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History, Geology and Water in the Lower Platte River Valley in Eastern Nebraska

Dave Gosselin
University of Nebraska-Lincoln, dgosselin2@unl.edu

Marv Carlson
University of Nebraska-Lincoln, mcarlson1@unl.edu

Matt Joeckel
University of Nebraska-Lincoln, rjoeckel3@unl.edu

FIELD TRIP 4

HISTORY, GEOLOGY AND WATER IN THE LOWER PLATTE RIVER VALLEY IN EASTERN NEBRASKA

Dave Gosselin, Marv Carlson,
Matt Joeckel

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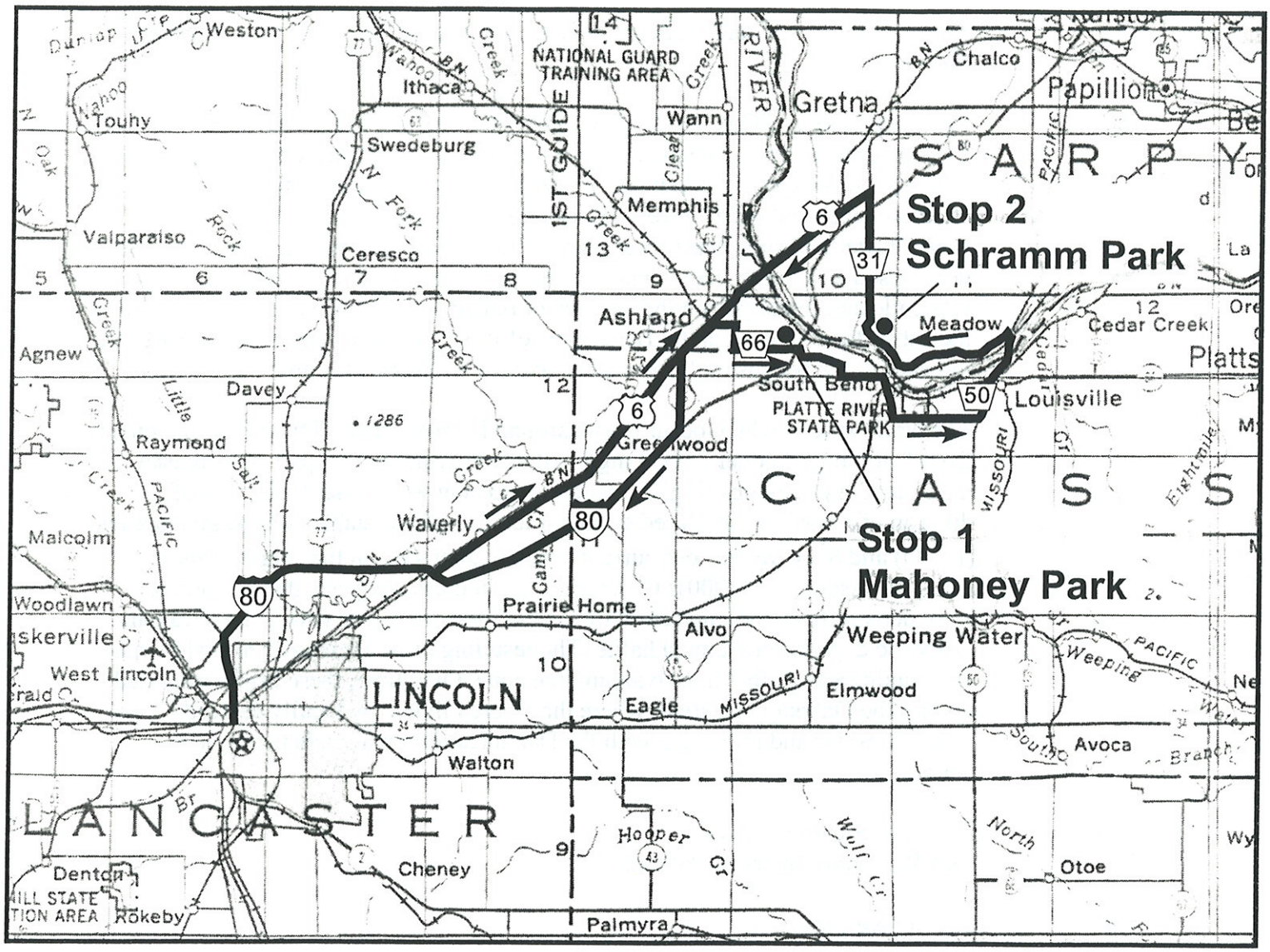
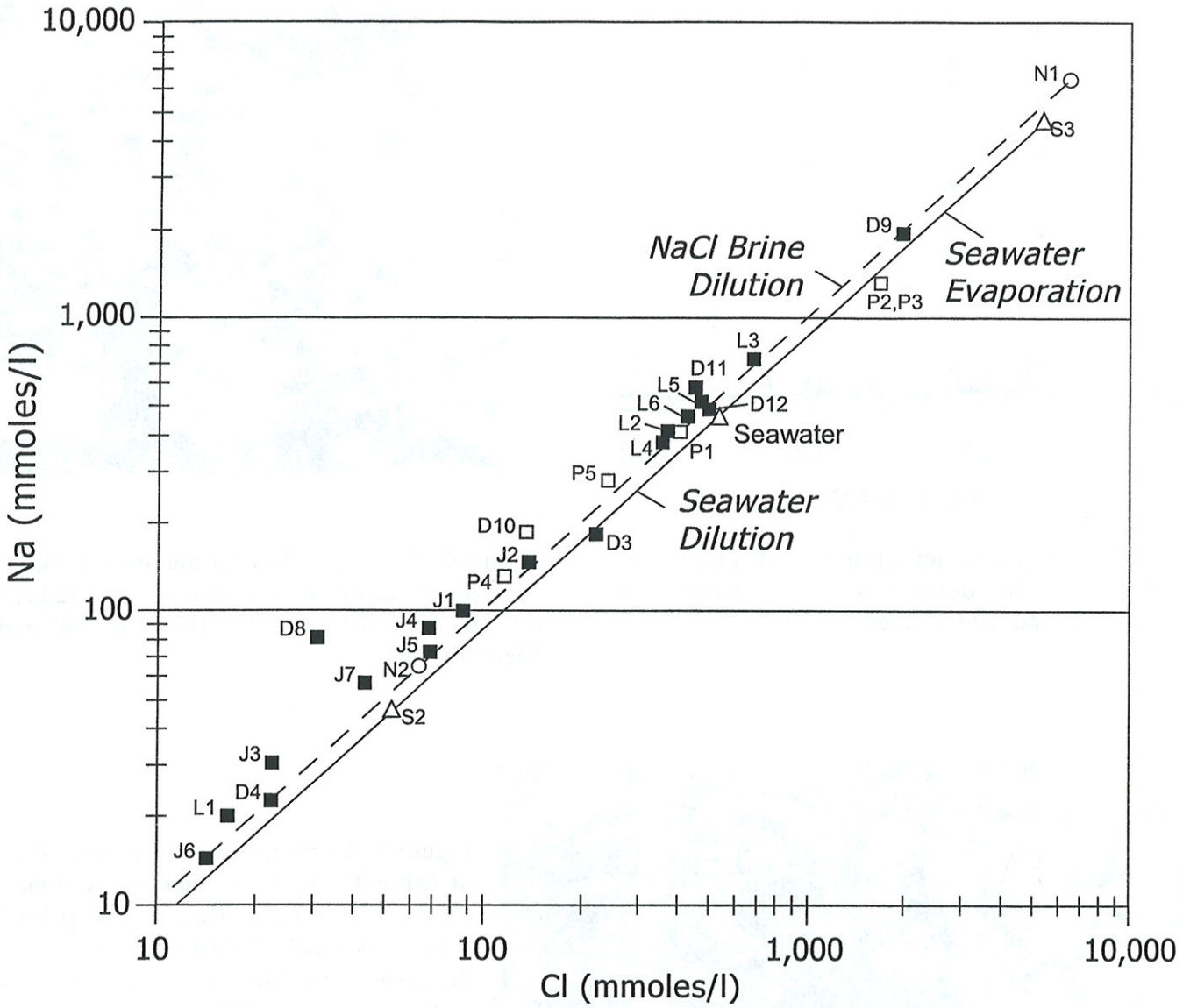


