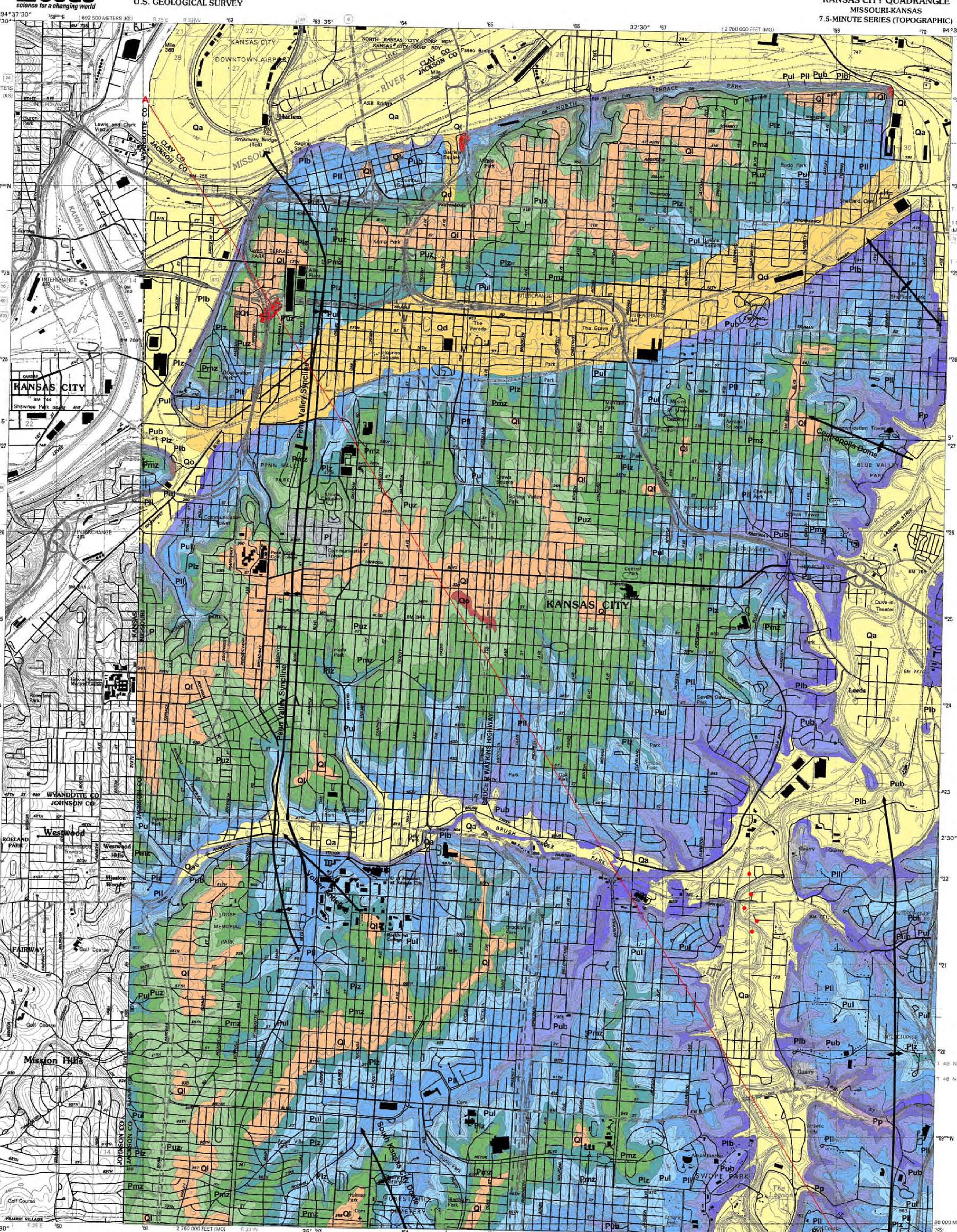
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

KANSAS CITY QUADRANGLE
MISSOURI-KANSAS
7.5-MINUTE SERIES (TOPOGRAPHIC)



Produced by the United States Geological Survey

Topography compiled 1934. Planimetry derived from imagery taken 1996 and other sources. Public Land Survey System and survey control current as of 1935. Boundaries current as of 2001

North American Datum of 1983 (NAD 83). Projection and 1 000-meter grid: Universal Transverse Mercator, zone 15. 10 000-foot ticks: Missouri Coordinate System of 1983 (west zone). 2500-meter ticks: Kansas Coordinate System of 1983 (north zone)

North American Datum of 1927 (NAD 27) is shown by dashed corner ticks. The values of the shift between NAD 83 and NAD 27 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software

