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CALVERT BLUFF (WILCOX GROUP) SEDIMENTATION AND THE OCCURENCE OF LIGNITE AT ALCOA AND BUTLER, TEXAS

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FIGURES

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REGIONAL GEOLOGY

The group will make two stops: Stop 1 is at the Aluminum Company of America (ALCOA) lignite strip mine 60 miles northeast of Austin, and Stop 2 is at the Elgin-Butler Brick Company clay pits 30 miles east of Austin (fig. 1). The freely given cooperation of ALCOA and Elgin-Butler personnel is gratefully acknowledged.

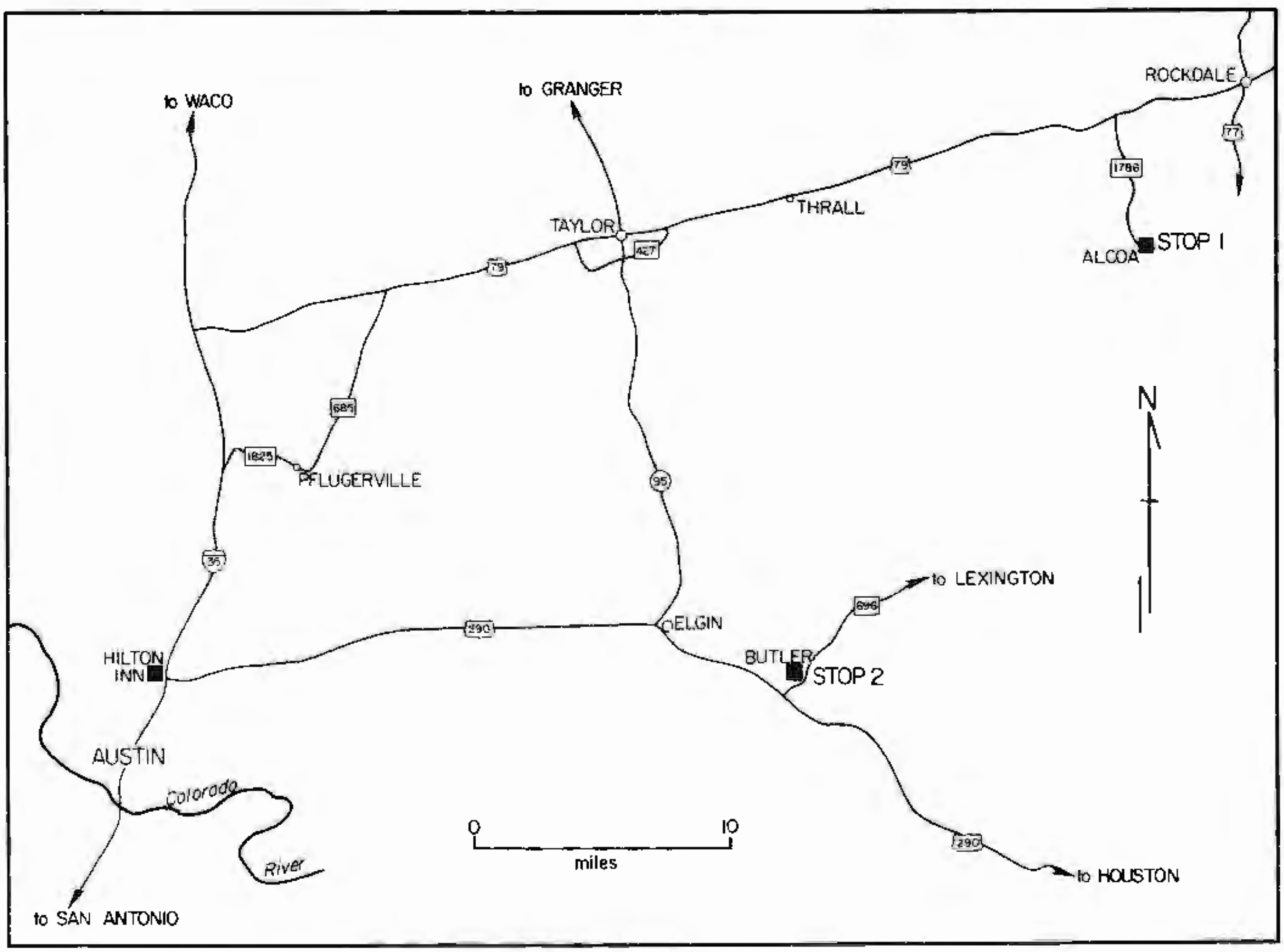
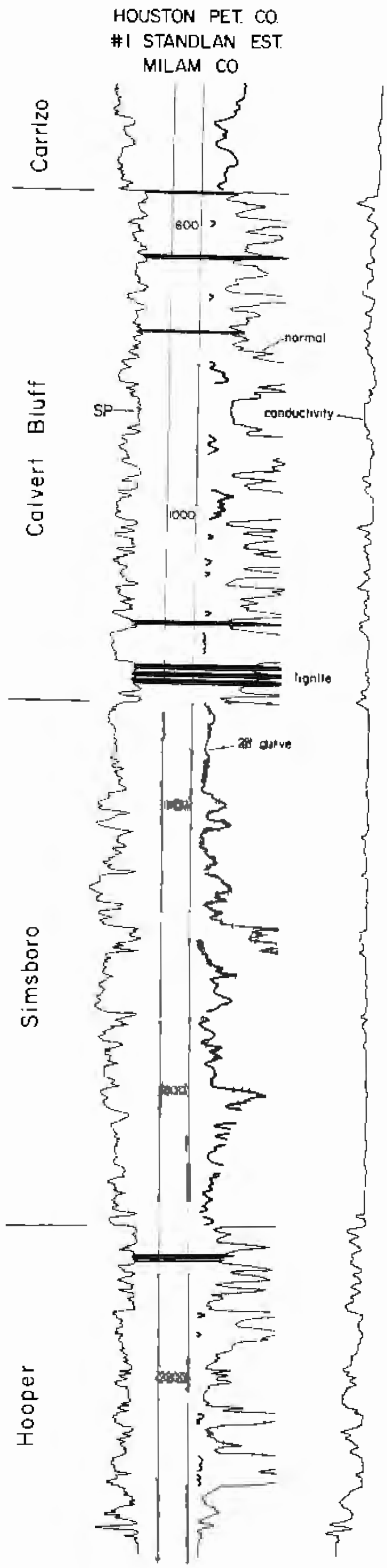