Figure 1. Map of field trip route.

Mileage	Description
0	Embassy Suites Hotel, 11th and O streets to 10th and O streets.
0.1	From corner of 10th and O streets proceed north on 10th Street to U.S. Interstate 180 (Fig. 1).
1.5-1.6	Pass Oak Lake and Oak Creek. Oak Lake is the site of a municipal dump that was used until the early 20th century. During early Euro-american settlement (1850s-1860s), it was known as a salt basin where halite-dominated surface efflorescences and crusts developed as a result of capillary wicking of groundwater and subsequent evaporation. Water was impounded on the site after it was used as a dump. Salt, a major attraction for early Euro-american settlers, was collected directly from the surface, or boiled from saline waters pumped from the subsurface, in the Capitol Beach area of west Lincoln as late as the 1880s. The industry failed because salt from other sources was soon available more cheaply. The NaCl waters, which occur in and around Lincoln, have TDS values that range from 1,300 mg/l to over 25,000 mg/l. All saline brines in this part of Nebraska have Na-Cl systematics (Fig. 2) that are consistent with variable degrees of dilution of a NaCl brine. Based on major ion chemistry, stable isotope systematics (D,^{18}O) and δ^{87}Sr values, our current conceptual model for the origin of these brines (Gosselin et al., 2001; Gosselin et al., in press) suggests that the brines were derived from the interaction of ancient meteoric water with Pennsylvanian evaporite deposits containing halite. The resulting brine eventually migrated into and equilibrated with Pennsylvanian limestone. Over time, these brines migrated up into the Dakota Formation, where they were diluted by locally derived meteoric water and interacted with the Dakota aquifer materials to varying degrees.
3.0	Pass over Superior Street.
3.2	Exit 401D onto Interstate 80 East.
5.8	27th St. overpass.
5.9	Salt flats to the north and south. These salt flats, similar to those that once existed in the Oak Lake area, are probably part of the Kanosha Basin described in early Euro-american accounts (see Joeckel and Ang Clement, 1999, for a full description). Arbor Lake (immediately north on 27th Street), which has been impounded to maintain a permanent water level, is now a protected habitat. Salt crusts from the Arbor Lake area consist mostly of halite (NaCl), with minor amounts of thenardite (Na_2SO_4) (Figs. 3, 4). Soils on the flats around the lake develop surface-sealing soil crusts in dry weather (Fig. 5), and contain vesicular horizons similar to those visible in some desert soils (Joeckel and Ang Clement, 1999).



