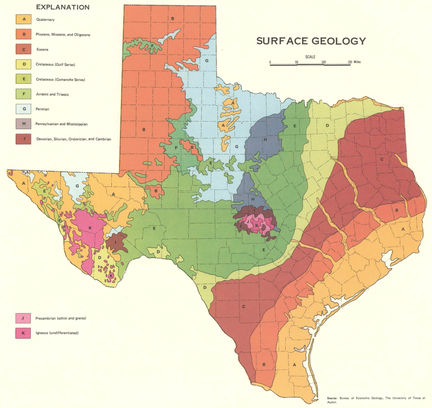
BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
W. L. FISHER, DIRECTOR

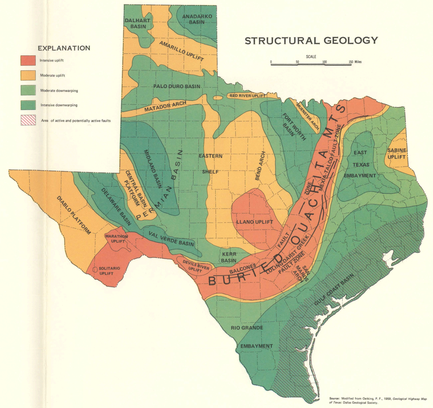
Scale 1:500,000
1 inch equals approximately 8 miles

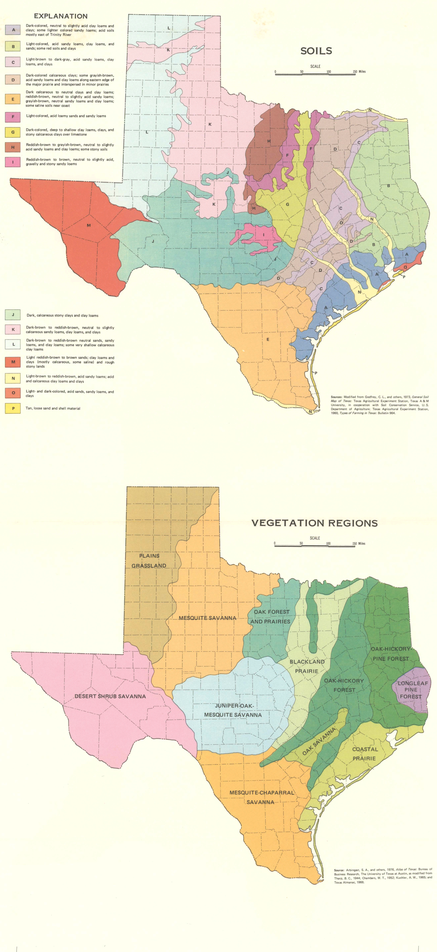
S. W. QUADRANT

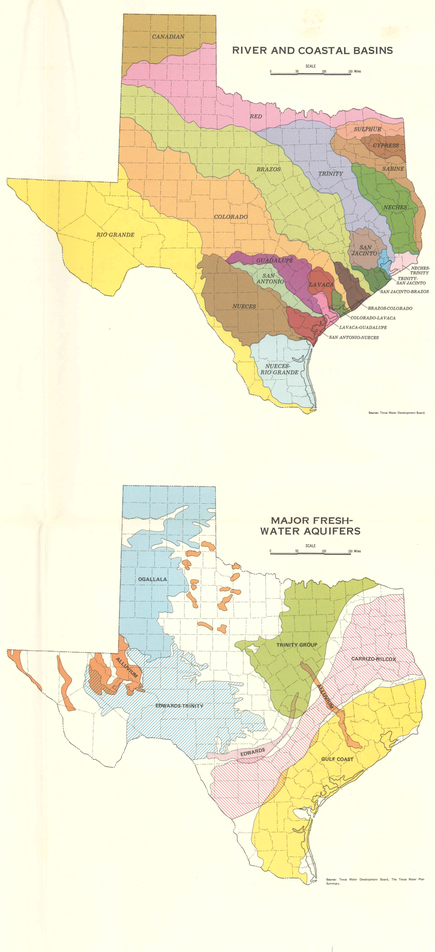
LAND RESOURCES OF TEXAS

R. S. KIER, L. E. GARNER, AND L. F. BROWN, JR.









EXPLANATION

GEOHYDROLOGIC UNITS: areas of ground-water recharge to aquifer systems.