Figure 1. Index map of Stops 1 and 2.



Stratigraphy

In east-central Texas, or the area between the Colorado and Trinity Rivers, the Wilcox Group (lower Eocene) is divided into three formations. Up section they are the Hooper, Simsboro, and Calvert Bluff. At Alcoa and Butler, lower Calvert Bluff sediments are exposed. The Calvert Bluff Formation conformably overlies the highly resistive, massive, fluvial Simsboro Sand and is recognized by its finer grain size, as reflected in reduced resistivity on normal curves, and by the first occurrence of lignite (fig. 2). The formation is unconformably overlain by the Carrizo Sand, a high-resistivity unit of fluvial origin. Lignite is operationally defined to be those beds with baseline spontaneous potential (SP) and a sharp resistivity spike (Kaiser, 1974, p. 32). In the Butler-Alcoa area immediately downdip from the outcrop, the Calvert Bluff is 700 to 1500 ft thick (213 to 457 m) and averages 1,000 ft thick (305 m, n=30). Regionally the Calvert Bluff thickens southward growing at the expense of the thinning Simsboro. In effect, the lower Calvert Bluff and upper Simsboro are facies equivalents.

The most important commercial lignite deposits occur in the lower one-third of the Calvert Bluff immediately above the Simsboro (fig. 2). Lignite occurs persistently at this stratigraphic position throughout east-central Texas at the outcrop and in the subsurface. Commercial deposits occur less persistently in the upper Calvert Bluff being best developed north of the Brazos River. Lignite of lesser importance occurs in the upper Hooper Formation just below the Simsboro (fig. 2). Though commercial deposits probably exist, they are expected to be smaller and more widely scattered along the trend.