Open triangles: values associated with sea water and its evaporation (S3) or dilution (S1).

Open circles: values associated with the dissolution of halite (N1) and its corresponding dilution.

Open squares: ground water samples from the Pennsylvanian limestones.

Closed squares: ground water samples from the Dakota Formation in Jefferson County (J), Lancaster County (L) and Table 1 (in Gosselin, 2001) (D).

Sample D10 is from Pennsylvanian Limestones in western Nebraska.

Figure 2. Plot of Na versus Cl for saline ground water from Lancaster and Jefferson counties of Nebraska (from Gosselin et al., 2001).

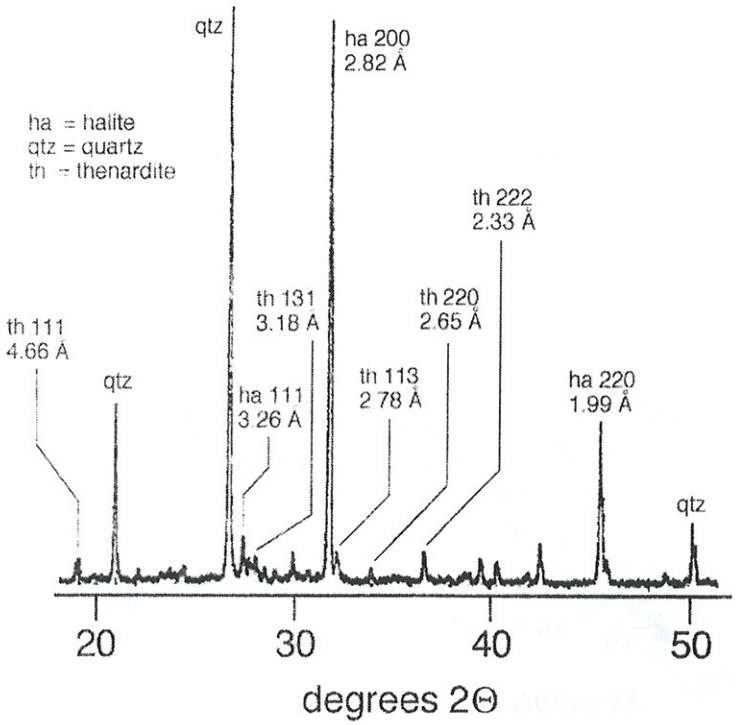


Figure 3. X-ray diffractogram of salt crust from Arbor Lake; halite dominates soluble constituents (from Joeckel and Ang Clement, 1999).

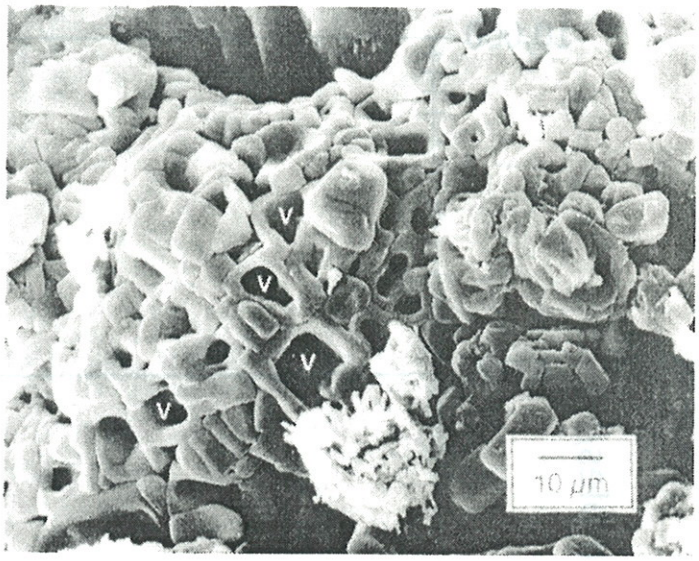


Figure 4. Scanning electron microscope photograph of halite crystals from salt crust at Arbor Lake. Many crystals contain voids (v) (from Joeckel and Ang Clement, 1999).

Figure 5. Crusted soil from surface of salt flat at Arbor Lake, near Lincoln. Cyanobacterial (1) and fungal (2) filaments help bind soil which is sealed and hardened by clay dispersion from Na^+ in solution (from Joeckel and Ang Clement, 1999).

6.1 Cross Little Salt Creek. Little Salt Creek has been straightened immediately to the north, and has subsequently entrenched itself to depths greater than 4 meters below floodplain level. A few abandoned segments of the former shallow, meandering channel are visible nearby, especially south of the interstate. Alluvium exposed in the banks of Little Salt Creek in this area is Holocene in age and includes the Gunder, Roberts Creek, and Camp Creek members of the DeForest Formation; the Camp Creek Member largely postdates initial Euro-american settlement (Mandel and Bettis, 1995).

8.0 56^{th} St. overpass.

8.8 Salt Creek valley to the south.

9.0 Lincoln Electric System windmills. The first of these wind turbine generators began operating in December of 1998. The second turbine was built in October of 1999. From the completion of the second turbine through December 2002, the two turbines together generated a total of 9,906,243 kilowatt-hours. The foundations for each turbine go down 31 feet (9.45 meters) into the ground, and they each stand 290 (87 meters) feet tall, including the three blades, each of which is 77 feet (23.5 meters) long.