A-1 Recharge sand—**Physical properties:** moderate to high slope stability, high foundation strength, high permeability, moderate corrosion potential, excavation easy (locally difficult). **Topography:** flat to rolling with local scarps. **Vegetation:** hardwood forest in most areas, pines in East Texas, scrub brush and grasses in semiarid areas.

A-2 Perched coastal aquifers—**Substrate:** sand. **Physical properties:** low slope stability, moderate foundation strength, high permeability, high to moderate corrosion potential, excavation easy. **Topography:** low ridge and swale. **Vegetation:** oaks and grasses; none on beaches.

A-3 Edwards recharge zone—**Substrate:** limestone, locally includes clay muds and alluvial materials. **Recharge zone of Edwards underground reservoir as defined in Texas Water Quality Board Order 74-0326-4. Shown by overprint pattern only.**

A-4 Secondary aquifers—**Substrate:** muddy sand and alluvial material, fractured and weathered granite; limestone in Central Texas. **Physical properties:** variable slope stability, high to moderate foundation strength, low to moderate plasticity, high to moderate permeability, moderate corrosion potential. **Topography:** variable. **Vegetation:** scrub brush, cacti, and grasses in West and Central Texas; mixed hardwoods and pines in East Texas.

MINERAL LAND UNITS: lands where significant deposits of economic value occur.

B-1 Massive limestone—**Physical properties:** high slope stability, high foundation strength, low to high permeability possibly fracture controlled, low corrosion potential, excavation difficult. **Topography:** flat with locally deep and dense dissection. **Vegetation:** oak, juniper, grasses, and some mesquite. **Resources:** dimension stone, crushed stone, high-purity limestone, lime, ground-water development.

B-2 Thin-bedded limestone—**Physical properties:** high slope stability, moderate to high foundation strength, permeability fracture controlled, low corrosion potential, excavation difficult to moderate. **Topography:** low cuestas. **Vegetation:** live oak, juniper, and grasses. **Resources:** crushed stone, road base material, local ground-water development.

B-3 Potential cement material—**Substrate:** chalk. **Physical properties:** high slope stability, high foundation strength, moderate permeability locally fracture controlled, low corrosion potential, excavation moderate to difficult. **Topography:** rolling prairie. **Vegetation:** oak, juniper, and grasses. **Resource:** cement material.

B-4 Caliche with soil cover—**Substrate:** calichified bedrock and alluvial material. **Physical properties:** high slope stability, high foundation strength, moderate to low permeability, low corrosion potential, excavation moderate to difficult. **Topography:** rolling prairie. **Vegetation:** oak, juniper, mesquite, and grasses; chaparral in South Texas (varies with climate). **Resource:** road base material.

B-5 Caliche—**Substrate:** calichified bedrock and alluvial material. **Physical properties:** high slope stability, high foundation strength, moderate to low permeability, low corrosion potential, moderate solubility, excavation moderate to difficult. **Topography:** rolling. **Vegetation:** scrub brush, creosotebush, cacti, and sparse grasses. **Resource:** road base material.

B-6 Clay mud and sandstone—**Physical properties:** moderate slope stability, moderate foundation strength, moderate plasticity, low to moderate permeability, high corrosion potential, excavation easy to difficult; thin limestones indicated by black lines. **Topography:** rolling hills. **Vegetation:** scrub brush, mesquite, cacti, and grasses; live oak and juniper on limestone; creosotebush in West Texas. **Resources:** coal and lignite, sand, clay, crushed stone (in limestone beds).

B-7 Ceramic clay and lignite/coal—**Physical properties:** low to moderate slope stability, low foundation strength, clay moderately plastic and moderately expansive, low permeability, moderate corrosion potential, excavation easy. **Topography:** rolling prairie. **Vegetation:** mesquite and grasses. **Resources:** ceramic clay, lignite/coal, local ground-water development.

B-8 Greensand-ironstone—**Physical properties:** high slope stability, high foundation strength, moderate to high permeability, high corrosion potential, excavation moderate to easy except in local hard beds. **Topography:** steep slopes and rolling hills. **Vegetation:** mixed hardwood and pine forest and local grasses. **Resources:** iron ore extraction in northeast Texas; soil conditioner, road base material.