Houses of worship, schools, and other labeled buildings verified 1955

UTM GRID AND 2001 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048

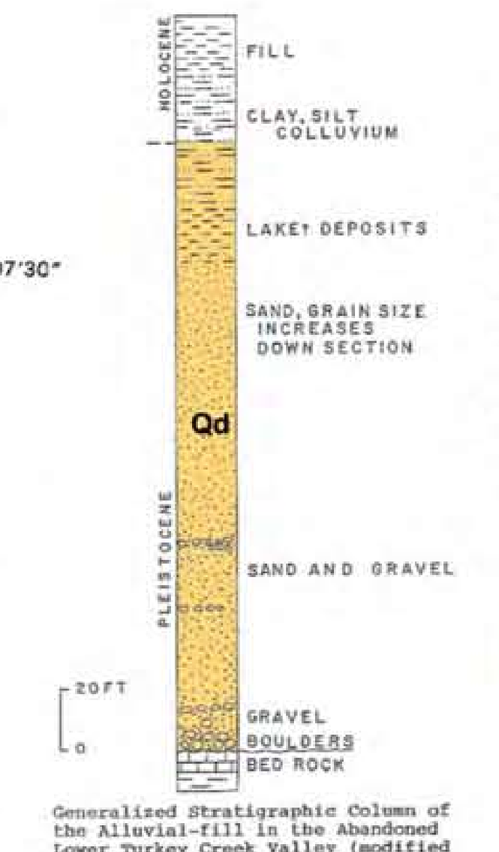
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, P.O. BOX 25286, DENVER, COLORADO 80225
DIVISION OF GEOLOGY AND LAND SURVEY
MISSOURI DEPARTMENT OF NATURAL RESOURCES, ROLLA, MISSOURI 65401
AND KANSAS GEOLOGICAL SURVEY, LAWRENCE, KANSAS 66044
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ADJOINING 7.5' QUADRANGLES: 1 Parkville, 2 North Kansas City, 3 Liberty, 4 Shawnee, 5 Independence, 6 Lenexa, 7 Grandview, 8 Lees Summit

ROAD CLASSIFICATION
Primary highway hard surface; Light-duty road, hard or improved surface; Secondary highway hard surface; Unimproved road; Interstate Route; U.S. Route; State Route

KANSAS CITY, MO-KS
1996
NIMA 7062 II SE-SERIES V879

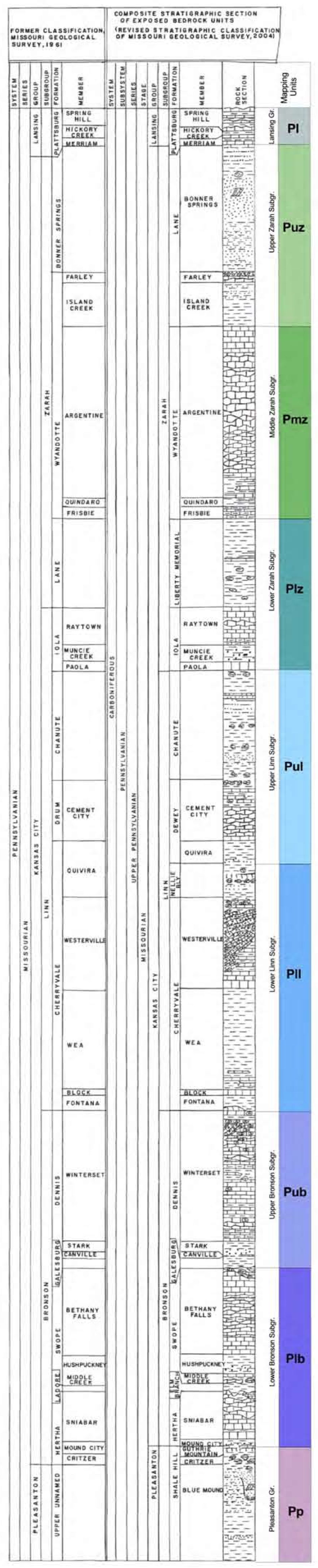


Generalized Stratigraphic Column of the Alluvial-fill in the Abandoned Lower Turkey Creek Valley (modified after Moore, 1994)

Qa Unconsolidated alluvial deposits of clay, silt and sand with sandy gravel lenses near the bottom underlie flood plains of larger streams. This alluvium belongs to the Late Pleistocene/Holocene Series, Quaternary System. About 15% of map area is alluvium. Thickness of alluvium under floodplains of major streams is as follows: Missouri River 150 ft; Kansas River at West Bottoms 75 ft; Blue River and the lower reaches of Brush Creek 50 ft. About 30 ft of unconsolidated material underlies the floodplain of Brush Creek near Troost Street and Volker Avenue, but it is difficult to distinguish between alluvium, colluvium, and fill in test boreholes.

Qd Diversion channel and ice margin channel filled alluvium

STRATIGRAPHIC SECTION



DESCRIPTION OF LOESS AND TILL (DIAMICTON)

Ql

PLEISTOCENE SERIES
WISCONSINAN GLACIATION
BIGNELL-PEORIA LOESSES (undifferentiated)
Silt, yellowish-brown 10 YR 5/4 to dark yellowish-brown 10 YR 4/4, homogenous, non-calcareous; stands in vertical face in excavation. 0-65 ft

SANGAMONIAN INTERGLACIAL
Paleosol (Sangamon)
Clay, yellowish-brown 10 YR 5/4; carbonized roots to 0.5 inch in diameter and several inches long; thickness increases to 5 ft in places where Loveland Loess is absent or is indistinguishable and the Sangamon-Yarmouth Paleosols merge and change color to dark reddish-brown with a stone line near top. 5 ft

ILLINOIAN GLACIATION
LOVELAND LOESS
Silt, moderate brown 5 YR 4/4, clayey, homogenous, columnar jointing. 12 ft

YARMOUTHIAN INTERGLACIAL
Paleosol (Yarmouth)
Clay, yellowish-brown, silty; sparse quartz sand grains. 2 ft

Qt

PRE-ILLINOIAN STAGE
INDEPENDENCE? FORMATION
Diamicton, clay, silt, sand; pebbles and cobbles of quartzite; quartz pebbles with glacial striations, polish and beveled edges; weathered granite; fragments of locally derived shale; leached of calcium carbonate and oxidized to moderate yellowish-brown 10 YR 5/4; patches of medium-gray, non-calcareous diamicton near bottom; interbedded diamicton and lenses of cross-bedded sandstone. Thickness increases to 35 ft in solution cavities in Argentine Limestone Member. 0-35 ft