10.0 Abandoned channel of Salt Creek. Compare the depth and cross-sectional shape of this natural channel to those of the engineered channel visible approximately 0.3 mile (0.48 kilometer) ahead. The abandoned natural channel is clearly much shallower, and there is evidence for point bars along many abandoned channel segments of Salt Creek, whereas the straightened segments of the creek are deeply entrenched and usually show alternating bars at low stage.

10.3 Cross Salt Creek. Salt Creek figures prominently in the early history of Lincoln and Lancaster County. The salt springs and salt flats alongside it attracted the attention of Native Americans and early Euro-american travelers. Between Lincoln and the Platte River near Ashland, Salt Creek has been shortened to approximately half its length by channelization. Major channel-straightening work began just prior to 1900 and continued in 1917-1918, 1932-1936, and after a major flood in 1942. Multiple large floods have occurred along Salt Creek, the floods of July 1908 and May 1942 being perhaps the most noteworthy. During the 1908 flood, all of the Salt Creek valley bottom was flooded from Lincoln to the Platte River, and the runoff-swollen stream exceeded 2 miles (1.6 kilometers) in width.

12.2 Exit 409 to U.S. Highway 6.

12.7 Turn right onto U.S. Highway 6; proceed east.

12.7-19.6 Floodplain of Salt Creek.

14.7	Overpass at west edge of Waverly
18.1	Cross Camp Creek.
19.0	Williams LP gas storage facility. A cavern was excavated at this location between the depths of 325 feet (101.6 meters) and 350 feet (106.7 meters) in the Kansas City Group (Upper Pennsylvanian) limestone and shale. The plan of the cavern resembles a city street with blocks. Excavation was by the room-and-pillar method with room dimensions of 20 feet by 20 feet (6.1meters by 6.1 meters) separated by large pillars. The facility provides storage capacity of approximately 400,000 barrels of LP gas.
19.8	Cross Dee Creek.
20.4	Enter Greenwood.
20.7-20.9	Grain elevators.
21.7	Salt Creek to the north.
24.1	Cross Callahan Creek.
26.0	Woodland Hills development to the south. Water wells south of this area penetrate into sandstones of the Dakota Formation (Albian-Cenomanian, Cretaceous). Groundwater from the Dakota aquifer in this area is dominantly Ca-HCO_3 or Ca-Mg-HCO_3 waters having TDS less than 500 mg/l (Gosselin et al., 2001). The low TDS in these bicarbonate-dominated waters is consistent with these groundwaters having been recharged relatively recently. The saturation indexes for iron minerals indicate their importance in controlling the iron concentrations in the water.
26.5	Exposures of basal Dakota Formation conglomerates (Albian, Lower Cretaceous), which are dominated by chert and quartz pebbles, crop out on the hill on the south side of the highway. Basal Dakota Formation conglomerates typically contain a few cobble- to boulder-sized clasts of chert eroded from local Upper Pennsylvanian limestones; some exposures contain exotic clasts from as far away as the Canadian Shield (Joeckel et al., in press). The major Early Cretaceous drainages in western Iowa and eastern Nebraska appear to have trended NW-SE to E-W (Brenner et al., 2000). Westward drainage is apparent in paleocurrent measurements from sandstones in the lowermost Platte River valley (Joeckel et al., in press).
27.2	Highway 63 to downtown Ashland. The bridge over Salt Creek at Ashland spans a wider channel than that observed at Lincoln. This point is only a few kilometers upstream from the mouth of Salt Creek, where the stream enters the Platte River.

Both the Platte River and Salt Creek were known to French explorers and traders by the early 18th century.

27.4 Turn right (east) onto Nebraska Highway 66.

28.1 Nineteenth-century native stone house, probably constructed from locally quarried Cass Formation (Douglas Group, Upper Pennsylvanian) limestone. Blocks of well-cemented Dakota Formation sandstone were also quarried for building and foundation stone in the lowermost Platte Valley during the 19th and early 20th centuries.

28.2 Iron Horse development. The former Ashland Stone Company quarry at this site was excavated as deep as the Cass Formation (Douglas Group, Upper Pennsylvanian). The main part of the quarry is now filled with water, but the Dakota Formation is still extensively exposed (Fig. 6). The Dakota sediments, including small amounts of laminites interpreted as tidal sediments, exposed in the quarry represent an Early Cretaceous fluvial-estuarine valley fill incised into bedrock (Joeckel et al., in press).

30.9 Strategic Air and Space Museum. Considered the nation's most outstanding air and space museum, the $29.5-million facility opened its doors on May 16, 1998. The museum showcases past U.S. aircraft and missiles. Its collection of 33 planes and six missiles represents part of the military history of the Cold War and highlights the significance of the Strategic Air Command (SAC), the nation's top nuclear weapons command center, during that period. The 300,000-square-foot building includes a glass atrium, two aircraft display hangars, a traveling exhibit area, a children's interactive gallery, and an aircraft restoration gallery. The glass atrium encloses the Lockheed SR-71 Blackbird and is made of 525 glass panels.