B-9 Gypsum-anhydrite—**Physical properties:** low permeability except along fractures and in solution channels, high solubility with collapse structures, high corrosion potential, excavation easy to moderate. **Topography:** flat with local steep slopes. **Vegetation:** creosotebush, cacti, and sparse grasses. **Resource:** gypsum.

B-10 Conglomerate—**Physical properties:** high slope stability, moderate foundation strength, high permeability, excavation moderate to difficult. **Topography:** steep slopes. **Vegetation:** juniper, scattered oak, and grasses. **Resources:** sand, gravel, crushed stone.

B-11 Siliceous sand and gravel—**Physical properties:** moderate slope stability, high foundation strength, high permeability, moderate to high corrosion potential, excavation easy. **Topography:** flat to rolling with steep margins. **Vegetation:** pecan, willow, and grasses. **Resources:** sand, gravel, local ground-water development.

B-12 Limestone sand and gravel—**Physical properties:** moderate slope stability, moderate to high foundation strength, high permeability, moderate to high corrosion potential, excavation easy. **Topography:** flat to rolling with steep margins. **Vegetation:** oak, juniper, elm, and grasses in Central Texas; grasses in West Texas. **Resources:** sand, gravel, local ground-water development.

B-13 Tuffaceous sand and mud—**Physical properties:** moderate to low slope stability, moderate to low foundation strength, moderate to high plasticity, highly expansive clays, low to moderate permeability, high corrosion potential, excavation easy to moderately difficult. **Topography:** rolling to steep with local badlands. **Vegetation:** chaparral and grasses in arid regions; hardwood and pine forest and grasses in humid regions. **Resources:** bentonite, fuller's earth, volcanic ash, local uranium extraction; timber in East Texas.

B-14 Sand and mud with lignite and bentonite—**Physical properties:** low slope stability, low foundation strength, moderate to high plasticity, local expansive clays, low to moderate permeability, high corrosion potential, excavation easy to moderate. **Topography:** low to moderately rolling. **Vegetation:** hardwood and pine forest, mesquite, and grasses. **Resources:** lignite, bentonite, local ground-water development; timber in East Texas.

PHYSICAL PROPERTIES UNITS: areas where substrate composition is the dominant physical feature.

C-1 Expansive clay mud—**Physical properties:** low slope stability, low foundation strength, high plasticity, commonly calcareous expansive clay, low permeability, high corrosion potential, excavation easy. **Topography:** flat to rolling prairie. **Vegetation:** mesquite and grasses.

C-2 Expansive clay mud and hard limestone (undifferentiated)—**Physical properties:** low to high slope stability, low to high foundation strength, high to low plasticity, expansive clay, low to high permeability, high to low corrosion potential, excavation moderate to difficult. **Topography:** rolling to steep. **Vegetation:** limestone—oak and juniper; clay—mesquite and grasses.

C-3 Limy mud—**Physical properties:** moderate to low slope stability, low to moderate foundation strength, moderate to high plasticity, moderately expansive, low permeability, low to moderate corrosion potential, excavation easy. **Topography:** gentle slopes. **Vegetation:** juniper, mesquite, and grasses.

C-4 Hard limestone and limy mud (undifferentiated)—**Physical properties:** moderate slope stability on clays, high slope stability on limestones, high to moderate foundation strength, moderate plasticity on clays, moderately expansive clays, moderate to low permeability, low to moderate corrosion potential, excavation difficult to easy. **Topography:** variable. **Vegetation:** juniper, oak, and grasses.

C-5 Sand and mud (undifferentiated)—**Physical properties:** moderate slope stability, moderate foundation strength, moderate to high plasticity, moderately to highly expansive clay, low to moderate permeability, high corrosion potential, excavation easy. **Topography:** low rolling hills and prairies. **Vegetation:** grasses and some mesquite; chaparral in arid regions.

C-6 Hard sandstone, mud, and mudstone (undifferentiated)—**Physical properties:** moderate to high slope stability, moderate to high foundation strength, low plasticity, moderate to low permeability, high corrosion potential, excavation moderate to difficult. **Topography:** steep to moderately sloping hills. **Vegetation:** oak, mesquite, and grasses.