DESCRIPTION OF BEDROCK UNITS

Pl

LANSING GROUP
PLATTSBURG FORMATION: About 8 ft underlies loess cover at 30th and Main Street at 1000 ft M.S.L elevation, the highest in map area.
SPRING HILL LIMESTONE MEMBER: 4 - 6 ft of weathered brown limestone in wavy 3- to 6-inch-thick beds separated by thin shale. Contains brachiopods Chonetina flemingi, Crurithyris planoconvexa, productids; crinoid columnals and cryptosome and fenestrate bryozoans. Lower 1.5 to 2.0 feet is blocky jointed bed containing Chonetina flemingi and small crinoid columnals. Upper part of member has been eroded and is overlain by loess.
HICKORY CREEK SHALE MEMBER: About 0.5 ft of dark-gray to black noncalcareous shale with small brachiopods.
MERRIAM LIMESTONE MEMBER: 2.5 to 3.0 ft of dark bluish-gray limestone in two beds of equal thickness separated by a 0.2 ft bed of greenish gray shale with the bryozoan Rhombopora. Limestones are composed almost entirely of algae encrusted, sand-sized fossil fragments (Osagia) and are classified as grainstones. Contains fusulinids.

KANSAS CITY GROUP

Puz

UPPER ZARAH SUBGROUP
LANE FORMATION
BONNER SPRINGS SHALE MEMBER: 30 to 40 ft of shale, silty shale and sandstone. 8-feet-thick-bed of fine-grained, cross-bedded, micaceous sandstone with sandstone concretions up to 1 ft diameter is near top. Upper 5 to 6 feet is silty shale with 0.5-feet-thick shale at top with abundant pelecypods Myalina and Aviculopecten. Lower half of member is interbedded micaceous sandstone and shale with fragments of carbonized plants.
FARLEY LIMESTONE MEMBER: 3 ft of wavy thin-bedded limestone at bottom. Upper half is a cross-bedded grainstone composed of ooids, pellets and algae-covered fossil fragments Osagia.
ISLAND CREEK SHALE MEMBER: About 10 ft of medium-gray shale. Upper half is interbedded with thin beds of sandstone (ripple marked) and siltstone.

Pmz

MIDDLE ZARAH SUBGROUP
WYANDOTTE FORMATION
ARGENTINE LIMESTONE MEMBER: Over 40 ft thick along Missouri River Bluff and in downtown Kansas City. Well exposed for over 2 miles along Cliff Drive at North Terrace Park. Upper half is thick light-gray wavy bedded with abundant phylloid algae. Limestone has a brecciated texture with small dissolution cavities and vugs filled with brownish-red clay. Rugose corals and brachiopods. Underlying upper thick beds is 15 to 20 ft of thin wavy to nodular beds of clayey limestone with phylloid algae. Lower 5 to 10 ft of member consists of thin to thick beds of limestone intercalated with gray shale forming a reentrant. Large springs flow from base of member, including one along Cliff Drive, and several large springs at Westport. The latter were favorite watering stops for covered wagon trains going west, but these springs have been piped under. The Argentine thins to about 10 to 20 feet in southwestern part of map area. It is poorly exposed along the bluff at Brush Creek just south of Country Club Plaza.
QUINDARO SHALE MEMBER: 0.5 to 1.5 ft of gray shale with thin lenses and nodular beds of tan limestone. Small crinoid columnals and bryozoans are common.
FRISBIE LIMESTONE MEMBER: 0.5 to 3.0 ft of dark-gray, thin-bedded shaly limestone that weathers to tan rubble that covers slope. Fossils include abundant small crinoid columnals, some fenestrellid bryozoans and Ammovertellid encrusting foraminifera.

Plz

LOWER ZARAH SUBGROUP
LIBERTY MEMORIAL FORMATION: Dark-gray to dark bluish-gray shale that is 20 to 25 ft thick in downtown Kansas City. Thin interval 8 to 10 ft from top of member yields abundant crinoids, pelecypods, gastropods, bryozoans and productid brachiopods. Slabs of shale with almost complete specimens of crinoids Ethelocrinus, Aesiocrinus, Graphiocrinus and Delocrinus were collected in the excavation for Emery, Bird and Thayer Building at 11th and Grand Avenue in 1889 and are in museum collections throughout the United States and Europe. The formation thins to 5 to 10 feet in east-central and southwestern parts of map area. Clay ironstone (siderite) concretions to 0.5 ft diameter occur in lower part of the formation. The concretions are typically, flattened, dark-gray and weather to reddish brown fragments.

IOLA FORMATION
RAYTOWN LIMESTONE MEMBER: 6 to 10 ft of even, thick beds at top and bottom with wavy beds 0.2 to 0.5 ft thick in middle. Phylloid algae Archeolithophyllum missouriensis occurs abundantly throughout unit and large spiny brachiopods Echinaria, Antiquatonia and Linoproductus are common in upper 2 feet. Bottom 0.4 to 1.0 ft of member is single persistent bed of shaly bioclastic limestone containing abundant small crinoid ossicles. It is a diagnostic marker bed throughout the Kansas City area. Marker bed is overlain by 0.4 to 1.0 feet of greenish gray shale with fenestrate bryozoans and the brachiopod Hustedia.
MUNCIE CREEK SHALE MEMBER: 4 ft thick in extreme northwestern part of map area. Thins southward to 0.1 ft at the University of Missouri-Kansas City Campus and retains this thickness beyond southern limit of map area. Where unit attains maximum thickness, it is composed of soft gray shale with a bed of black fissile shale near the middle. The fissile shale is metalliferous and contains nodules and lenses of calcium phosphate. The nodules are spheroidal to ellipsoidal, 1.0 to 1.5 inches in diameter, have rough dark-gray exteriors, weather whitish-gray, and typically have fossil fragments as nuclei. The black fissile shale pinches out southward, but calcium phosphate nodules are common in the 0.1-ft-thick soft gray shale layers in the southern part of map area. These same nodules are partially embedded in the top of underlying Paola Limestone at places where the Muncie Creek is 1 inch thick or less.
PAOLA LIMESTONE MEMBER: 0.9 to 1.5 ft of hard dark bluish-gray thick-bedded limestone. Vertical joint sets strike NW and NE and intersect at almost at right angles to form blocks having dimensions of 1 to 2 feet on a side. A 0.1- to 0.3- ft-thick limestone bed with abundant crinoid ossicles is at the bottom.