31.0 Mahoney State Park entrance. The park is named for Eugene T. Mahoney, former police officer, Nebraska state senator, and director of the Nebraska Game and Parks Commission from 1976-1988. It is lies along over the scenic Platte River valley (Fig.7) and includes 690 acres of recreational facilities. Among these are cabins, two lakes, many trails, and an ice-skating rink. Lower Cretaceous Dakota Formation sandstones and Upper Pennsylvanian cyclothems crop out in and around the park. A Native American settlement existed near this area as recently as the mid-1850s: both the Oto, a Siouan tribe that originated in the Great Lakes region, and the Pawnee, longer term Nebraska residents, frequented the area. A mid-19th-century village of the Omaha tribe existed as nearby as the Millard, Nebraska, area on the southern outskirts of the present Omaha metropolitan area.

32.1 Turn towards Running Deer cabins.

32.3 Native American burial mound/Running Deer cabin area.

32.4 Trail to spring and sandstone grotto at the northern boundary of Mahoney State Park. A few tens of meters of tabular cross-stratified Dakota Formation sandstones, with set thicknesses of as much as 5.3 feet (1.6 meters), are exposed in the northern part of the park and along the adjacent Burlington Northern Railroad tracks (Fig. 8). Presumably, groundwater sapping has created the grotto-like ravine at the park's northern boundary, at which a spring still issues.

32.7 Riverview Lodge observation tower. The mouth of Salt Creek, which enters the mouth of the bedrock gorge of the lowermost Platte River near Ashland, is visible to the north and northeast. Bedrock-covered headlands exist on both sides of the Platte from this point eastward to La Platte, a few kilometers west of the confluence of the Platte and Missouri rivers.

34.2 Exit Mahoney State Park.

34.7 Cross Interstate 80.

35.0 Lee G. Simmons Conservation Park and Wildlife Safari. A 360-acre facility operated by Omaha's Henry Doorly Zoo, the park/safari's main purposes are education about, and conservation and breeding of, threatened and endangered wildlife. Species include bison, elk, pronghorn antelope, white-tailed deer, gray wolves, wild turkeys, Sandhill cranes, pelicans, trumpeter swans, herons and many kinds of waterfowl. It also contains meadows that provide key habitat for the birds. Plans include showcasing endangered whooping cranes. A plot of tallgrass prairie surrounds the visitor center and includes 57 plant species native to eastern Nebraska. A Sacred Hoop Garden, reflecting the vision of the Lakota holy man Black Elk more than a hundred years ago, has been established nearby. Black Elk's vision was popularized by Nebraska writer John Neihardt in *Black Elk Speaks*. Published in 1939 near the end of Black Elk's life, it was intended to preserve the essence of the traditional Lakota way of life in the wake of its transformation following Euro-american settlement. It is often used as a high school and college text in anthropology and literature classes.

36.1 Cross Pawnee Creek. The type section of the Little Pawnee Shale (Cass Formation, Upper Pennsylvanian) is nearby.

36.3 Dakota Formation sandstones cropping out atop Upper Pennsylvanian limestones. Plans for the construction of an amphitheatre for musical performances just south of the highway here were recently abandoned, in part because of water supply problems.

38.1 Enter South Bend. The type section of the South Bend Limestone (Stanton Formation, Lansing Group, Upper Pennsylvanian) lies nearby.

38.8 Lakes filling former sand and gravel pits to the north. The Platte River valley provides the major supply of sand and gravel across Nebraska.