C-7 Moderately hard sandstone—**Physical properties:** moderate slope stability, high foundation strength, moderate to high permeability, moderate to high corrosion potential, excavation moderate to easy. **Topography:** rolling with local scarps. **Vegetation:** post oak and grasses.

C-8 Hard sandstone and conglomerate (undifferentiated)—**Physical properties:** high slope stability, high foundation strength, commonly high permeability, high to moderate corrosion potential, excavation difficult. **Topography:** rugged hills and scarps. **Vegetation:** post oak and chaparral.

C-9 Loose surficial sand—**Physical properties:** moderate to low slope stability, high foundation strength, high permeability, excavation easy. **Topography:** flat to gently sloping. **Vegetation:** scrub brush and grasses.

C-10 Gypsiferous red beds with dolomite—**Substrate:** mud and sand with gypsum and dolomite beds. **Physical properties:** moderate to high slope stability, moderate foundation strength, local clays moderately plastic, low permeability, high solubility in gypsum with local collapse structures, high to moderate corrosion potential, excavation easy to difficult. **Topography:** rolling to steep slopes. **Vegetation:** juniper, cacti, and sparse grasses.

C-11 Fractured, steeply dipping rock—**Substrate:** indurated rock of variable composition. **Physical properties:** high slope stability, high foundation strength, high permeability in fractures, excavation difficult. **Topography:** commonly deeply and densely dissected. **Vegetation:** scrub brush, creosotebush, cacti, and grasses.

C-12 Hard crystalline rock—**Substrate:** metamorphic and intrusive igneous rocks. **Physical properties:** high slope stability, high foundation strength, low to high permeability, excavation difficult. **Topography:** gently rolling to steep. **Vegetation:** scrub brush and grasses.

GEOMORPHIC UNITS AND FEATURES: lands where topography or landform is the dominant physical characteristic.

D-1 Desert mountain terrain/sedimentary rock—**Substrate:** highly variable with loose rubble at surface. **Physical properties:** Highly variable. **Topography:** steep, rocky land. **Vegetation:** lowlands—scrub brush, ocotillo, Spanish dagger, cacti, and sparse grasses; upper plains and arroyos—Mexican buckeye, Mexican walnut, Mexican persimmon, desert willow, scrub brush, and sparse grasses; mountain slopes—live oak, pinon pine, juniper, and grasses; generally above 6,000 feet—Douglas fir (Chisos and Guadalupe Mountains), aspen, Arizona cypress (Chisos Mountains), maple, ponderosa pine, and madrone (Chisos, Guadalupe, and Davis Mountains).

D-2 Desert mountain terrain and canyon land/volcanic rock—**Substrate:** highly variable with loose rubble at surface. **Physical properties:** Highly variable. **Topography:** rugged, numerous box canyons. **Vegetation:** lowlands—scrub brush, ocotillo, Spanish dagger, cacti, and sparse grasses; upper plains and arroyos—Mexican buckeye, Mexican walnut, Mexican persimmon, desert willow, scrub brush, and sparse grasses; mountain slopes—live oak, pinon pine, juniper, and grasses; generally above 6,000 feet—Douglas fir (Chisos and Guadalupe Mountains), aspen, Arizona cypress (Chisos Mountains), maple, ponderosa pine, and madrone (Chisos, Guadalupe, and Davis Mountains).

D-3 Terraces—**Substrate:** sand, gravel, and mud. **Physical properties:** moderate slope stability, low to high foundation strength, low to high permeability, high corrosion potential, excavation easy, moderate flood potential. **Topography:** low-relief surfaces. **Vegetation:** pecan and other hardwoods, grasses.

D-4 Inactive alluvial fan and slopewash deposits—**Substrate:** sand, gravel, and mud. **Physical properties:** high slope stability, moderate to high foundation strength, variable permeability, excavation moderate to easy. **Topography:** steep to gentle slopes. **Vegetation:** scrub brush and grasses; sparse in arid regions.