Figure 2 (left). Representative electric log illustrating Wilcox stratigraphy and the occurrence of lignite. Log is 8 miles due east of Rockdale, Texas.

Depositional Systems

The Calvert Bluff Formation is a dip-oriented channel system dipping coastward at 1/2 to 2°. As revealed by the sand-percent map, the major river systems flowed from west-northwest to east-southeast (fig. 3). A bifurcating channel geometry is displayed downdip in the deep subsurface. At the limit of recognition of the tripartite Wilcox stratigraphy, in southern Brazos County, the base of the Calvert Bluff is at minus 5283 ft (-1611m) subsea. Updip immediately adjacent to the outcrop, the channels are straight or slightly dendritic. This geometry, based on analogy with modern deltas, is representative of the transition between the bifurcating distributary channel facies of the lower delta plain and the dendritic fluvial channel facies of the high alluvial plain. Therefore the outcrop is positioned at the transition zone between the lower alluvial plain and the upper delta plain. Southward, the bifurcating channel geometry is closer to the outcrop indicating convergence of depositional and structural strike (fig. 3). Thus, to the south the outcrop occupies a position somewhat lower on the ancient delta complex.

Lignite Accumulation

Commercial lignite deposits occupy an interchannel position. In the interchannel basins, developed between natural levee and meanderbelt deposits of the major river courses, swamps and marshes were the sites of organic accumulation. On the sand-percent map, ancient interchannel basins are revealed by relatively lower sand-percent areas. Of significance here is the low-sand-percent areas downdip from the Alcoa and Butler lignite deposits (fig. 3). Palynology of the main lignite seam at Alcoa indicates that fresh-water marsh and hardwood swamp conditions alternated (Atlee and others, 1968). At Butler, dominantly marsh conditions are indicated by the palynology where the apparent absence of swamps is consistent with a position lower on the ancient delta complex.

A modern analogue of a Calvert Bluff interchannel basin is the Des Allemands-Barataria basin of the Mississippi delta complex (fig. 4). The Des Allemands-Barataria basin lies between the alluvial ridges formed by the modern Mississippi and an older Mississippi river course now occupied by Bayou Lafourche. A coastward zonation from fresh-water swamp to marsh through saline marsh as well as an interconnected lake system is well developed. Peat is most extensively developed far from the contaminating influence of active channels and inland from the destructive effects of the Gulf. Peat beds of the upper delta plain and inland areas tend to be thicker and more widespread (Frazier and Osanik, 1969; Gagliano and van Beek, 1970). Maximum development is to be expected at the junction of the delta plain and alluvial plains.