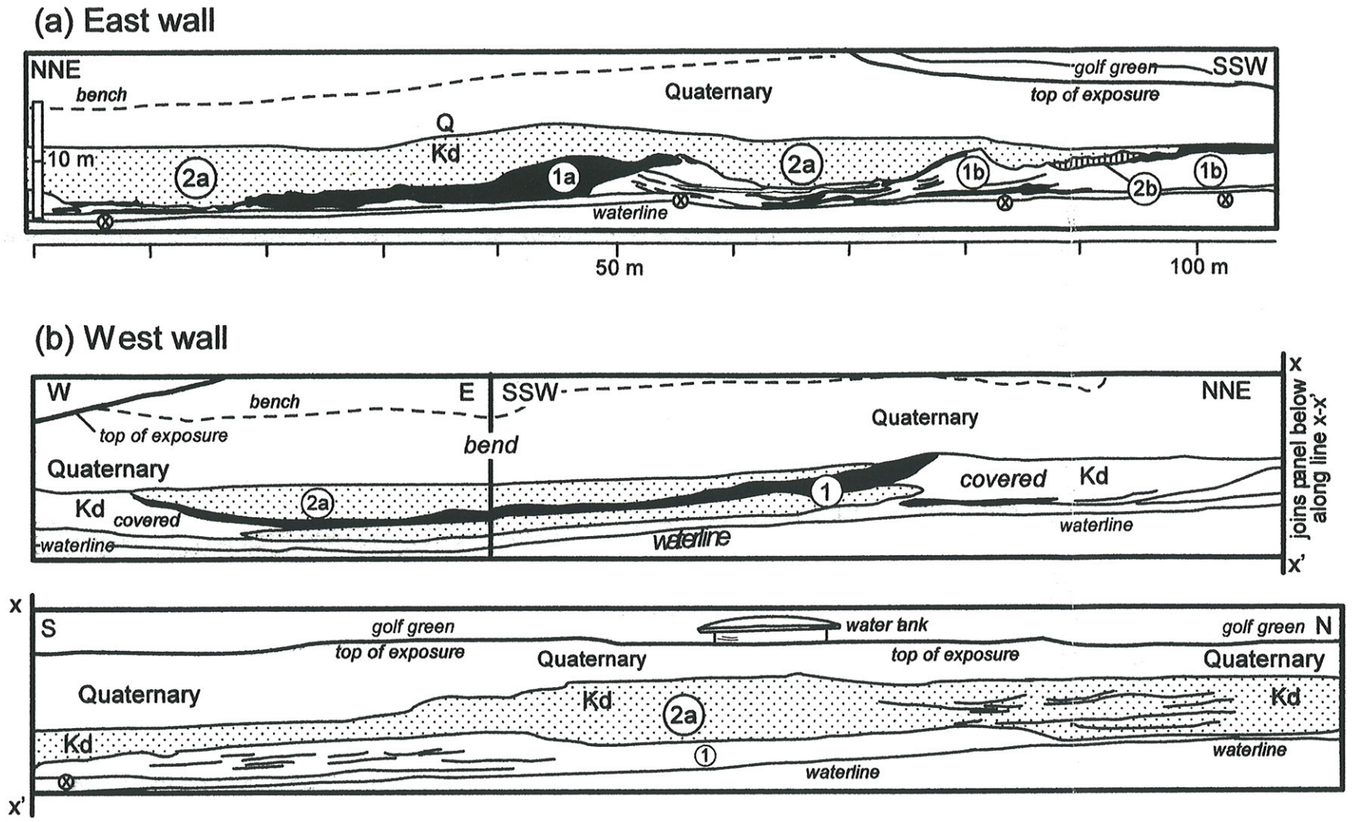


Figure 6. Exposures of Early Cretaceous fluvial-estuarine valley fill exposed in former quarry at Iron Horse development near Ashland, Nebraska. Units 1a and 1b are on earlier valley fill, which includes probable tidal sediments. Unit 2a is a later fill, which is dominated by cross-stratified sandstone (from Joeckel et al., in press).

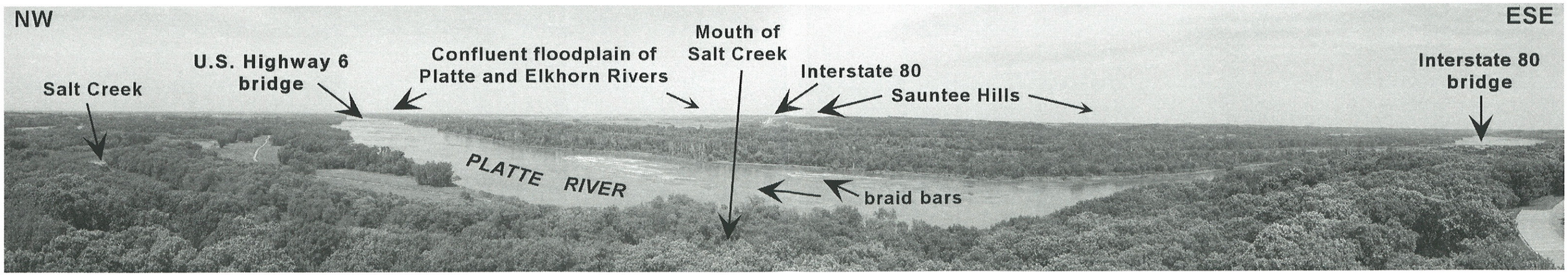


Figure 7. Panoramic view of Platte River Valley from observation tower at Mahoney State Park.

