Brent A. Elliott

This STATEMAP work involved 1:24,000-scale mapping of the Small quadrangle (Elliott, 2023) in the Trans-Pecos alkaline igneous belt (figs. 1 and 12). This mapping builds on previous STATEMAP mapping to the south in the Silver King Canyon quadrangle and to the west in the Gunsight Hills South and Lasca quadrangles, and supports future mapping in the region. West Texas quadrangle maps assist in mineral resource exploration, critical mineral identification, and resource development potential in the State of Texas.

The Small quadrangle mapping utilized geophysical data from the Texas portion of the broader Cornudas geophysical survey area extending from New Mexico across the Diablo Plateau, extending south of the Sierra Blanca area adjacent to the Small quadrangle (Bultman, 2021). The region is host to intrusive and hypabyssal or subvolcanic units emplaced at medium to shallow depths in the crust (Barker and others, 1977). Igneous bodies include discordant sheets, sills, plugs, domes, and laccoliths intruded into Lower Permian limestone and Lower Cretaceous limestone and sandstone. These igneous rocks show limited compositional variation, ranging from nepheline rhyolite, syenite, and phonolite to nepheline syenite and trachyte (Barker and others, 1977). The recent USGS airborne survey validated and demonstrated large magnetic anomalies across the region that coincide with exposed igneous outcrop and several locations where buried intrusions are highly likely. The Finlay dikes and sills intrude Permian and Cretaceous sedimentary rocks and represent one of these critical mineral prospective areas mapped in the Small quadrangle.

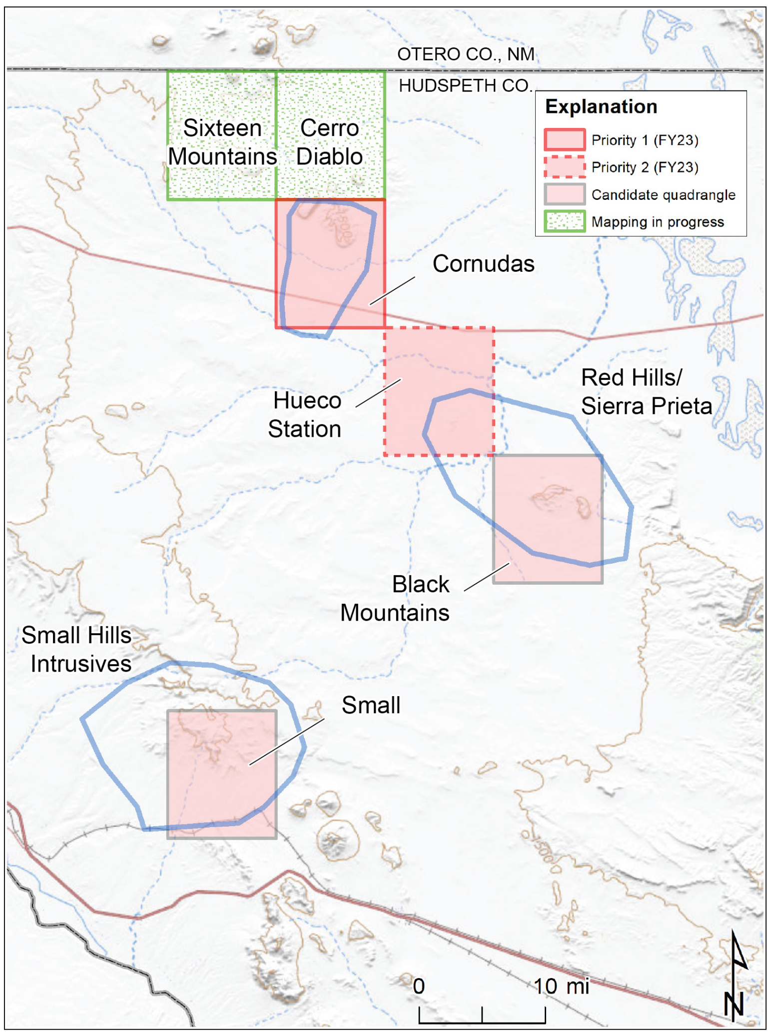

Figure 12. Map of the Trans-Pecos critical minerals mapping area (project area 4, fig. 1). Also shown are quadrangles being completed this year as part of an Earth MRI project (Sixteen Mountains and Cerro Diablo), and three quadrangles being considered for mapping (Cornudas, Hueco Station, Red Hills/Sierra Prieta, and Black Mountains).