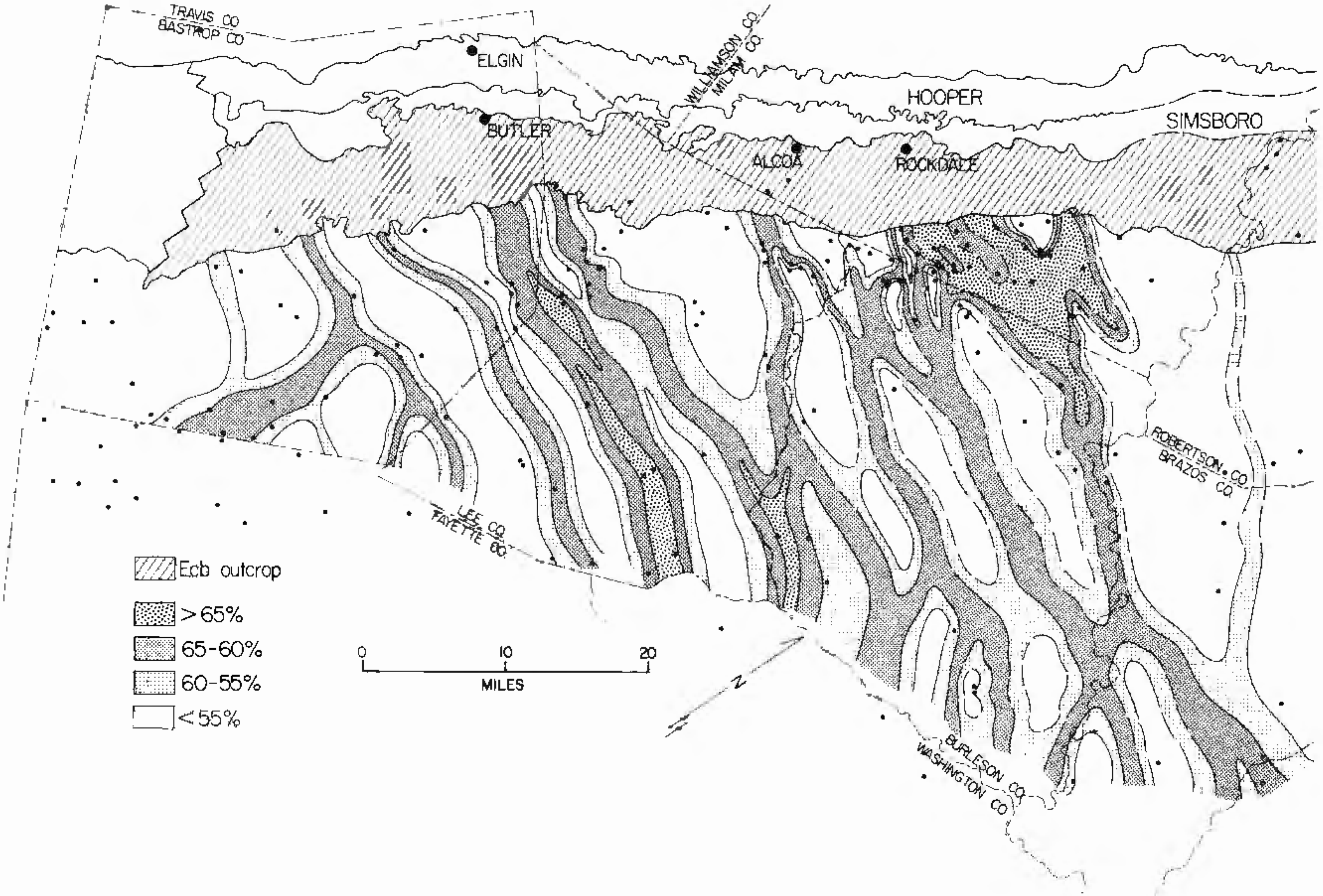


Figure 3. Calvert Bluff Formation sand-percent map of the subsurface Ecb. Wilcox outcrop from Geologic Atlas of Texas, Austin Sheet.