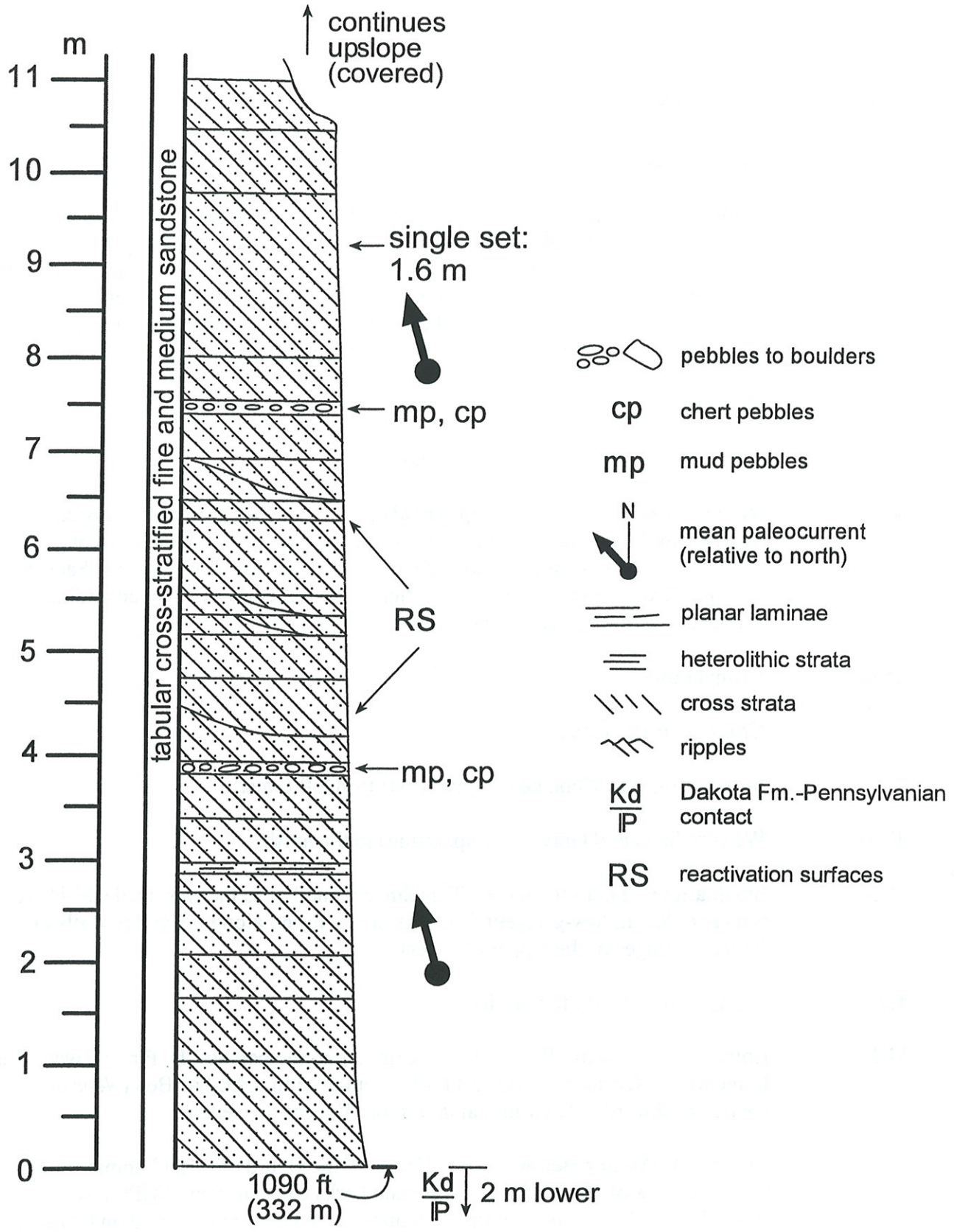


Figure 8. Stratigraphic section of basal Dakota Formation sandstones along Burlington Northern Railroad adjacent to northern boundary of Mahoney State Park (from Joeckel et al., in press).

39.0	Cross creek.
39.4	Camp Kitaki to left (north).
41.1	Entrance to Platte River State Park. This park (of 418 acres or 167.2 hectares) is one of the "anchors" of the Platte River recreation corridor. In the park, hardwood forests intergrade with thin fingers of tallgrass prairie and elongate tracts of Platte River floodplain woodlands. Government land surveys from the 1850s, as well as reports of travelers in the first half of the 1800s, indicate that the valley sides in this area were originally covered with oak savannas and tallgrass prairie.
41.6	Decker Creek.
43.3	Highway 50 intersection; turn left (north).
44.1	Ruin of a house with a foundation made out of Dakota Formation sandstone quarried locally. Nearby Louisville, Nebraska, has several buildings along its main street that have walls made of large blocks of Dakota sandstone. Sandstone was quarried in Sarpy and Cass counties at least as early as 1856, according to the original government land surveys.
45.9	Pump houses.
46.0	Cross the Platte River.
46.2	Intersection with Nebraska Highway 31; turn left (west).
47.7	Western Sand and Gravel pit (operating) to the north.
48.3	Small alluvial fan to the north. This fan and another to the west (mile 49.1) are typical of small, low-gradient fans that can be found along the valley walls of larger drainages in the Upper Midwest.
49.1	Small alluvial fan to the north.
51.5	Entrance to Schramm Park. The park lies along the bank of the Platte River. It is home to the Nebraska Game and Parks Commission's Ak-Sar-Ben (*Nebraska* spelled backwards) Aquarium and Outdoor Education Center.
52.1	Entrance to Ak-Sar-Ben Aquarium. In 1879, the Board of Fish Commissioners, the forerunner of the Nebraska Game and Parks Commission (NGPC), was created. That board and the private Sauntee Hatchery, then located on this site, worked together to purchase fish to stock Nebraska rivers and streams. Three years later, the board bought the hatchery and the 54 acres around it. Originally the natural spring water made it an ideal place for a hatchery. Eventually,

however, the water volume became insufficient for this purpose, and the area was transferred to the NGPC Parks Division as a state recreation area. The geological display in the park exposes a classic U.S. Midcontinent cyclothem section (Fig. 9): the Plattsburg Limestone Formation near the base of the exposure is usually interpreted as a regressive limestone, and its upper contact is marked by a regional exposure surface. The overlying Vilas Shale Formation consists of mudstone and shale, and contains a widespread paleosol. The basal members of the overlying Stanton Formation, the Captain Creek Limestone and the Eudora Shale (a black, phosphatic shale) represent transgression and the probable maximum water depth (almost certainly <100 meters). The Stoner Limestone and overlying Rock Lake Shale members farther upsection represent the subsequent fall of sea level. A paleosol is present regionally in the Rock Lake Shale (Joeckel, 1989).