Pul

UPPER LINN SUBGROUP
CHANUTE FORMATION: Usually 6 to 25 ft thick and dominantly gray shale over most of map area. Thickness ranges from 18 to 25 ft but thins abruptly to about 6 ft in extreme northwestern part of map area. A 2-ft-thick sandstone comprising individual beds about 0.1 ft thick occurs 5 to 6 ft below the top. It is overlain by a thin zone of the brachiopod Derbyia. The sandstone beds are tightly cemented with calcium carbonate and form a low ridge. Trace fossils are a common on the surfaces of sandstone ripples. A few feet of purplish-red or green claystone near the middle with irregular-shaped limestone nodules is a diagnostic marker bed. Where present it aids in identifying Chanute. The lower several feet has interbedded shale and thin beds of sandstone with pieces of carbonized wood and a thin zone of Derbyia at the top. The bottom several inches is nodules of limestone in a gray shale matrix.

DEWEY FORMATION
CEMENT CITY LIMESTONE MEMBER: Thickness ranges from 8 to 14 ft, increasing northward by addition of several feet of thin-bedded light-gray limestone intercalated with gray shale. Fossils are abundant and include the brachiopods Composita, Derbyia crassa, Meekella, the bryozoan Fenestrellina and crinoid columnals. Locally the limestone is bioclastic. Lower 6 to 9 ft of member is persistent throughout map area and comprises thin wavy beds that weather brown. The large rugose "horn" coral Caninia torquia is an aid to identifying the unit.
QUIVIRA SHALE MEMBER: 4 to 6 ft total thickness. Lower 1 to 2 feet is black fissile shale with phosphatic nodules and a thin fossil zone at the top. Overlying 3 to 4 feet is soft medium-gray shale with 0.5-ft-thick soft black shale layer about 1 foot from the top.

Pll

LOWER LINN SUBGROUP
NELLIE BLY FORMATION: 4 to 10 ft of gray shale with a thin discontinuous coal bed or plant fossil zone underlain by nodules of limestone in gray clay matrix. Sparse sandstone laminae are in the lower part. Formation thins or is absent in southeastern and northwestern parts of map area where underlying Westerville Limestone Member increases to over 15 ft in thickness.

CHERRYVALE FORMATION
WESTERVILLE LIMESTONE MEMBER: Thickness is more variable than that of any other unit in map area. Lower 3.5 to 6 ft is thick even beds of limestone overlain by a few feet of interbedded limestone and shale in central part of map area. In southeastern part of map area and along the Missouri River Bluffs the member increases in thickness to 18 to 20 ft by addition of light-gray, cross-bedded oolitic limestone (grainstone). The oolitic limestone contains an abundant and diverse invertebrate fauna representing several phyla.
WEA SHALE MEMBER: 20 to 25 ft of gray shale. Lower 2 to 5 ft is interbedded with dark-gray thin clayey beds of limestone with an abundance of the brachiopod Crurithyris planoconvexa and encrusting foraminifera (ammovertellids).
BLOCK LIMESTONE MEMBER: Single bed of limestone 1.0 to 1.5 ft thick that is broken into blocks by sets of vertical joints striking NW and NE. Chonetid brachiopods are the most common fossils.
FONTANA SHALE MEMBER: 1 to 4 ft of medium-gray shale with 0.05-ft-thick coal bed or well-preserved plant fossil zone at the bottom that rests on underlying Winterset limestone in northern part of map area. A thin persistent zone of the brachiopod Chonetina flemingi is in the upper part and overlain locally by a zone of algae-encrusted fauna of bryozoans, crinoid columnals, orthoconic nautiloids, high-spired gastropods, pelecypods, productid and chonetid brachiopods.

Pub

UPPER BRONSON SUBGROUP
DENNIS FORMATION
WINTERSET LIMESTONE MEMBER: 30 to 35 ft thick and subdivided into lower and upper units separated by 1 to 2 ft of gray shale with lenses and nodular beds of limestone. Lower unit is 15 to 20 ft thick and comprises thin to thick beds of limestone with shale partings and sparse light-gray chert nodules and lenses. Lower 2 to 4 ft is interbedded with 2 or 3 dark-gray shale beds 0.2 to 0.5 ft thick. In southeastern part of map area several feet from bottom is a zone of the spiny brachiopods Kozlowskia and Echinaria. Other fossils include the brachiopod Composita, the gastropod Trepospira, the pelecypod Aviculopecten and fenestrellid bryozoans. Upper unit comprises 12 to 16 ft of medium-bedded limestone becoming thin-bedded and intercalated at the top with shale that weathers into tan shaly limestone fragments. The trilobite Ameura major is common locally. Dark bluish gray chert nodules and lenses are abundant in the upper unit. Silicified snails and carbonized plants (predominately fern fronds) and Cordaites leaves are common in the upper few inches of interbedded dark siliceous limestone and gray shale. 1 to 3 feet of cross-bedded grainstone or in some places bedded limestone with dark bluish-gray chert nodules fills a channel eroded into the upper part of the member along Brush Creek. A well-developed scour surface is at the bottom. Along Brush Creek, the deposit in the upper part is interpreted to have filled a tidal channel.
STARK SHALE MEMBER: 3 to 4 ft thick with lower half being black fissile shale with calcium phosphate nodules. Conodonts are common on shale bedding planes. Black fissile shale grades upward into soft light-gray shale at top. Black shales are metalliferous, containing up to 2000 ppm zinc and 50-100 ppm uranium.
CANVILLE LIMESTONE MEMBER: 0.01 ft of dark-gray shaly limestone. Member unit grades laterally into dark-gray shale but is identified by the presence of the small mud-dwelling brachiopod Crurithyris.