D-5 Severely eroded lands—**Substrate:** silty mud. **Physical properties:** low slope stability, low foundation strength, low permeability, moderate corrosion potential, excavation easy, high flood potential. **Topography:** densely dissected gullies and low hills (typical badlands topography). **Vegetation:** sparse or absent.

D-6 Undissected red beds—**Substrate:** mud and sand. **Physical properties:** moderate slope stability, moderate to high foundation strength, low to moderate plasticity, low to moderate permeability, high corrosion potential, excavation easy. **Topography:** flat to gently sloping. **Vegetation:** mesquite and grasses.

D-7 Dissected red beds—**Substrate:** mud and sand. **Physical properties:** moderate slope stability, moderate to high foundation strength, low to moderate plasticity, low to moderate permeability, high corrosion potential, excavation easy. **Topography:** moderately steep slopes, high local relief. **Vegetation:** mesquite and grasses.

D-8 Stairstep topography—**Substrate:** limestone and marl. **Physical properties:** moderate to high slope stability, moderate to high foundation strength, low to moderate plasticity on marl, variable permeability with local seeps and springs, low to moderate corrosion potential, excavation easy to difficult. **Topography:** steep slopes and benches. **Vegetation:** juniper, live oak, mesquite, and grasses.

D-9 Karstic limestone and gypsum terrain—**Physical properties:** high to low slope stability, moderate to high foundation strength, high permeability in fracture and solution zones, high solubility in gypsum collapse areas, low corrosion potential, excavation moderate to difficult. **Topography:** limestone—flat with local depressions (sinkholes); gypsum—flat to gently sloping with local hummocks. **Vegetation:** scrub brush and grasses.

D-10 Shallow salt domes—shallow piercement, projected outline (approximate) of dome, normally expressed as a topographic high at surface.

D-11 Faults—breaks in Earth's crust along which movement has occurred; most faults show no evidence of movement in historic times. See structural geology map for Gulf Coast area where active and potential active faults occur.

PROCESS UNITS: areas of significant dynamic processes.

E-1 Flood-prone areas—**Substrate:** sand, gravel, and mud; includes some bedrock areas. **Process:** flooding. **Physical properties:** low to moderate slope stability, moderate to high foundation strength, high to low plasticity, local expansive clays, high to low permeability, moderate corrosion potential, excavation easy. **Topography:** flat with local shallow depressions. **Vegetation:** water-tolerant hardwoods and conifers, grasses.

E-2 Levee and crevasse deposits—**Substrate:** sand, silt, and mud. **Process:** flooding. **Physical properties:** low slope stability, low to moderate foundation strength, variable plasticity, local expansive clays, low to moderate permeability, high corrosion potential, excavation easy. **Topography:** low ridges adjacent to streams. **Vegetation:** locally tree, grass, or marsh covered.

E-3 Alluvial fans—**Substrate:** sand, gravel, and mud. **Process:** flooding. **Physical properties:** low to moderate slope stability, high foundation strength, high permeability, moderate corrosion potential, excavation easy. **Topography:** steep to gentle slopes. **Vegetation:** scrub brush and sparse grasses.

E-4 Playas—**Substrate:** mud. **Process:** repeated flooding. **Physical properties:** low slope stability, high plasticity, highly to moderately expansive, low permeability, high corrosion potential, excavation easy. **Topography:** shallow depressions. **Vegetation:** grasses.

E-5 Alkali flats—**Substrate:** alkali- and salt-impregnated clay and very fine-grained sand with dolomite. **Process:** repeated flooding. **Physical properties:** low permeability, high solubility, high corrosion potential, excavation easy. **Topography:** flat.

E-6 Blowouts—**Substrate:** sand and silt. Locally transitional between wind-tidal flat and aolian sand in coastal zone; area adjacent to Laguna Madre includes numerous clay domes with properties similar to E9. **Process:** area of active deflation, subject to flooding in coastal zone. **Physical properties:** moderate to high permeability, high corrosion potential. **Topography:** flat with low active dunes.

E-7 Windbrown sand—**Substrate:** sand, strong relict grain of leveled dunes. **Process:** wind erosion and dune migration. **Physical properties:** moderate foundation strength, high permeability, excavation easy. **Topography:** flat to rolling, locally active dune blowout areas. **Vegetation:** scattered oak mottes with local fresh-water marsh during wet cycles in coastal zone; bunch grasses.