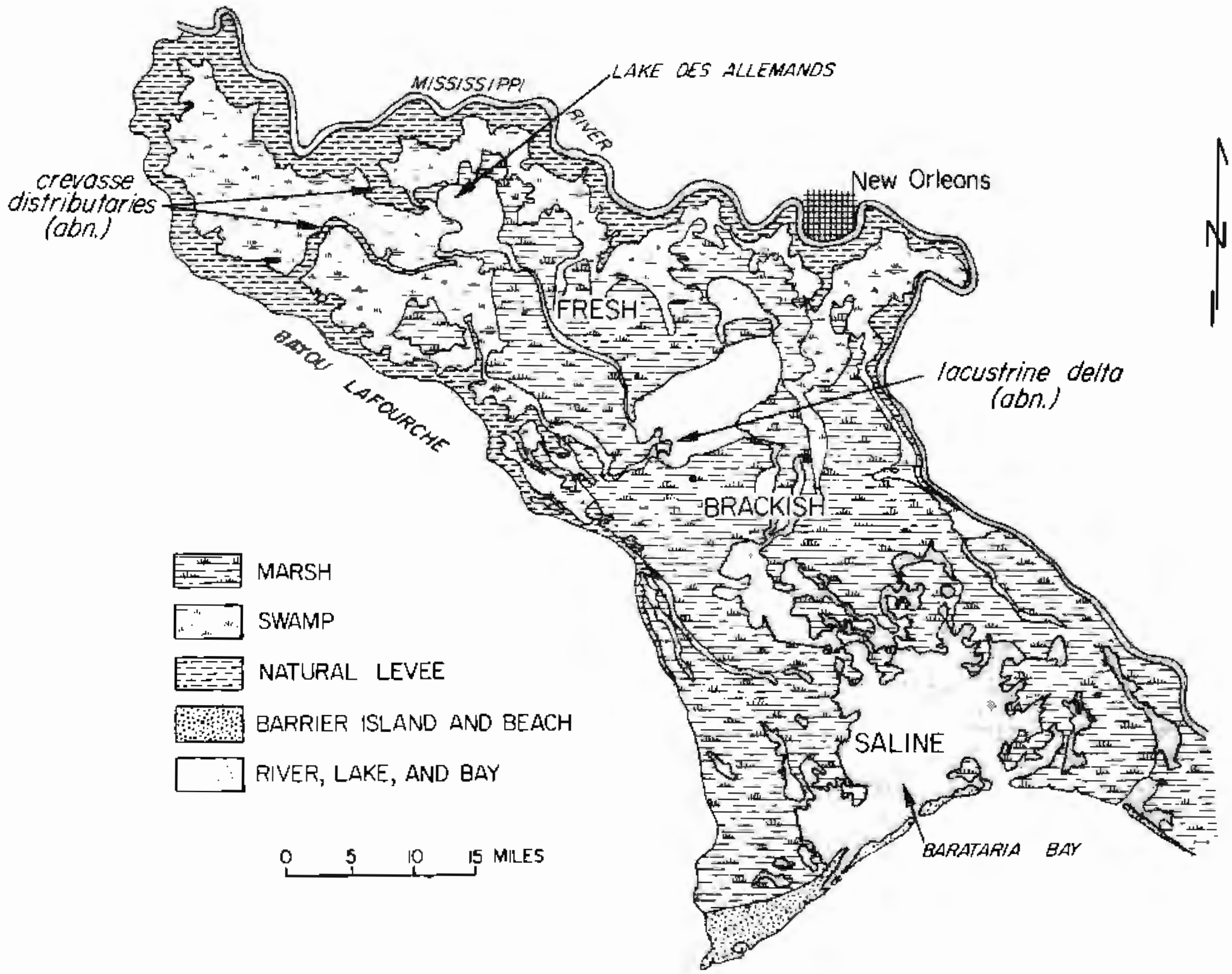


Figure 4. Des Allemands-Barataria basin of the Mississippi delta complex, a modern analogue of a Calvert Bluff interchannel basin. Adapted from Gagliano and van Beek, 1970.