GALESBURG FORMATION: 3 to 4 ft of medium-gray shale with sparse small, irregular-shaped limestone nodules in lower part.

Plb

LOWER BRONSON SUBGROUP
SWOPE FORMATION
BETHANY FALLS MEMBER: 18 to 21 ft of light-gray limestone that averages about 20 ft thick in most of map area. It is divided into four units in ascending order a) thick even beds of limestone with combined thickness of 2 to 4 ft; b) 7 to 10 feet of light-gray thin wavy beds of limestone with slightly darker gray mottles and having persistent 1- to 2-in-thick gray shale bed near the middle; c) thick limestone beds with combined thickness of 2 to 4 ft; d) 0.5- to 3.0-ft-thick unit of light-gray irregular-shaped limestone nodules in a gray claystone matrix with scour surface at the bottom. Nodular limestone weathers to rubble that resembles wet concrete. A characteristic feature of Bethany Falls is its tendency to weather gray, whereas other thick limestones in the stratigraphic section tend to weather various shades of brown.
HUSHPUCKNEY SHALE MEMBER: 3 to 4 ft thick with lower 1 to 1.5 ft being dark-gray to black fissile shale containing spheroidal to ellipsoidal phosphate nodules up to 0.1 ft diameter. The metalliferous, black fissile shale grades upward through dark-gray to light-gray shale at top.
MIDDLE CREEK LIMESTONE MEMBER: Two thin limestone beds separated by shale, and total thickness about 2.5 ft. Upper limestone is even bed 1 to 1.5 ft thick that is fractured into rhomboidal blocks several feet wide by set of closely spaced vertical joints. The bed is hard, dark bluish-gray and fine-crystalline limestone. Middle unit is gray shale about 0.5 ft thick with abundant bryozoans of genus Rhombopora. Lower unit is light-gray, nodular- to irregular-bedded limestone about 0.5 ft thick.

ELM BRANCH FORMATION: 0.3 to 2.0 ft of medium-gray shale. 0.05-feet-thick coal bed is at bottom in southeastern part of map area.

HERTHA FORMATION
SNIABAR LIMESTONE MEMBER: Thickness ranges from 10 to 14 feet. Lower unit of thick-bedded, fine-crystalline limestone with combined thickness of 4 to 6 ft. It is separated by 1 to 3 soft gray shale beds 0.1 ft thick. Unit weathers to characteristic chocolate-brown color. Upper unit is nodular beds of limestone or nodules of limestone in gray clay matrix. Thickness of upper unit ranges from a few feet to 8 ft and is underlain by a scour surface. Increased thickness of the upper nodular unit affected deposition of overlying units. Elm Branch shale thins to a few inches and the lower limestone unit of Middle Creek is absent along Brush Creek at Cleveland Avenue where Sniabar is 14 ft thick.
THE MOUND CITY SHALE MEMBER: 0.6 to 1.5 ft thick. Lower several inches is dark-gray to black shale with calcium phosphate nodules. It grades upward through medium-gray to light-gray shale at top.

Pp

PLEASANTON GROUP
SHALE HILL FORMATION: Over 100 ft total thickness, but only upper part is exposed in southeastern part of map area along Blue River.
GUTHRIE MOUNTAIN SHALE MEMBER: 0.5 to 2.0 ft thick. Coal bed (Ovid) is 0.1 ft thick and is overlain by 0.1-ft-thick shaly limestone bed that forms the uppermost unit of the member. Coal bed is underlain by underclay and claystone ranging in thickness from 0.5 to almost 2 feet.
CRITZER LIMESTONE MEMBER: 0.5 to 2 ft of light-gray irregular shaped limestone nodules in olive-gray claystone matrix. Limestone nodules weather brown and cover slope.
BLUE MOUND SHALE MEMBER: 10 to 20 ft of gray shale interlaminated with light-gray, fine-grained sandstone ripples. Amount of sandstone decreases down section, and lower several feet is gray shale. Dark-gray clay ironstone (siderite) concretions occur in upper part of unit. Channel-fill of fine-grained cross-bedded sandstone 5 to 20 ft thick has replaced upper part of unit locally.

Qo Glacial outwash

LEGEND

Stratigraphic contact - solid line where location is probable

Anticline - dipping strata of anticline - solid line where location is probable; linear axis is crest of anticline with arrows pointing in down-dip directions of dipping strata; difference in length of arrow shafts (the long shaft the more shallow limb) denotes asymmetry; arrowhead on linear axis denotes plunge

Syncline - dipping strata of syncline - solid line where location is probable; linear axis is trough of syncline with arrows pointing in down-dip directions of dipping strata; difference in length of arrow shafts (the long shaft the more shallow limb) denotes asymmetry; arrowhead on linear axis denotes plunge