Maps for this region provide a basic geologic framework to aid in managing water and earth resources; planning land use; and identifying sources of rare earth elements, precious and base metals, uranium, thorium, fluorine, beryllium, and other critical earth resources. This study area includes the Mesozoic sedimentary rocks located west of known rare earth element resource prospects at Round Top and adjacent igneous bodies in the Sierra Blanca Complex (Pingitore and others, 2014; O'Neill and others, 2017; Elliott, 2018; Piccione and others, 2019). The igneous rocks in the map area intrude the Cretaceous Cox sandstone, Finlay limestone, Campagrande limestone, and Permian limestone and marlstone. The Tertiary intrusive and volcanic rocks provide excellent potential for hydrothermal mineral resource formation, skarn development, and magmatic ore resources in West Texas.

PROJECT 5: U.S. GEOFRAMEWORK INITIATIVE TASKS

Support was provided to create a statewide subsurface salt distribution map and geodatabase, create three GeMS compilation maps, update the NGMDB catalog, and begin an inventory of items in Bureau publications that are amenable to three-dimensional geologic models.

Statewide Salt Distribution Map and GeMS Database

John R. Andrews

Cast among three recognized salt provinces in Texas—the East Texas, South Texas, and Gulf Coast Salt Provinces—lurk 83 known salt diapirs of varying depths and morphology. Though many of these domes have been the subject of intense study for nearly a century, others are less well known. Nevertheless, we conducted an exhaustive literature search and assembled journal articles, reports, maps, spreadsheets, and ancient database printouts comprising structural and morphological descriptions of onshore domes in Texas. For approximately 60 of the 83 domes, structure contour maps in peer-reviewed publications were available (e.g., fig. 13) and digitized using GlobalMapper software. For the remainder, either partial structure contours or other data—including cross-sections, well control, 3D renderings, or dome outlines—were available to assist

