Preliminary Geologic Map of Southernmost Texas, United States, and parts of Tamaulipas and Nuevo Leon, Mexico: Environmental Health Investigations in the United States-Mexico border region

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Preliminary Geologic Map of Southernmost Texas, United States, and parts of Tamaulipas and Nuevo Leon, Mexico: Environmental Health Investigations in the United States-Mexico border region

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Introduction

The primary purpose of this map is to provide an integrated, digital, geologic map dataset for display and analyses on an Arc Internet Map Service (IMS) Web site dedicated to studies of environmental health issues in southern Texas, United States, and in parts of the states of Tamaulipas, and Nuevo Leon, northeast Mexico. The IMS Web site was prepared by members of a U.S. Geological Survey project titled "United States-Mexico Border Health Initiative" (USGS, 2004a; 2004b). The IMS Web site address is *http://gisdata.usgs.net/website/BorderHealth*, and the project home site is *http://borderhealth.cr.usgs.gov*. The objective of the project is to acquire, evaluate, analyze, and provide earth and biological resources data within a geographic framework using an IMS to further our understanding of the linkages between the condition of the physical environment and public health issues. This geologic map is just one of many datasets included in the Web site; other datasets include geochemical, geophysical, biologic, hydrologic, geographic, and human health themes.

The geologic map covers the southernmost part of Texas (parts of Jim Hogg, Brooks, Starr, Hidalgo, Zapata, Willacy, Kenedy, and Cameron Counties), and parts of the states of Nuevo Leon and Tamaulipas, Mexico. Geologic units become younger from west to east across the map area. The oldest rocks are in the western part of the map area in Mexico and include mostly Jurassic and Cretaceous marine limestone, sandstone, shale, and evaporite units exposed in a series of north to northwest-trending ranges. These rocks are highly folded and are part of the Sabinas foldbelt (Ewing, 1991), a compressional terrane that formed during the Laramide orogeny (Cretaceous to Paleocene) due to complex interactions related to subduction of the Pacific plate beneath North America. The Mesozoic rocks were intruded by Oligocene and Miocene igneous rocks.

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The central and eastern parts of the map cover the Gulf Coastal Plain province extending across southern Texas, United States, and Tamalupias and Nuevo Leon, Mexico. Rocks in the central part of the map area are Tertiary units consisting mostly of sandstone, shale, and claystone units deposited in mixed marine and continental environments. These Paleocene to Pliocene rocks dip east and formed as a result of rapid deposition and progradation of sediments across the continental margin into the Gulf of Mexico. The rapid infilling resulted in the development of syndepositional growth faults which formed episodically from Paleocene to the Pliocene. The growth faults (Ewing, 1986) are subparallel with the modern coastline and are mostly concealed to form a structurally complex Gulf Coast Tertiary basin. Tertiary bedrock units are important because they contain oil and gas resources in south Texas and in Tamaulipas, Mexico (Burgos basin) (USGS, 2004c), and uranium deposits in the South Texas Uranium District (Galloway and others, 1979; Eargle and others, 1971; Henry and Kapadia, 1980). The Catahoula, Fleming, Oakville, and Goliad Formations are part of the Gulf Coast aquifer in the study area, an extensive artesian aquifer that produces water primarily for irrigation and municipalities (Ashworth and Hopkins, 1995).

Rocks bordering the Gulf of Mexico are the youngest units in the map area and are Quaternary and modern sediments consisting of alluvium and flood-plain alluvium of the Rio Grande, and coastal deposits of deltaic, tidal-flat, beach, barrier island, lagoon, esturary, and dune environments (Brown and others, 1980). A high-resolution gamma-ray survey flown over parts of Cameron, Hidalgo, and Willacy Counties indicates that flood-plain alluvium along the Rio Grande (map units **Qas** and **Qam**) has anomalously high concentrations of uranium (Duval, 2005). Preliminary studies of these sediments suggest that the high uranium concentrations potentially pose a radon gas hazard in populated areas along the Rio Grande mapped as **Qas** and **Qam** (J.S. Duval, unpub. data).

This report is an initial version that presents the existing geologic map data with limited interpretation. We are currently preparing a second version of the map that will include new stratigraphic map unit correlations between the U.S. and Mexico datasets based primarily on remote sensing techniques. This methodology was developed to establish a template that can be utilized in compiling geologic datasets across the entire U.S.-Mexico border.