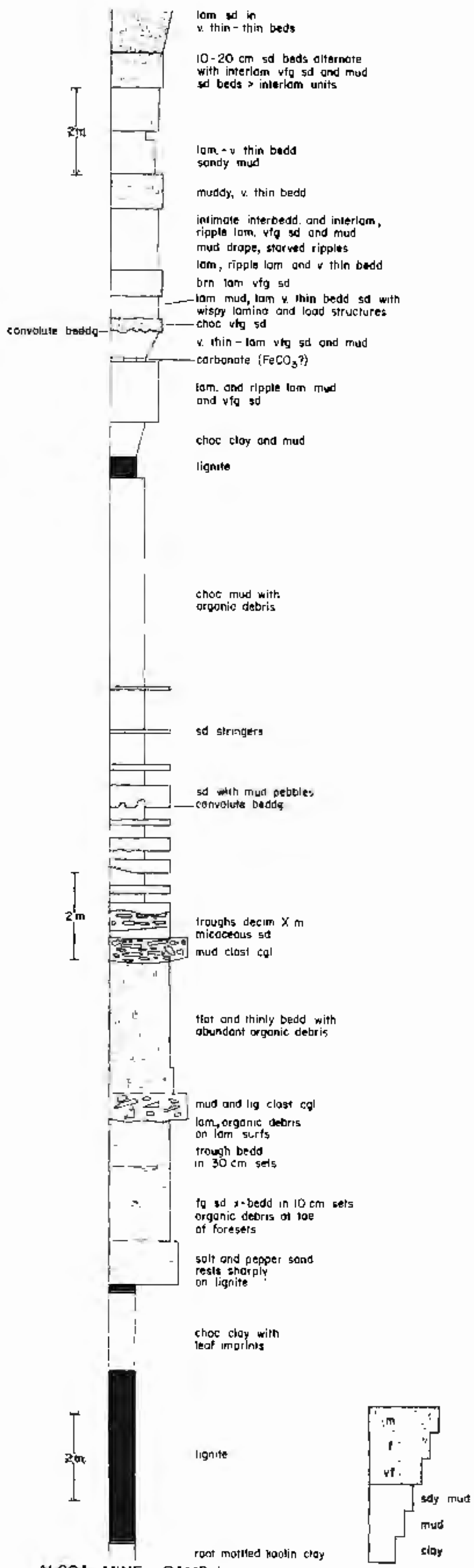
Pattern of Sedimentation

Peat accumulation halts when organic accumulation no longer keeps pace with subsidence or upon major sediment influx. On the Mississippi delta, peat accumulates at a rate of 6 m/1000 years, and subsidence averages 1 m/1000 years. Rapid subsidence triggers the growth and development of interchannel lakes. Initial deposition is fine grained mainly from suspension during overbank flooding. With the advent of extensive crevassing, crevasse splays advance toward the lowest part of the interchannel basin depositing upward-coarsening sediment sequences. Infilling is accomplished by the continued progradation of crevasse splays and lacustrine deltas basinward. Upon the joining of advancing splays and their abandonment, swamps and marshes may again reestablish themselves. Reinitiation of crevassing repeats the cycle. In this manner, a cyclic sequence of coarsening-upward interchannel basin cycles bounded by lignites is generated. Six or more such cycles have been recognized on logs (inverted Christmas-tree pattern) in the subsurface. However, the same log pattern is also indicative of the delta front. Therefore one must know the major facies tract (lower alluvial plain or lower delta plain) to make a correct interpretation.

ALCOA

The ALCOA strip mine is located south of the major Calvert Bluff sand-input area (fig. 3). Exposed in the ramps and pits are the characteristic sequences and sedimentary structures of alluvial plain sedimentation. We will first visit the active pits to see the lignite and overlying sediment. Depending on the mining activity, we hope to see coarsening-upward sequences, inclined accretionary bedding, trough crossbedding, mud-clast conglomerate, and laminations of several kinds. A typical coarsening-upward sequence (interchannel basin cycle) is approximately 15 m thick and begins with lignite, then passes into clay, mud, interlaminated very fine-grained sand and mud, and finally flat-bedded fine sand. Inclined accretionary bedded and associated trough crossbedded sands are interpreted as point-bar deposits. Sequences of parallel laminated mud are seen as lacustrine deposits (Coleman, 1966).

The majority of the time will be spent examining the exposures in the highwall of Ramp 1 and abandoned pits immediately south. A large channel complex oriented northwest to southeast and its associated facies is excellently exposed. The axis of the complex, marked by a mud-clast conglomerate at least 7 m thick with clasts to 70 by 40 cm, is exposed in the southernmost abandoned pit. In the next pit north, the upper channel complex is exposed. Its multilateral character, fining-upward grain size, and extensive ripple bedding are well displayed. At the west end of Ramp 1 is a thick (30 m?) composite sand body composed of vertically stacked channel deposits. The measured section (fig. 5), from midway down the ramp, shows both an excellent fining-upward sequence and overbank deposits (at the top, above the thin lignite), which can be traced along the top of the highwall up the ramp into the thick multistory sand body. Delicate laminations and convolute bedding suggest rapid sedimentation in a subaqueous environment probably during flood stage. This sequence is reminiscent of delta-front sequences and illustrates the importance to interpretation of knowing the major facies tract. Down Ramp 1, the channel complex pinches out into interchannel sediment; at the bottom of the ramp, the channel is gone.