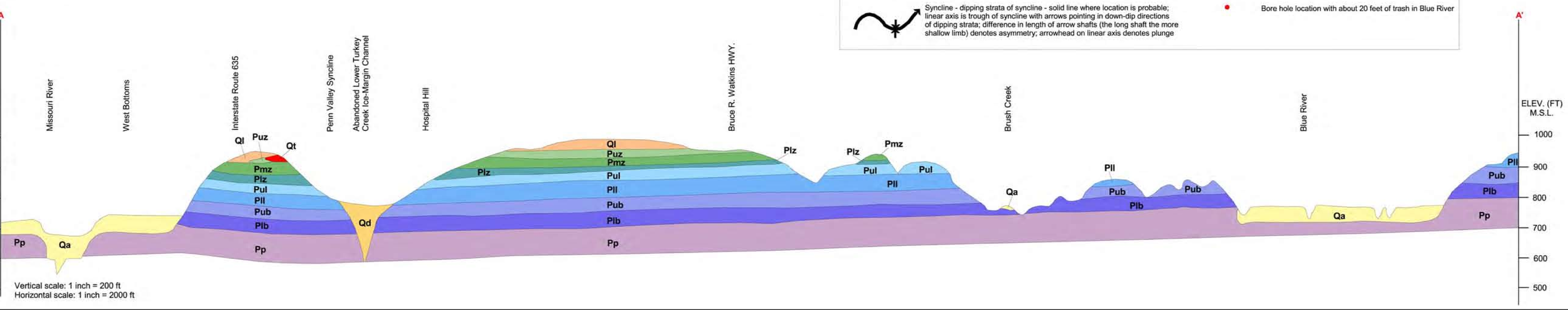
A —— A' Cross section - line locates the placement of the cross section with end line symbols

Strike of strata with low angle dip

Abandoned limestone quarry

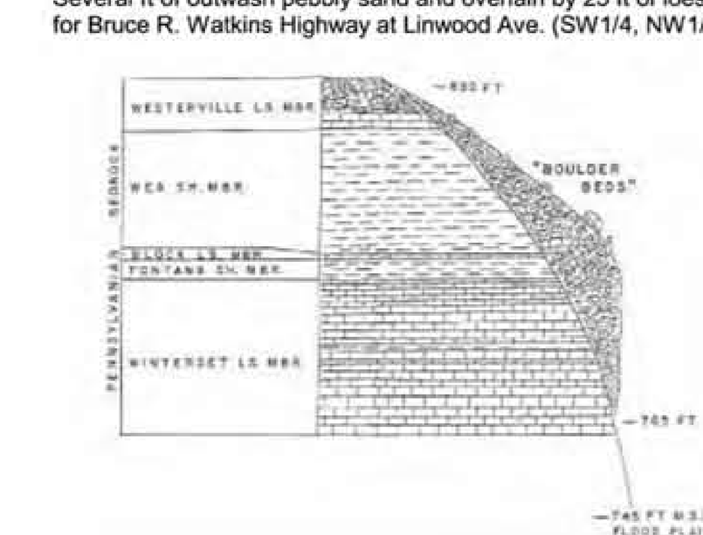
Bore hole location with about 20 feet of trash in Blue River

CROSS SECTION



AGE AND RELATIONSHIP OF THE "BOULDER" BEDS TO PENNSYLVANIAN BEDROCK UNITS

PLEISTOCENE SERIES
PRE-ILLINOIAN
"BOULDER" BEDS
Unconsolidated deposit consisting of over 99% locally derived limestone with size range from pebbles to boulders, some over 4 feet diameter; sub-rounded to well-rounded; sparse angular clasts in larger size fraction; 0.1% of glacier erratics mostly granite gneiss, some granite and sandstone; matrix of clayey quartz sandstone. Interpreted to be the deposit of a short, high velocity ice-margin stream.
EAST SIDE OF HILL CAMBRIDGE BUSINESS PARK, S1/4, SE1/4, SW1/4, SW1/4, Sec 07, T49N, R35W. Several ft of outwash pebbly sand and overlain by 25 ft of loess was exposed in 1997 in an excavation for Bruce R. Watkins Highway at Linwood Ave. (SW1/4, NW1/4, SE1/4, Sec 16, T49N, R33W).



GEOLOGIC MAP OF THE MISSOURI PART OF THE KANSAS CITY MO-KS 7.5' QUADRANGLE, JACKSON COUNTY, MISSOURI

Geology by
Richard J. Gentile, Principal Investigator
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Department of Geosciences, University of Missouri-Kansas City
GIS Digital Compilation by
Karen L. Loveland

June, 2004

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MISSOURI DEPARTMENT OF NATURAL RESOURCES
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PRODUCED IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY, NATIONAL COOPERATIVE GEOLOGICAL MAPPING PROGRAM - EDMAP

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INTRODUCTION

The Missouri portion of the Kansas City, MO-KS 7.5 minute quadrangle covers 52 square miles and is completely urbanized with a population of 210,000 (2000 census). Included within the quadrangle are the Kansas City Business District, Municipal Airport, industrial complexes, a network of interstate highways and railroad lines and yards, hospitals, two University of Missouri campuses and residential areas.

All bedrock in the quadrangle is of sedimentary origin and is overlain by loess, mostly on the hilltops, and small areas of glacial drift.

This is the first map that depicts the configuration and the extent of an ice margin diversion channel 6.5 miles long, 0.5 miles wide and filled with alluvium to a depth of over 200 ft. The lower part of the section of alluvium in the ice-margin diversion channel is pre-Illinoian in age, whereas the upper part probably encompasses the time interval from pre-Illinoian to Holocene.

Bedrock units form the surface rocks over most of the quadrangle. They have a maximum thickness of 310 ft and occur in cyclical sequences called cyclothems that comprise relatively thin beds of limestone, shale and sandstone with minor amounts of coal, conglomerate and underclay. The exposed bedrock units belong to the upper Pleasanton, Kansas City and lower Lansing groups, Missourian Stage, Pennsylvanian Subsystem, Carboniferous System.