Methods

The map was compiled by integrating geologic unit polygons, lines, and point data from the McAllen-Brownsville (Bureau of Economic Geology, 1976), Matamoros (INEGI, 1982a), Rio Bravo (INEGI, 1982b), Reynosa (INEGI, 1983), and Monclova (INEGI, 1991) 1:250,000-scale quadrangles. In ArcInfo, the geologic datasets listed above were queried by their original source unit symbol designations and were redefined into the new unit symbols used for the merged bi-national dataset. The datasets were then appended and boundaries removed between like units. New unit description tables and ages were joined together by the new unit name attribute.

The attribute tables for the map database include columns for new map symbol, source map symbol, unit name, unit age, and unit description. The map symbol column includes map symbols redefined from the source map symbols in order to develop a consistent scheme using USGS map standards. The capitalized first letter of the map symbol represents the geologic period as follows; “Q” for Quaternary, “T” for Tertiary,

"K" for Cretaceous, and "J" for Jurassic. The capitalized first letter is followed by lowercase letter, or letters, derived from the formal formation name or informal rock type in the unit name column. The source map unit column lists the source unit map symbol as a guide in visualizing how the redefined units relate to the original units. In some cases, the new symbols are the same as the source map symbols, but in general, most units were assigned new symbols for overall consistency. The unit names and map unit ages were derived mainly from the source maps. The unit description column includes lithologic descriptions which are abbreviated versions from the source maps, and for greater detail on units, the reader is referred to the original source maps. Supplemental information for map unit thickness and lithology is from Humphrey and Diaz (2003).

Map unit polygons were essentially unchanged from the source maps except for one unit in the western part of the study area in the Monclova 1:250,000-scale quadrangle, Mexico. Source map unit **Ki(lu-ar)** was combined with unit **Ki(cz)** because of overlap between the two units, and the new assigned symbol is **Kwt** (Lower and Upper Cretaceous Washita Group through Lower Cretaceous Taraises Formation).

We interpreted only one direct map unit correlation between the Mexican and U.S. map datasets. Source map unit **To(lu-ar)** (Mexico) and **MOcf** (U.S.) both include the Catahoula, Frio, and Vicksburg Formations, and were combined into one unit redefined as **Tcv**. The Vicksburg Formation was not defined as part of **MOcf** on the Texas map, but well data in this area (Dodge and Posey, 1981) indicate the Vicksburg Formation is present in the subsurface and we subsequently included it with map unit **Tcv**. The Goliad Formation (**Tg**) (Pliocene) is interpreted to conceal surface outcrops of the Fleming Formation and Oakville Sandstone (**Tfo**) in southernmost Texas. This is based on relations that show a north-trending sequence of **Tfo** in Tamaulipas projecting northward beneath the Goliad Formation in Starr and Jim Hogg Counties, Texas, and the reappearance of **Tfo** further north in Duval County, Texas.

Geologic line (structures including faults, fractures, folds, and dikes) and point (strike and dip) data are essentially unchanged from the source map versions, although we incorporated the system of Paleocene to Pliocene growth faults of Ewing (1991). Although concealed, these faults are important in controlling the geometry of geopressured oil, gas, and ground-water aquifers in the region. It should be noted that the traces of these faults were digitized from a much smaller-scale map (1:750,000-scale) and so their positions on the 1:250,000-scale map should be qualified as concealed and approximately located.

Description of Map Units

FS **Artificial fill and spoil (Modern)--**Artificial fill (F) and spoil (S) material consisting of mixed mud, silt, sand, and shells. Exposed in the Laguna Madre area, Texas

Qal **Holocene alluvium, undivided--**Clay, silt, sand (mostly quartz), gravel, and organic matter. Gravel along Rio Grande consists of Tertiary and Cretaceous sedimentary and igneous rock clasts; also includes sidestream alluvial gravels consisting of Tertiary rock clasts and chert derived from the Uvalde Gravel

Qam **Muddy flood-plain alluvium (Holocene)—**Flood-plain deposits of the lower Rio Grande; mostly mud

Qas **Silty and sandy flood-plain alluvium (Holocene)—**Flood-plain deposits of the lower Rio Grande; mostly silt and sand

Qtf **Tidal flat deposits (Holocene)--**Sand, silt, mud, and shells

Qbi **Barrier island deposits (Holocene)--**Mostly high-permeability, fine-grained sand, but also includes silt, sand, and shells; unit becomes more muddy landward. Deposited in beach-ridge, spit, tidal-channel, tidal-delta, washover-fan, and sand-dune environments

