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A GEOLOGIC CROSS SECTION OF THE MISSOURI RIVER VALLEY AT KANSAS CITY, MISSOURI

by

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AREAL GEOLOGY

Description of Surficial Materials

River Bluffs

The tops and moderate to gentle slopes of the river bluffs are covered by glacial drift and loess of Pleistocene age. A representative section of Pleistocene deposits uncovered in the early 1980s in the excavation for Interstate Route 670 near the central business district at Kansas City, Missouri is shown in the cross section (Figure 2) and the stratigraphic section is described in Figure 3. The Pennsylvanian bedrock has been deeply weathered. Solution cavities in the upper Argentine Limestone Member have dimensions of several feet and are filled with reddish-brown clay and fragments of glacial till, chert, limestone, and shale (Figure 4).

Glacial drift belonging to the Kansan Stage (middle Pleistocene) rests unconformably on Pennsylvanian bedrock. The thickness of the drift ranges from 0 to over 20 feet on the bluffs along the line of the cross section but increases to over 40 feet in places on the bluffs, several miles east of Kansas City.

The drift consists of till interbedded with lenses of outwash (stratified drift). The till is composed mostly of clay- to sand-sized particles but 10 to 20 percent is of gravel-size. Isolated boulders commonly occur in the fine-grained matrix, hence the name "boulder" clay.

The glacial drift has been deeply weathered. It has been oxidized to shades of yellowish-brown and reddish-brown and most carbonate rocks and minerals have been leached from the drift. The remaining non-resistant rocks and minerals are extensively altered. Granite and granodiorite crumble under slight hand pressure and limestone boulders and blocks are weathered to form nodules of soft, white calcium carbonate. The resistant rocks include gravel-size particles of pink quartzite, milky quartz, and chert.

Small isolated patches of unweathered till occur below or within the weathered drift. Unweathered till is dark gray; about 80-90 percent of the gravel-sized fraction is locally-derived pieces of limestone with lesser amounts of shale and sandstone. The resistant fraction consists of gravel-sized rock and mineral types with compositions similar to that found in weathered till.

Outwash (stratified drift) occurs as lenses of sand and gravel interbedded with the till. The sorting in outwash varies considerably but most outwash is poorly-sorted with gravel- and sand-sized particles intermixed. The lenses of outwash commonly are convoluted and distorted.

A localized patch of loess, several feet thick and assigned to the Illinoian Stage (Loveland Formation), was exposed in an excavation for highway construction on the bluff at the intersection of Interstate Route 435 and Missouri Highway 210 (SE¼ SW¼ NE¼ sec. 9, T. 50 N., R. 32 W.) about 5 miles east of the line of the cross section (Bayne et al., 1971). The Illinoian loess is

separated from the Kansan till by a poorly-developed paleosol (Yarmouth). In most places, Illinoian loess has been removed by erosion or incorporated into the Sangamon paleosol. The Sangamonian Stage is represented by one of the most extensively developed and widespread of the Pleistocene paleosols. The Sangamon is recognized over large areas in northeastern Kansas and northern Missouri. Development of the Sangamon soil was so intense that in most areas where the intervening Illinoian loess (Loveland) was deposited, soil-forming processes extended all the way through the Illinoian loess and into the underlying Yarmouth paleosol (Bayne et al., 1971). The Sangamon paleosol is typically 1 to 3 feet thick, but the underlying zone of weathering extends to a depth of several feet in places where the paleosol is developed on glacial drift. The weathered zone is oxidized to shades of yellowish-brown to reddish-brown, leached of calcium carbonate minerals, and typically overlies dark- gray "fresh" unweathered till and outwash.

The Sangamon paleosol is overlain by a thick layer of loess assigned to the Wisconsinan Stage. The loess is over 75 feet thick in places along the bluffs and is easily recognized by the homogeneous texture, tan to yellowish-brown color, and the property of standing in vertical face in excavations. Most of the section of Wisconsinan-age loess is assigned to the Peoria Formation.

Along the Missouri River bluffs, in particular the central business district of Kansas City, the loess deposits have been extensively disturbed by industrialization. In the early days of Kansas City it was common practice to "push a hill into a valley" to make space for the construction of buildings and streets.