Glacial drift consists of till (diamicton) and outwash that belongs to the pre-Illinoian Stage, Pleistocene Series, Quaternary System.

Loess is classified as belonging to the Wisconsinan Stage, Pleistocene Series and is underlain by localized loess deposits belonging to the Illinoian Stage, Pleistocene Series.

Stream alluvium belonging to the Late Pleistocene/Holocene Series, Quaternary System underlies the flood plains of the Kansas, Missouri and Blue rivers, and Brush Creek. About 15% of the quadrangle is alluvium-filled stream valleys.

Pennsylvanian bedrock units are grouped into nine map units: Pleasanton, lower Bronson, upper Bronson, lower Linn, upper Linn, lower Zarah, middle Zarah, upper Zarah, and Lansing. Glacial drift, alluvium-filled ice margin diversion channel, loess and stream alluvium are shown individually on the map.

BRIEF HISTORY OF MINERAL COMMODITY EXPLOITATION

Limestone, oil and gas, clay and shale, sand, gravel, coal, water and soil are nonmetallic mineral commodities that were exploited commercially in the early days of Kansas City (McCourt et. al, 1917). There has been no production in recent years. The major mineral commodity was quarried limestone. All limestone members over about 5 ft thick in the Kansas City Group were utilized for a number of purposes. Almost every city block that was underlain by one or more limestone beds had an operating quarry. The most visible evidences today of the extent of early quarrying operations are the stone walls and houses. Cement City Limestone (known as the "Building Ledge") was quarried most extensively in Kansas City. The Cement City supplied building stone and rubble for the rustic masonry of bungalow-type house construction so common around the turn of the nineteenth century (Parizek and Gentile, 1965). Scofield Hall on the University of Missouri-Kansas City Volker Campus is constructed of Cement City Limestone from a quarry on the north side of Flarsheim hall that is now a parking lot. Westerville Limestone was quarried at three locations along the Missouri River Bluff now part of North Terrace Park. Quarries in the southeastern part of the quadrangle also produced from the Westerville Limestone. Several buildings on the University of Missouri-Kansas City Campus are constructed of the upper cross-bedded oolitic facies of the Westerville, known as "Kansas City oolite." The Bethany Falls Limestone was quarried and mined by horizontal tunnel into hillsides along 63rd Street in the southeastern part of the quadrangle. The quarries are abandoned or they serve other useful purposes. However, the space left after mining Bethany Falls Limestone has been converted to secondary uses at Winchester Business Park. Bethany Falls was once mined by vertical shaft at the Downtown Industrial Park at 31st and Mercier Street. The 45-acre underground space left after mining has been converted to secondary usage, mostly for storage. The interior wall of the vestibule at the Nelson-Atkins Museum of Art is constructed out of polished Raytown and Argentine limestones. Wells in the quadrangle produced small quantities of natural gas for private use. The first wells were drilled in the late 19th century with most activity dating from the late 1920s until World War II. There has been no production for many years. All of the anticlines and domes described in the Structural Geology Section have yielded small quantities of natural gas for residential use from wells 300 to 400 ft deep. Several wells produced small quantities of gas on the 40-acre University of Missouri-Kansas City Volker Campus. Eight of the wells were located along 52nd Street from Holmes Street to Troost Avenue (Gentile, 1979). The first wells were drilled for W.S. Dickey, from 1912 to 1919. Dickey built Scofield Hall as a one family residence, now used for administrative purposes on the University of Missouri-Kansas City Volker Campus.

STRUCTURAL GEOLOGY

Regional dip of bedrock is northwesterly at about 10 ft/mi, but it is not uniform throughout the area, as there are several gently folded structures named by Clair (1943)*. These are subtle structures with closures rarely exceeding 30 ft. The largest structure is the Penn Valley syncline, a broad, shallow, northwesterly-plunging syncline that trends northward from Brush Creek and plunges under the alluvium of the Missouri River Valley. The northwesterly plunge of the Penn Valley syncline increases to about 20 ft/mi at the Central Business District of Kansas City, Missouri. A small anticline with dip to 50 ft/mi plunges northwesterly from the University of Missouri-Kansas City Volker Campus and intersects the Penn Valley syncline at Country Club Plaza (NW¼ Sec 32 and S1/2 of Sec 29, T49N, R33W). This small anticline is hereby named the Volker anticline. The crest of this small anticline is near the center of the campus and is modified to form a small dome with about 10 ft of closure. A northerly-plunging anticline is located in the southeastern part of the quadrangle (Sec 01, T48N, R33W and Sections 25 and 36, T49N, R33W) and is interpreted to be the northern extension of the Municipal Farm dome. The northern extension of the dome was not recognized by Clair (1943) because he lacked subsurface control. The Centropolis dome extends into the quadrangle in the vicinity of Blue Valley Park (Sec 12, T49N, R33W). The eastern part of a small domal structure extends into the western edge of the quadrangle from Kansas at Observation Park (Sec 07, T49N, R33W). The northern extension of the South Kansas City dome extends into the southern part of the quadrangle at Forest Hills Cemetery (N½ Sections 08 and 09, T48N, R33W). The major joint sets are oriented northwest-southeast and northeast-southwest, strike almost perpendicular to one another and are essentially vertical.

* The structural maps prepared by Clair (1943) were drawn on a datum at a depth of 300 to 400 ft. Geologists at an early date recognized that the amount of closure decreases upsection and structures with a pronounced amount of closure at depth become gentle folds at the surface.