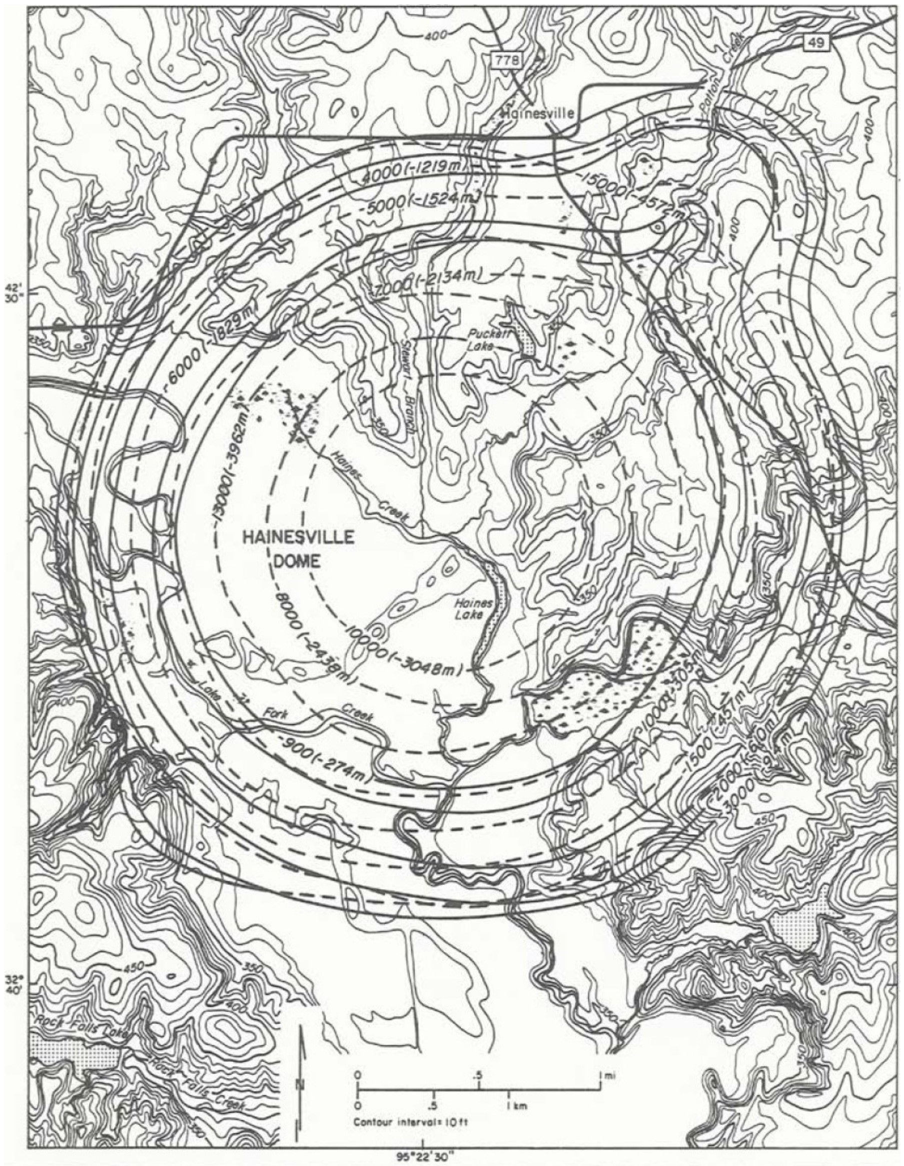

Figure 13. Published structure contour lines in peer-reviewed report. The majority of IsoValueLines in our salt geodatabase meet this standard of quality and ValueConfidence, 50 m (Jackson and Seni, 1984).

our mapping efforts (fig. 14). A separate spreadsheet with per-dome information was maintained, including fields for recording DataSourceID, Type, ValueConfidence, and sourceType. A python script was written and employed to import the 83 separate domal shapefiles—plus the Salado Formation contours, which were similarly digitized—and the aforementioned spreadsheet, and output a single, comprehensive, fully-annotated shapefile. This shapefile was subsequently imported into ArcGIS Pro software using GeMS_Tools.tbx version 2.12.9 and brought into