River Valley-fill Deposits

Variations in the thickness of surficial materials that fill the lower part of the bedrock valley of the Missouri River are controlled by erosional irregularities in the "buried" bedrock surface. Differences in surface elevation across the floodplain are relatively small and have little effect on the thickness of the valley fill materials.

The thickness of surficial materials varies considerably when traced from north to south across the valley. The thickness is controlled almost entirely by the topographic expression of the "buried" bedrock valley. The average thickness is 125 feet along the northern two-thirds of the valley, increasing to 186 feet in a deep, east-west trending trench and decreasing to 85 feet on an elevated surface south of the trench. The elevated surface is 30 feet higher than the bedrock valley north of the deep trench and is interpreted to be a bedrock terrace, an indication of more than one episode of valley erosion.

The major part of the surficial materials is classified as alluvium. These are the sediments that were transported and deposited by the Missouri and Kansas rivers and their ancestral counterparts. The alluvium is subdivided into three categories based on particle size, (in general, the particle size increases with depth): (a) The upper 10 to 35 feet of the alluvium is floodplain deposits of silt, clayey silt and fine-grained sand that settled from the backwaters when the Missouri River overflowed its banks. A soil profile has developed in the upper few feet. The floodplain deposits at Kansas City have been disturbed extensively by industrialization, including the construction of a system of earthen levees 20 feet high along the river. (b) The floodplain deposits are underlain by 75 to over 100 feet of sand with lenses of gravel. The gravel lenses are dispersed throughout the sand section and are rarely traceable for more than a few hundred feet. The maximum thickness of the individual gravel lenses ranges from a few inches to several feet. In places, isolated pebbles of gravel are scattered randomly throughout the sand section. The sand is predominantly quartz but a high percentage consists of fine-grained rock fragments and other minerals. Particles in the gran-

ule- to pebble-size range are mostly locally-derived chert and limestone, but a small percentage is pink quartzite, granite and gneiss that has been transported by continental glaciers from a northern source area, probably from as far north as Minnesota. Well-rounded small fragments of lignite are abundant at several horizons. (c) The lower (approximately) 5 feet of the alluvium contains isolated deposits of boulders with lenses of coarse-grained quartzose sand. The unit is informally called the "boulder" bed in reference to the large boulders and blocks that comprise a significant part of it. The largest boulders appear to be a few feet in greatest dimension and rest on the buried bedrock valley floor. The majority of the large boulders are limestone, but glacial erratics of pink quartzite, granite, and gneiss are common. The "boulder bed" is traceable intermittently in borings across the width of the valley. The association of boulders with lenses of coarse-grained sand indicates the deposit was worked by high-velocity currents. The large size and relationship of the boulders precludes distant transportation by running water and suggests that the boulder bed was derived from the glacial lobe that filled the deep trench with till.

The uppermost 15 to 30 feet of alluvium is classified as Holocene in age and includes the sediments underlying the floodplain, forming low terraces along the river, and in transport in the river channel.

The thick section of alluvium underlying the Holocene deposits is believed to be of Wisconsinan in age (Late Pleistocene) (Heim and Howe, 1963; O'Connor and Fowler, 1963, and Dort et al., 1987).

A Holocene and Wisconsinan vertebrate fauna has been collected from gravel bars along the lower reaches of the Kansas River (Martin et al., 1979; Johnson and Martin, 1987). Wisconsinan-age deposits are currently being eroded in response to an increase in channel depth brought on by deep-dredging operations for sand and gravel, and the construction of dams upstream, which has increased the scouring capacity of the river, resulting in erosion through the Holocene and into the Wisconsinan deposits.

The deepest part of the buried bedrock valley is filled with a heterogeneous mixture of clay- to boulder-size material, consisting of numerous rock and mineral types. The abundance of gray clay in a