BUTLER

Generally the scale of sedimentary structures and grain size seen at Alcoa is grander than anything seen at Butler. This is probably due to Butler's more distal and flank position on the delta complex or simply the vagaries of stratigraphy and facies. The east pit (east of FM 696) and the west pit (west of FM 696) will be visited on Stop 2.

In the east pit, lignite occurs at the pit floor at the base of a coarsening-upward sequence (fig. 6). Boundaries between units are gradational. The sequence is interpreted as a crevasse-splay deposit overlain by marsh organics. Its upward-coarsening grain size and thickness are similar to the vertical sequence and thickness of crevasse splays in the Mississippi delta Holocene (Coleman and Wright, 1975, p. 128-129).

Just to the south of the measured section is a large channel fill which has scoured deeply (to arrow fig. 6) into the crevasse sediments. The fill, at least 6 m thick, is a medium-grained, micaceous, salt-and-pepper, trough crossbedded (decimeters deep by meters wide) sand with no obvious vertical grain-size change. The exposure does not allow definite establishment of its orientation. Clearly, an abrupt channel boundary dips steeply west and seems to trend roughly north-south. When viewed from a distance, a channel bend swinging eastward and outward toward the observer is suggested. Directional features at this point are oriented eastward.

Figure 5 (left). Graphic measured section at Alcoa, Texas, ALCOA mine, Ramp 1.