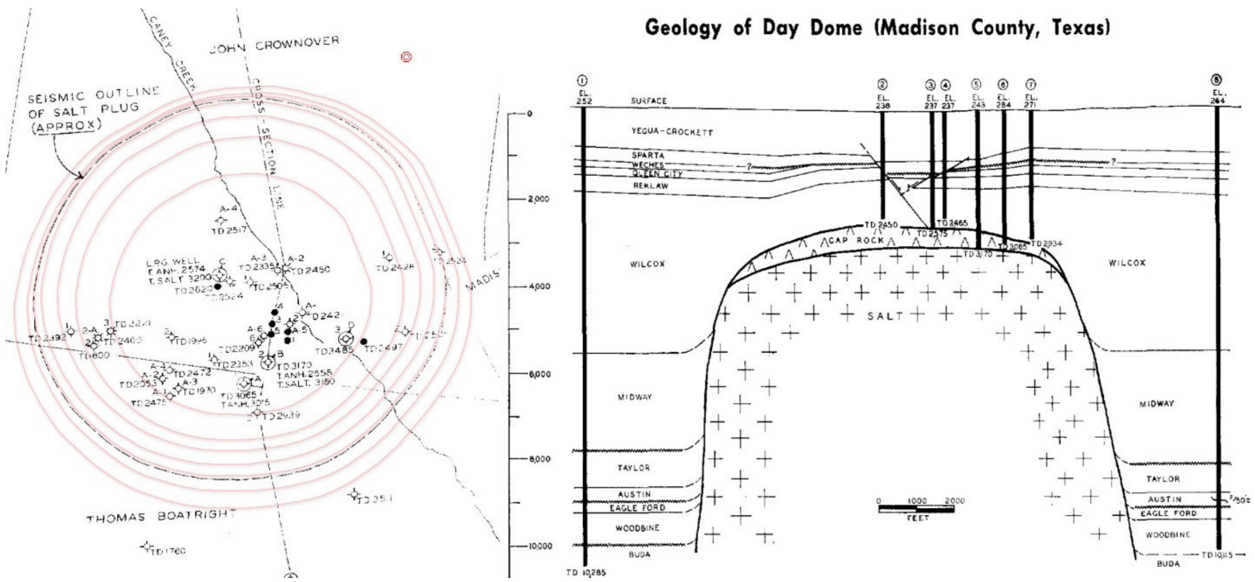

Figure 14. Published structure contours for Day Dome do not exist. For our salt geodatabase, structure contours were generated by the author (faint red lines) using available information including dome outline (dotted black line) and cross-section (Bornhauser, 1969). Methods and accuracy estimates are maintained per-IsoValueLine in the geodatabase.

GeMS compliance. The compiled data were then used to create an Open-File Map of salt distribution across Texas (Andrews, 2023).

GeMS Compilation Maps

Three GeMS-compliant compilation maps on the upper Texas coast, the middle Texas coast, and central Texas were completed at scales of 1:50,000 or 1:62,500 (fig. 1).

Upper Texas Coastal Plain Compilation Map and GeMS Database

Tiffany Caudle and Jeffrey G. Paine

A GeMS compilation geologic map of the Galveston East Bay area, including the Flake, Lake Stephenson, Frozen Point, Caplen, and High Island 7.5-minute quadrangles and portions of the Smith Point, The Jetties, Galveston, and Port Bolivar 7.5-minute quadrangles on the upper Texas Gulf of Mexico coastal plain was completed. Geologic mapping conducted from remote sensing and field-based approaches was completed in the component quadrangles from 2019 to 2022 (Caudle and Paine, 2019, 2020, 2021, and Caudle and others, 2022). Parts of the Port Bolivar, Galveston, and The Jetties 7.5-minute quadrangles were mapped in 2023 to complete the mapping of Bolivar Peninsula (fig. 2). Final deliverables for the Galveston East Bay compilation include an Open-File Map prepared at a scale of 1:50,000 (Caudle and Paine, 2023b) and a GeMS database.

Middle Texas Coastal Plain Compilation Map and GeMS Database
Jeffrey G. Paine, Benjamin A. Grunau, and Jennifer N. Morris

The middle Texas coast compilation map of the central Matagorda Bay area depicts the surface distribution of Pleistocene and Holocene fluvial, deltaic, estuarine, and barrier-island depositional units that span the period during and following the last interglacial at about 100 ka. Included in the compilation are four quadrangles (Turtle Bay, Palacios, Palacios NE, and Palacios SE) mapped at 1:24,000 scale during the two previous STATEMAP projects (Paine and Costard, 2021a, b; Paine and Costard, 2022; Paine and others, 2022) and three quadrangles (Palacios Point, Decros Point, and South of Palacios Point) that included narrow parts of Matagorda Peninsula that were mapped at 1:24,000 scale during this project. The central Matagorda Bay area compilation was completed as an Open-File Map (Paine, Grunau, and Morris, 2023b) and as a GeMS database. This compilation adjoins the western Matagorda Bay area compilation map (fig. 1) that was completed as a GeMS database in 2022.

Central Texas Compilation GeMS Database
Mark A. Helper and Brian B. Hunt

The central Texas compilation map (Helper and others, 2023) is within and adjacent to the Llano uplift geological province, a broad, low relief, structural dome and erosional window that exposed Mesoproterozoic and Paleozoic rocks rimmed by the Cretaceous carbonates of the Edwards Plateau in central Texas. Two major rivers, the Llano and Colorado, traverse the area; parts or all of lakes Buchanan, Marble Falls and Lyndon Baines Johnson, and smaller Inks Lake, are impoundments of the Colorado that lie within the area. The Mesoproterozoic geologic history is recorded by polydeformed and metamorphosed approximately 1.3-1.12 billion year old meta-igneous and metasedimentary rocks that are intruded by billion-year-old granite. The former comprise parts of three lithotectonic domains (stratigraphic Supersuites). These are, from oldest to youngest and from structurally highest to lowest, the Coal Creek, Packsaddle, and Valley Spring Domains. Late-kinematic to post-tectonic granite plutons, dikes and sills intruded all three domains c. 1.1-1.0 billion years ago (Mosher, 1998). Late Cambrian to Pennsylvanian clastic and carbonate rocks were deposited on this igneous and metamorphic basement before Ouachita-age uplift and faulting produced a system of northeast-trending horsts and grabens. Faulting was followed by a period of nondeposition and erosion that lasted until Early Cretaceous burial of all rock units by terrestrial and marine sediments. A final, still ongoing phase of erosion, likely beginning in the Miocene, produced the erosional window and topography observed today.