Qcd **Clay dune and clay to sand dune deposits (Holocene)--**Eolian deposits consisting of calcareous clay, silt, and sand; mostly clay and silt in coastal areas, and clay, silt, and sand inland. Dunes are exposed mostly on downwind side of intermittently wet basins

Qsd **Active dunes on mainland (Holocene)—**Eolian deposits consisting of mostly sand and silt (high permeability) forming banner and barchan dunes elongated in northwest direction and developed on stabilized dune (Qds) surfaces

Qds **Stabilized sand dunes (Holocene)--**Eolian deposits consisting of mostly sand (moderate to very high permeability) with relict eolian grain. Exposed in blowouts and small depressions

Qs **Sand sheet deposits (Holocene)--**Eolian deposits consisting mostly of sand with little or no relict grain

Qt **Terrace deposits (Pleistocene)--**Rio Grande river terraces consisting of gravel, sand, silt, and clay

Qb **Beaumont Formation, undivided (Pleistocene)--**Clay, silt, sand, and gravel; stream-channel, point-bar, natural-levee, and backswamp deposits

- **Qbf** **Flood-plain deposits--**Floodplain deposits of the Beaumont Formation consisting of mud veneer over meander-belt sand. Little or no relict grain; grass covered

- **Qbm** **Clay and mud--**Mostly low permeability mud and clay of Beaumont Formation deposited in meander belt, levee, crevasse-splay, and distributary channels

Ql **Lissie Formation (Pleistocene)--**Clay, silt, sand, gravel, and caliche

Qa **Quaternary alluvium, undivided--**Clay, silt, sand, gravel, and some caliche. Gravel includes sedimentary and igneous rock clasts

Qcg **Quaternary conglomerate--**Conglomerate; clasts are mostly limestone with some sandstone; minor calcium carbonate cement

Qli **Littoral deposits (Quaternary)--**Mixture of sand and shell fragments (mainly bivalves and gastropods). Unit exposed along coastline in beach and barrier-bar depositional environments and is the principal sediment source for eolian deposits

Qla **Coastal lacustrine deposits (Quaternary)-**-Mixture of silt, mud, and organic matter exposed along the coast in the Mexican Laguna Madre area. Unit contains shell fragments of oysters, bivalves, and gastropods; also some oolites, dessication cracks, and halite crystals. Halite is mined locally

Qeo **Eolian deposits (Quaternary)--**Eolian deposits consisting of a mixture of quartz sand and shell fragments deposited mostly in sand dunes along the coastline. Unit also includes some clay dunes

QTu **Uvalde Gravel (Pleistocene or Pliocene)--**Gravel consisting of well-rounded chert clasts. About 6 m thick

Tg **Goliad Formation, undivided (Pliocene)--**Clay, sand, sandstone, marl, caliche, limestone, and conglomerate. Unit hosts uranium deposits in the South Texas Uranium Province and is mined for caliche in Hildago County, Texas. 180 m thick

Tgc **Caliche--**Caliche developed on the Goliad Formation with relict eolian grain

Tc **Caliche (Pliocene)--**Massive and dense caliche and some sand and gravel. Unit generally lies disconformably on Tertiary bedrock units

Tcg **Pliocene conglomerate--**Massive conglomerate beds and some lenses of fine-grained sandstone. Conglomerate has clasts of chert, intrusive rocks, and limestone; matrix composed of sand and silt; cemented with carbonate

Tscg **Pliocene sandstone and conglomerate--**Sandstone and conglomerate in massive beds and lenses; cemented with carbonate; crossbedded. Conglomerate has clasts of limestone, sandstone, chert, and quartzite. Unit also includes some horizons of clay and silt

Ttr **Tertiary travertine (Pliocene and Miocene)--**Limestone deposited from paleosprings; contains some plant impressions

Tl **Tertiary limestone (Pliocene and Miocene)--**Massive-bedded limestone coquina with abundant bivalves and *turritella*

Tbr **Tertiary breccia (Pliocene and Miocene)--**Sedimentary breccia, undescribed

Tli **Miocene limestone--**Limestone, undescribed

Tsc **Miocene sandstone and conglomerate--**Sandstone and conglomerate; conglomerate clasts include sandstone, chert, and quartzite; sandstone is cross-bedded and is partly conglomeratic; deposited in mixed marine and continental depositional environments

Tfo **Fleming Formation and Oakville Sandstone, undivided (Miocene)--** Crossbedded sandstone and sandy shale; partly oolitic; some beds contain abundant oysters and bivalves. Unit lies disconformably on Oligocene units, and disconformably below Pliocene units. Unit hosts uranium deposits in the South Texas Uranium Province. Unit about 250 m thick