E-8 Sand dunes—includes local stabilized dunes and vegetated fore-island dunes in coastal zone, stability varies with climatic conditions and man's activities. **Process:** active dunes subject to wind erosion and transport. **Physical properties:** low to moderate slope stability, high permeability, high corrosion potential. **Topography:** rolling with moderate relief. **Vegetation:** foreisland dunes—grasses and nongrassy herbs (forbs); abundance dependent upon climatic conditions.

E-9 Clay dunes—**Substrate:** mixed sand, silt, and clay; includes accretionary bars and ridges, rincons, and potreros. **Process:** slow windward accretion. **Physical properties:** moderate to low slope stability, moderate plasticity, moderately expansive, low permeability, high corrosion potential, excavation easy. **Topography:** low rolling. **Vegetation:** scrub brush and sparse grasses.

E-10 Tidal inlets and subaqueous tidal deltas—inlets connect open Gulf and bays; depths in channels 10-40 feet, depths on deltas less than 10 feet; generally normal salinity. **Substrate:** dominantly sand and shell. **Process:** strong tidal currents and rapid sediment transport through inlets, with sediment deposition in tidal deltas. **Biota:** high species diversity; clams, snails, echinoderms, marsh plants, and marine grasses.

E-11 Wind-tidal flats and tidal flats—**Substrate:** mixed mud, sand, and shell. **Process:** subject to rapid and sudden inundation by astronomical, storm, and wind-driven tides, subject to moderate wind erosion between floods. **Physical properties:** moderate to high permeability, very high corrosion potential, excavation easy. **Topography:** flat. **Biota:** blue-green algal mats, crustaceans.

E-12 Bay-margin sand and shoals—salinity variable; water depths less than 6 feet. **Substrate:** sand and mud. **Process:** locally high wave and current activity with rapid erosion, transportation, and redeposition of sand, strong wave activity during storms. **Biota:** high species diversity; clams, snails, crustaceans, and local marine grasses.

E-13 Mainland beaches—**Substrate:** local shell and sand beaches and berms. **Process:** commonly flooded and modified by storms, highly susceptable to erosion. **Biota:** crustaceans and clams.

E-14 Potential hurricane-surge channels—**Substrate:** loose sand and shell. **Process:** storm washover areas, subject to extensive flooding by storm tides and significant transport of sediment during hurricanes, extensively modified by wind between major floods. **Physical properties:** very high corrosion potential.

BIOLOGIC UNITS: areas dominanted by biologic habitation, activity, and productivity

F-1 Fresh-water marsh—**Substrate:** mud and sand; commonly high water table. **Physical properties:** very high corrosion potential. **Biota:** waterfowl, fur-bearers, rushes, cattail, and sloughgrass.

F-2 Swamp—**Substrate:** mud and sand; permanently high water table. **Physical properties:** very high corrosion potential. **Biota:** waterfowl, fur-bearers, water-tolerant hardwoods, dwarf palmetto, cypress, elm, mulberry, and water oak.

F-3 Brackish- to salt-water marsh—**Substrate:** mud and sand. **Process:** frequently flooded by saline water. **Physical properties:** very high corrosion potential. **Biota:** fish, shrimp, and waterfowl; sustoilerts; cordgrass, saltwort, seepweed, glasswort, rushes, and other grasses.

F-4 Marine grassflats—**Substrate:** mud with sand; shallow, subaqueous less than 6 feet. **Biota:** clams, snails, crustaceans, fish, and marine grasses.

F-5 Oyster reefs—**Substrate:** shell material; water depth less than 12 feet. **Process:** high wave and current activity. **Biota:** oysters with associated clams, coral, bryozoans, fish, and crustaceans.

ESTUARY-LAGOON-OPEN GULF UNITS: submergent coastal lands.

G-1 River-influenced bay—**Substrate:** laminated mud and sandy mud. **Process:** commonly flushed by river water, salinity generally low. **Biota:** low species diversity; clams, snails, and crustaceans.

G-2 Restricted bay—**Substrate:** mottled organic-rich mud with concentrations of shell. **Process:** little circulation and exchange with other parts of bay; away from tidal or riverine influence. **Biota:** low species diversity; clams, snails, and oysters.