The compiled geology was derived from (1) five, 1:24,000 scale geologic quadrangle maps published from 1976 to 1982 by the Bureau of Economic Geology (Barnes, 1976; Barnes, 1978a, b; Barnes, 1982; McGehee, 1977), (2) 15 newly georeferenced unpublished maps from MS and Ph.D. theses completed in 1957 to 2021 (such as McGehee, 1963; Zumbro, 1999) and (3) c. 1990 to 2010 research publications that summarize structural, geochronologic, and metamorphic studies of the Mesoproterozoic geology (Mosher, 1998; Roback, 1996; Reese and others, 2000; Barker and Reed, 2010).

Results include a new geologic map and GeMS-compliant database that will improve geologic and hydrogeologic understanding of the resources in this area.

NGMDB Updates

Carson Werner

In our continuing effort to add non-STATEMAP funded Bureau publications to the NGMDB, 40 Geological Circulars, the remainder of the series, have been cataloged in a NGMDB-supplied spreadsheet and georeferenced for inclusion in the NGMDB (BEG_NGMDB_additions_GCs.xlsx). The digital files of these publications have been included in this submission. Over half of these new entries are now freely available and the URLs provided in the spreadsheet point to open access pages on the Bureau's store. The Bureau is working to make more publications open access, and we will continue to update links in the NGMDB as that happens. The updated spreadsheet and the publication files were delivered to the USGS on 11/27/2023 by posting the files on a server for download by NGMDB staff.

In addition, the NGMDB staff provided a spreadsheet (TXGS-in-NGMDB_RequestPDFs-updated_CWW.xlsx) of geologic maps created by the Bureau that are already in the NGMDB but need both images and additional metadata to complete the entries. Corrections, where necessary, were made to titles and series names and numbers for all 253 items. Links to the individual maps on the Bureau's store were added, as well as an "order number" consistent with previous revisions to NGMDB entries we have submitted. The high resolution map files and any accompanying booklets (as a PDF or zip) were included for all the entries (TXGS-in-NGMDB_Map_Image_Files.zip) and made available to NGMDB staff by download from a server.

Figure Inventory and 3D Applications

Carson Werner

Work has begun on an inventory of figures from Bureau publications, with the goal of identifying and tagging figures that are amenable to three-dimensional geologic mapping. The figures from most of our Reports of Investigations and Oil and Gas Atlas series have been compiled into an SQLite database. These series were given priority as they are most likely to have isopach maps, structure maps, cross sections, and other data pertinent to creating three-dimensional models. SQLite was chosen due to its efficiency, cross-platform support, and open-source design.

There are two tables in the database (BEGFigures.db): "pubs" has the publication title, our publication ID, and where applicable, the current NGMDB ID; "figures" has our publication

ID, the figure's number, caption, page number, image file name, and tags/keywords. The figure images are JPEGs named in a systematic way ([publication ID]-[figure number]) and included in a folder ("images") outside of the database file.

The SQLite format provides many flexible options for using the data. One example is the "figure explorer" (https://coastal.beg.utexas.edu/statemap/), a simple web app developed to browse, search and view the figures in the database. Exporting the data to csv or writing SQL queries to extract information from the database to use in other, existing systems could also be done with ease. The database and image collection were delivered to the USGS on 11/27/2023 by posting the files on a server for download by NGMDB staff.

Work will continue on the database by adding tags (with a shared nomenclature between the Bureau and USGS), adding new figures, and correcting figure caption errors from the conversion of scanned text.

ACKNOWLEDGMENTS

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contained in this report and on the accompanying maps should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Publication authorized by the Director, Bureau of Economic Geology.

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