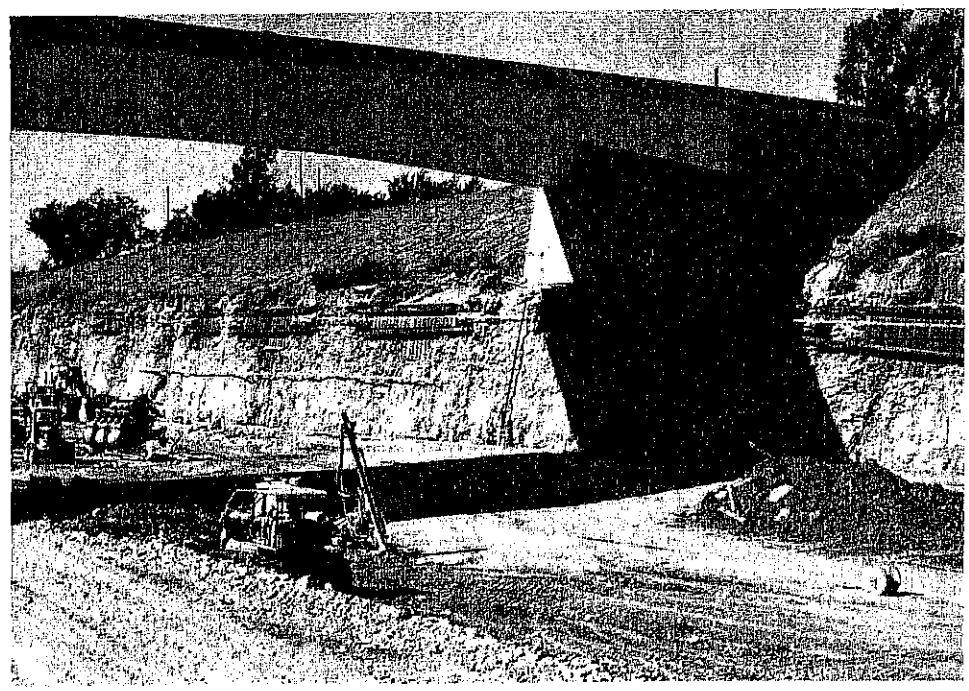

Figure 4.
Solution features in the upper Argentine Limestone Member. Excavation for Interstate Route 670 at the Summit Ave. Bridge, Kansas City, Missouri, 1981. The retaining forms cover the solution cavities and stabilize loose fill materials in them.

heterogeneous mixture of clay- to boulder-size particles suggests this material is a glacial till. The gravel-sized fraction includes glacial erratics of pink quartzite and locally-derived limestone. The glacial till underlies the alluvium and is about 15 feet thick. In comparison to the width of the buried bedrock valley, the portion that is filled with till is relatively narrow. In reality, the till fills the lower part of a deep trench eroded into the bedrock valley floor. Borings C-1, -2, -3 for the TMRT are located to give information about the deep trench. The drill in Boring C-3 penetrated 12 feet of limestone, interpreted to be a large boulder or block.

The bottom of the deep trench is about 90 feet below the surface of the bedrock terrace south of it, and 60 feet lower than the bedrock surface north of the trench. The till-bedrock contact at the bottom of the trench is 555 feet (m.s.l.). The section of till in the excavation for the I-670 Interchange (Figure 2) is about 950 feet (m.s.l.) near the highest elevation in Kansas City. The difference in elevation is almost 400 feet, an indication of the minimum thickness of the ice sheet that filled the Missouri River Valley and advanced southward over the highest hills. This figure is based on the assumption that the till at both places was deposited from the same ice lobe.

A deep comparable trench was encountered in boreholes during construction of the Intercity Viaduct for Interstate Route 70 across the Kansas River, approximately 2 miles upstream and southwest of the TMRT. O'Connor and Fowler (1963) report that the trench is 1,500 feet wide, 150 feet deep and is filled with glacial till. The elevation at the bottom of the deep trench is 515 feet (m.s.l.), a figure that compares somewhat favorably with the 555 foot elevation at the bottom of the deep trench recorded from borehole data during the site investigation for the TMRT. Sections of alluvium underlain by glacial drift with a total thickness of 150 to 200 feet have been recorded from borehole samples at several additional places along the Kansas and Missouri River valleys at Kansas City. These places of relatively thick sections of alluvium and glacial drift appear to be restricted to narrow, deep trenches. Most of the information about them is included in unpublished site investigation reports. Whether the deep trenches are integrated into a single system with a common base level has not been determined due to the lack of subsurface data. The depth, location and the extent of the deep trenches within the lower Kansas and Missouri river valleys are of considerable importance in design of deep structures in the Kansas City area.