G-3 Open bay—**Substrate:** mottled mud with concentrations of shell. **Process:** good circulation with other parts of bay. **Biota:** high species diversity; clams, snails, oysters, sponges, bryozoans, and crustaceans.

G-4 Tidally influenced open bay—**Substrate:** mottled mud and sandy mud. **Process:** strong tidal influence, good circulation. **Biota:** high species diversity; clams and snails.

G-5 Interreef flats—**Substrate:** mud, sand, broken shell, isolated clumps of oysters; serpulid reefs in Baffin Bay area. **Biota:** fish, clams, snails, corals, bryozoans, sponges, and crustaceans.

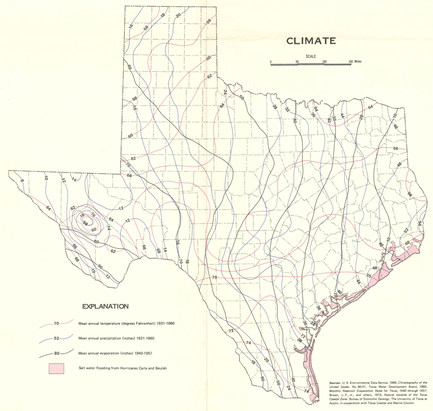
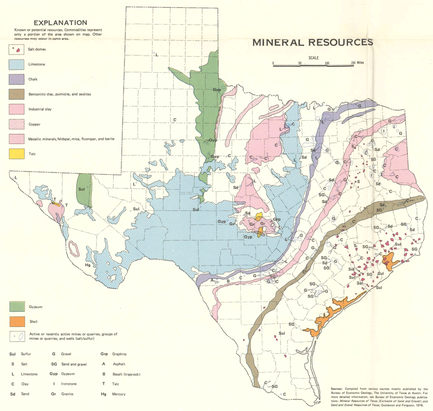
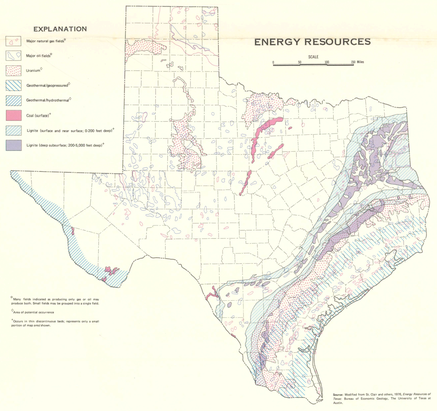
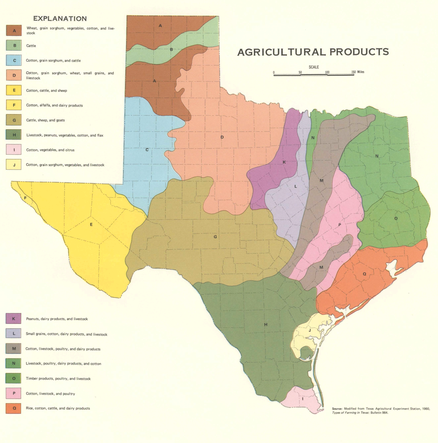
G-6 Shoreface sands—includes surf zone along Gulf shoreline from mean low tide to depths of about 12 feet. **Substrate:** sand and shell. **Biota:** clams, snails, echinoderms, crustaceans, and fish.

MAN-MADE UNITS OR FEATURES: areas where man's activities have altered the environment or created new environments.

H-1 Surface-water storage area—**Physical property:** high to very high corrosion potential.

H-2 Wildlife refuges, forests, and parks—includes several land resource units, use restricted by Government. Shown by overprint pattern only.

H-3 Urban area—metropolitan area undifferentiated, includes residential, commercial, and industrial areas. Shown by overprint pattern only.

Made land and subaerial spoil—**Substrate:** composition highly variable; mixed mud, silt, sand, and shell. **Physical properties:** highly variable. **Topography:** locally steep relief.

Subaqueous spoil—**Substrate:** composition variable; mixed mud, silt, sand, shell. **Physical properties:** highly variable. **Topography:** forms shoals commonly near subaerial spoil and made land in bays, estuaries, and open Gulf.