ENGINEERING GEOLOGY CONSIDERATIONS

There are few construction problems associated with the integrity of bedrock in the quadrangle. Large structures have stable footings on the numerous limestone beds underlying the area. Minor amounts of creep of soil and loess cover on steep slopes has resulted in the displacement of rock walls. Some potential construction problems to be avoided are described below.

The alluvium-filled Lower Turkey Creek Valley is an obstruction to the location of tunneling projects especially for pipelines and tunnels. Various municipal planning organizations over the years have proposed constructing a subway system through the Bethany Falls Limestone. It will connect the Central Business District with areas to the south. The alluvium-filled Lower Turkey Creek channel will pose a major obstruction to this project.

Argentine Limestone lies near the surface and is over 30 ft thick in the northern half of the quadrangle. The brecciated and porous texture of the Argentine makes it susceptible to dissolution and a pinnacled upper surface lies beneath the cover of glacial materials. The excavation for the I-670 extension at 14th and Summit Street encountered large solution cavities filled with loess and glacial till that extended through the thickness of Argentine Limestone (Gentile, 1995). Large volume springs flow from beneath the Argentine Limestone, particularly in the Westport area. Most of the springs have been piped under, but construction projects along the outcrop band of the Argentine should be aware of seepage problems. Water seepage on the parking lot of a large hotel was difficult to contain.

The upper several ft of Winterset Limestone contains in places up to 50% chert nodules and lenses that can cause extreme wear on construction equipment. Special rock cutting tools were used along Brush Creek, east of the Country Club Plaza, during excavation of Winterset Limestone in a channel modification project. High urbanization in the area prevented use of explosives. A thick covering of fill materials and trash obscure bedrock in places along the Missouri River Bluff, Blue River and Brush Creek. Test borings in the alluvium-filled valley at the confluence of Brush Creek and Blue River encountered 20 to 40 ft of bricks, bottles, etc.

The cover of loess along the Missouri River Bluff at Kansas City was at one time over 65 ft thick. Most of the loess cover has been removed in the Central Business District and used to fill 3 deep ravines that drain northward into the Missouri River. Due to the ease of excavation of loess, it was customary in the early days of Kansas City to "push a hill into a valley" to form a flat, stable foundation for large structures and to reduce the gradient of roads.

PLEISTOCENE LOESS DEPOSITS

Most upland areas are covered by loess. Thickness is over 65 ft along the Missouri and Kansas river bluffs. However, most of the loess cover has been removed in construction projects, especially in the Central Business District. Thickness decreases southward from the Missouri and Kansas river bluffs and is 10 to 15 ft thick near the center of the quadrangle at the University of Missouri Volker campus and along the Brush Creek bluffs. Thickness is 5 to 10 ft on highland areas at the southern limit of the quadrangle. Loess is thin on the steeper hill slopes or has been removed by erosion, exposing the bedrock.

Thickness of loess cover was determined mostly by extrapolation. Thickness measurements at random locations are inferred to approximate thickness over a large part of an upland area. Thickness of loess cover was found to vary greatly over short lateral distances because of erosion, depositional rates or anthropogenic activity. Consequently, thickness and areal extent of loess cover locally should be considered to be inconclusive until more data becomes available.

Several feet of colluvium is typically encountered in excavations near the bottoms of hills and overlying the floodplains of the larger streams. Colluvium is composed mostly of reworked loess that was transported downslope. The colluvium has properties similar to loess and can easily be confused with it.

THE ABANDONED LOWER TURKEY CREEK VALLEY

The Abandoned Lower Turkey Creek Valley is an ice-margin diversion channel 6.5 miles long and 0.5 miles wide. The southwest-northeast oriented channel is located just south of the Central Business District of Kansas City, Missouri. The channel is eroded into Pennsylvanian cyclical strata and is filled with pre-Illinoian alluvium to a depth of over 240 ft. A test bore hole at 15th and Benton Street passed through 261 ft of sand and gravel and bottomed in coarse boulders at a depth of 261 ft (572 ft M.S.L.). An interpretation of the configuration of the bedrock valley and the physical properties of the alluvium that fills it is based on an analysis of the records of over 200 borings, most of them drilled to bedrock.

THE GEOLOGIC HISTORY OF THE ABANDONED LOWER TURKEY CREEK VALLEY

A pre-Illinoian ice lobe damned the Kansas River at Kansas City. The major river in the Early Pleistocene was the Kansas (Kaw) River. The Ancestral Missouri River entered Missouri near Tarkio and flowed southeastward, joining the Kansas River near Carrollton about 70 miles east of Kansas City. As the ice lobe damned the eastward flowing ancestral Kansas River at Kansas City a large ice margin lake formed upstream, extending into Kansas. Drainage from the ice-margin lake became diverted through an outlet channel that breached a low divide between the ice-margin lake and Turkey Creek. Torrents of lake water were diverted into the Lower Turkey Creek Valley eroding the valley walls and deepening the channel to over 100 ft. As the ice lobe moved southward it covered the area between the Kansas River at Kansas City and the Lower Turkey Creek Valley, including the Downtown Kansas City area. Several ft of glacial till (diamicton) was recorded at 14th and Summit Avenue during construction of I-670 connection with I-70 and I-35, near the highest elevation in Kansas City (~ 950 ft M.S.L.), evidence that glacial ice once covered Downtown Kansas City. Consequently, Lower Turkey Creek became an ice-margin diversion channel. The boulder bed at Cambridge Business Park is interpreted to be the deposit of a short high velocity ice margin stream. With the recession of the pre-Illinoian glaciers the Lower Turkey Creek Valley was abandoned and filled with alluvium, and the Kansas River resumed its prior course, becoming the Missouri River at Kansas City.

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