There is general agreement that the deep trenches were eroded into the bedrock valley floor by large volumes of meltwater shortly before or during the maximum advance of the Kansan ice sheet (Fishel, 1948; O'Connor and Fowler, 1963; Heim and Howe, 1963b; Simms, 1965; Aber, 1988).

The Kansan (middle Pleistocene) was the most extensive Pleistocene glaciation and the only one to reach the Kansas City area (O'Connor and Fowler, 1963). Consequently, the glacial till filling the deep trench is assigned to the Kansan Stage. Also, it is reasonable to assume that at least part of the "boulder bed" that comprises the lower several feet of alluvium is of Kansan age and represents glacial outwash that was deposited from meltwater issuing from the receding ice lobe after it had advanced into the valley and filled the trench with till.

The Kansan drift has an age range between 0.7 to 0.6 million years B.P. (before present) based on radiometric dating of volcanic ash, biostratigraphy and paleomagnetism of till (Aber, 1991).

Revision of the standard classification system of Pleistocene units for the midcontinent U.S. has been proposed by Richmond and Fullerton (1986); Morrison (1991); and Aber (1991). Early and medial Pleistocene units have been assigned to the informal time division Pre-Illinoian and the

name Kansan is abandoned. The chronostratigraphic equivalence of the glacial deposits at Kansas City, Missouri with sections in other areas of the midcontinent has not been determined. Until the matter is resolved, the Kansan, a well-established name, is retained in this paper for glacial deposits along the Missouri River bluffs and in the deep bedrock trench at Kansas City. The classification system of Bayne et al. (1971) is followed in this report.

DESCRIPTION OF BEDROCK UNITS

The bedrock addressed in this study comprises a sequence of strata over 550 feet thick that is divided into 75 formally-named stratigraphic units that consist of four lithostratigraphic groups (in descending order): the Kansas City and Pleasanton Groups, Missourian Series, and the Marmaton and Cherokee Groups, Desmoinesian Series, Pennsylvanian System. The stratigraphic classification of the Pennsylvanian System is undergoing revision by midcontinent geologists. The classification currently in use by the Missouri Department of Natural Resources, Division of Geology and Land Survey (Thompson, et al., 1993) is retained in this report until an agreement is reached among midcontinent state geological surveys.

A composite stratigraphic section of the Pennsylvanian-age bedrock units along the line of the cross section is included in Appendix 1. Included in the section are some of the proposed revisions in classifications.

The long cores (B-1, -2, -3, -4, -5) from the site investigation for the Trans-Missouri River Tunnel project provided the necessary data to make a detailed stratigraphic analysis of the subsurface bedrock units. Prior to the current investigation, there was insufficient detailed stratigraphic information concerning the approximately 300 feet of bedrock that comprise the Lower Pleasanton, Marmaton, and Upper Cherokee Groups in the vicinity of Kansas City. This rock sequence makes up the bedrock section that lies below the elevation of the major river valleys and is accessible only by subsurface methods of investigation.

Kansas City Group

The average thickness of the Kansas City Group is approximately 260 feet in the Kansas City area (Greene and Howe, 1952). The upper 50-75 feet has been removed by erosion along the line of the cross section. The middle part is exposed along the Missouri River bluffs and is approximately 150 feet thick; the lower 40 feet lies below the elevation of the floodplain of the Missouri River.

The Kansas City Group consists mostly of limestone and shale beds that alternate throughout the section. The Bethany Falls Limestone Member crops out on the south bank of the Missouri River and is the oldest exposed bedrock unit.

The Argentine Limestone Member is found near the tops of the hills and is deeply weathered, especially at places where the Island Creek Shale Member is relatively thin. Solution along joints has widened some of them to more than 2 feet and a pinnacled surface has developed on the Argentine at places where solution has been excessive. Cavities and solution-widened joints are filled with reddish-brown plastic clay. At a few places, glacial erratics of resistant rock and mineral types are embedded in the clay.

Pleasanton Group

The Pleasanton Group is about 110 feet thick and consists predominantly of gray shale with beds of sandstone near the top, middle, and bottom of the group.

The Exline Member, a thin, persistent bed of limestone, is a diagnostic marker bed in the lower part of the Pleasanton throughout northwestern and west-central Missouri.

The complete thickness of the Pleasanton Group was encountered in test boring B-5 and the lower part of the group in test borings B-1, -2, -3, and -4 for the TMRT.