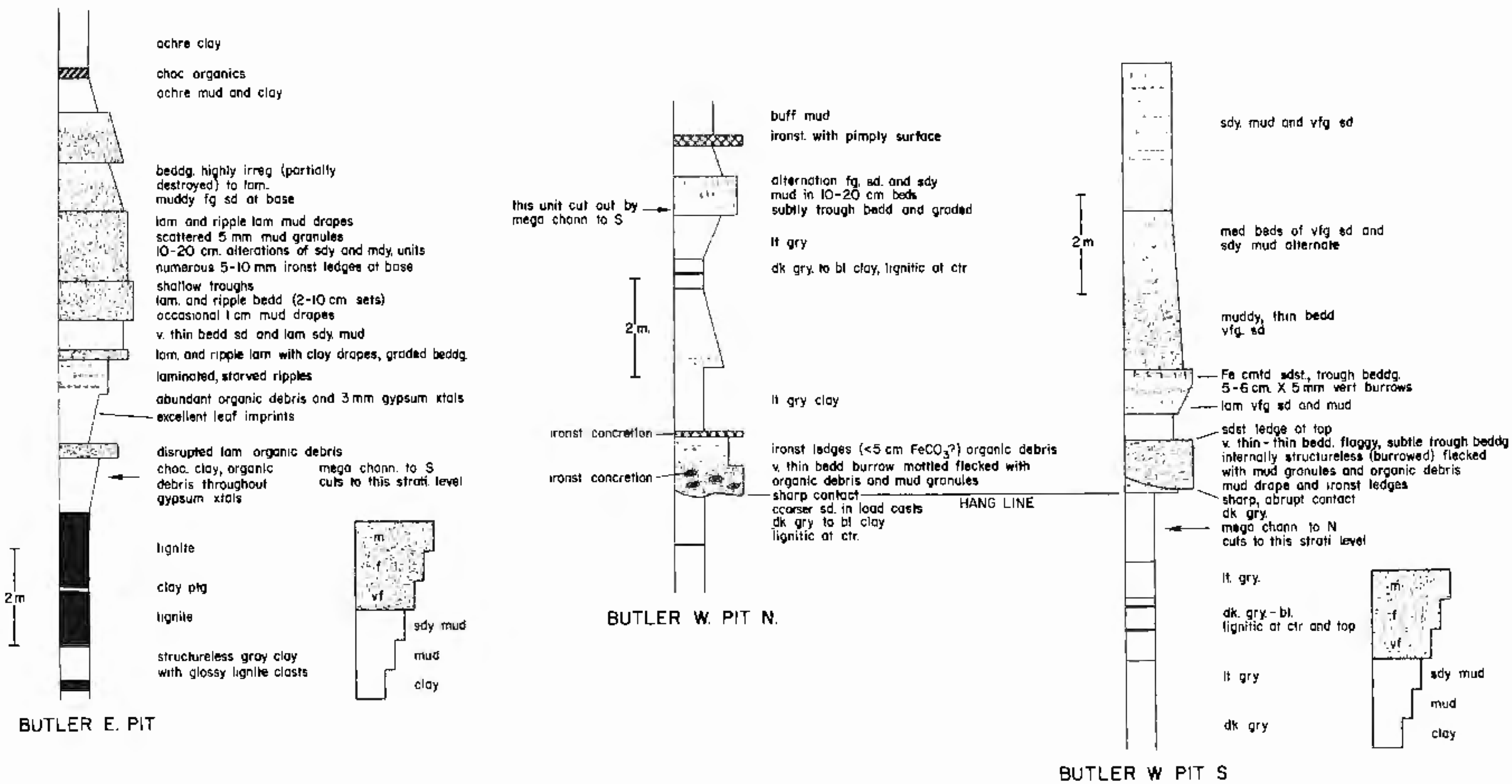


Figure 6. Graphic measured sections at Butler, Texas. At left, east pit (east of FM 696); middle and right, west pit (west of FM 696).

In the west pit, no lignite is exposed; however, thin lignitic zones a few centimeters thick and occasional lignitized wood chunks are found in the dark gray clays exposed in the lower pit wall (fig. 6). Also present are large nodules (up to 1 m) of spherulitic siderite in which individual spherulites measure about 1 mm in diameter. Two ancient environments are represented: marsh-swamp and crevasse splay. Dominant grain sizes are clay to very fine-grained sand. Sediments exposed are stratigraphically below those in the east pit, but details of the stratigraphic relationship of the east and west pits are unknown.

Two kinds of splay deposits are present, levee-crevasse splay and crevasse-distributary channel. The former is represented by the first sand unit above the gray clay (fig. 6, north and south sections). Splays of this type originate from low depressions in the channel levee and splay out as sheets and lenses of sand into the interchannel basin. The bulk of the sediment is deposited adjacent to the channel and near the toe of the levee. Flow may be unconfined, depositing sand sheets decimeters thick from suspension and traction. The deposits of confined flow, channel fills, are lenticular and commonly scour into previously deposited sediment. Here the sand is sheetlike, has a planar erosive base, and lacks internal structure. A proximal splay lobe is implied. Distally scour is absent (for example, top sand, north section, fig. 6).

Two crevasse distributary channel fills are exposed. They represent channels that broke through major channel levees, extended well into the interchannel basin, and probably fed large crevasses or subdeltas. Here the crevasse channels are oriented to the northeast and are postulated to be distributaries from a major channel system projected updip from the subsurface and lying south of Butler (fig. 3). One of these channel fills sits between the two measured sections and has removed considerable stratigraphic section down to the level indicated by the arrows in figure 6. Note that the south section itself is topped by a fining-upward channel sequence. The fill of alternating 10 to 30 cm beds of mud to muddy, very fine-grained sand and very fine- to fine-grained sand implies fluctuating flow conditions—certainly not the sort of fill one would expect in a permanently flowing major channel. Internally, a host of sedimentary structures are displayed such as large-scale contorted bedding, large- and small-scale trough bedding, small-scale accretionary bedding, ripple bedding, and laminations of several kinds. The other channel fill is exposed in the northwest wall of the pit. Its fill is finer grained, contains some excellent leaf imprints, and is fossiliferous (clams and snails) at one end. The highwall appears to skirt its flank. In both cases, channel boundaries are abrupt and steeply inclined and in this respect are similar to the east pit large channel fill.

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