Tcv **Catahoula (Miocene and Oligocene) and Frio and Vicksburg (Oligocene) Formations, undivided--**Mudstone, claystone, sandstone, tuff, and clay; moderately well indurated. Catahoula and Frio Formations host uranium deposits in the South Texas Uranium Province. About 245 m thick

Tmz **Monzonite (Miocene and Oligocene)--**Sodium plagioclase, biotite, and accessories of apatite and amphibole

Tgd **Granodiorite (Miocene and Oligocene)--**Quartz, potassium feldspar, actinolite, hematite, and apatite

Td **Diorite (Miocene and Oligocene)--**Diorite, holocrystalline; in dikes intruding Upper Cretaceous units on the southeast flank of Sierra de Los Picachos

Tsi **Syenite (Miocene and Oligocene)--**Nepheline syenite; essential minerals include orthoclase and oligoclase; accessory minerals include quartz, apatite, and zircon

Tcgl **Oligocene conglomerate--**Massive-bedded conglomerate and lensoidal sandstone; conglomerate clasts include limestone, igneous rocks, sandstone, and chert in a sandy to clayey matrix; contains some silicified wood fragments. About 80 m thick

Tj **Jackson Group (Eocene)--**Mostly sandstone and lesser amounts of clay. Unit is calcareous and contains fossil wood fragments, volcanic ash beds, and limestone concretions. Sandstone is friable to quartzitic and is laminated and crossbedded. Jackson Group hosts uranium deposits in the South Texas Uranium Province. About 110 m thick

Tjw **Jackson, Claiborne, and Wilcox Groups, undivided (Eocene)--**Alternating beds of shale and sandstone; sandstone is ferruginous and glauconitic; carbonaceous sandy shale beds contain gastropods and pelecypods; unit contains

some volcanic material such as detrital mica. Maximum thickness greater than 4,000 m

Claiborne Group (Eocene)

Ty **Yegua Formation--**Mostly clay and lesser amounts of sandstone. Some beds are lignitic and bentonitic; some fossil wood. Sandstone is partly glauconitic and ferruginous, and is indurated to friable. About 120 m thick

Tla **Laredo Formation--**Sandstone and clay. Abundant marine fossils and common limestone concretions. About 190 m thick

Tm **Midway Group, undivided (Paleocene)--**Claystone, sandstone, and shale; some bentonite and ferruginous and calcareous concretions. Sandstone is locally glauconitic. Unit has cone-in-cone structures, trace fossils, and contains some oysters and *turritella*. Unit from 0 to 1,250 m thick

Km **Mendez Shale (Upper Cretaceous)--**Fissile calcareous shale; hematite nodules; locally includes some intraclastic micrite and calcareous sandstone beds in lenses. Maximum thickness greater than 1,300 m

Kae **Austin and Eagle Ford Formations, undivided (Upper Cretaceous)--** Interbedded argillaceous limestone and calcareous shale; nodules and layers of iron oxide; some horizons of bentonite and sandy limestone; Eagle Ford contains *Inoceramus*; Austin contains some chert layers; basal and upper contacts of unit are transitional. About 550 m thick

Kwt **Washita Group (Upper and Lower Cretaceous), Kiamichi Formation, Aurora Limestone, La Pena, Cupido, and Taraises Formations (Lower Cretaceous), undivided--**Washita, Aurora, and Cupido are mostly micrite with black chert and hematite in layers and nodules. Kiamichi, La Pena, and Taraises are mostly argillaceous limestone and calcareous, silty shale. La Pena contains Aptian ammonites. Taraises contains Neocomian ammonites. About 800 m thick

Jlc **La Casita Group (Upper Jurassic)--**Limestone, sandy clay, and calcareous shale; shale is laminated to fissile; sandstone is fine-grained and has hematite and calcareous concretions cored by ammonites and pelecypods. Lower contact with Zuloaga Group is sharp; contact with overlying Taraises Formation is transitional. About 300 m thick

Jz **Zuloaga Group (Upper Jurassic)--**Mostly limestone with scarce chert; limestone is oolitic and contains sparse mollusk fragments. Unit also includes some interbeds of anhydrite and gypsum. About 130 m thick

Jm **Mina Viejas Formation (Upper Jurassic)--**Anhydrite and halite with interbeds of limestone, shale, sandstone, and bentonite. Unit exposed in the core of an anticline in deformed Cretaceous and Jurassic rocks on the west edge of the map.

Unit from 0 to 200 m thick

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