57.4 Cross Interstate 80, continue north on Nebraska Highway 31.

57.8 Intersection with U.S. Highway 6. Proceed westward to Ashland.

59.2 Late Pleistocene terrace of the Platte River. North of the easternmost Platte River gorge and upstream to the Fremont, Nebraska, area, the floodplains of the Platte and Elkhorn rivers are confluent. In places, approximately 6 meters of sediment have accumulated on this floodplain since the late Pleistocene. The Elkhorn is a relatively narrow, meandering stream that has clearly begun to rebound from early-20th century channel manipulation; it is also a major contributor to the permanency of flow in the lowermost part of the Platte. In its lower stretch, the Elkhorn flows at a level lower than the Platte, and flood flow from the Platte readily sweeps eastward or southeastward toward the Elkhorn. The confluent floodplains of the two rivers experience widespread and sometimes spectacular floods, but only when ice jams develop in mid-to-late winter and earliest spring. The last major flooding event occurred during the late winter of 1993 -- a memorable year of flooding nationwide.

60.4 Western opening of lowermost Platte River gorge to the left.

62.0 Linoma Beach. Formerly a widely-used recreation site and a celebrated nightspot, relatively clear, sand-bottomed artificial lakes, a small beach, a bar/restaurant, and an-out-of-town setting made Linoma Beach a popular post-World War II destination for residents of both Lincoln and Omaha (hence its name). By the late 1960s this popular attraction had declined markedly, but it was refurbished in the 1990s.

62.4 Cross the Platte River, pump house to the left.

63.0 Abandoned channel of Salt Creek.

63.2 Catfish Run Wildlife Management Area; note concrete weir.

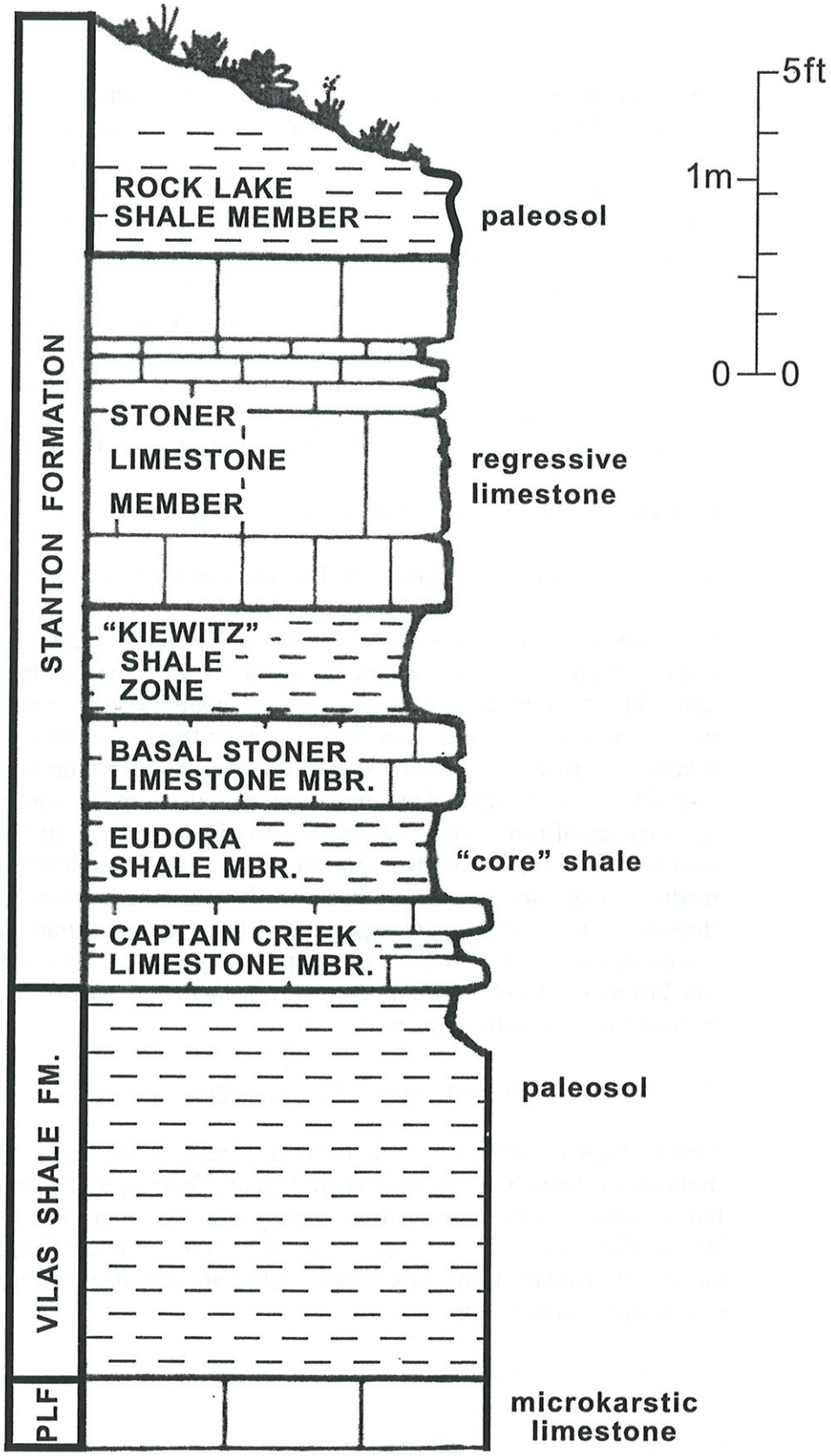


Figure 9. Section of Pennsylvanian strata (Lansing Group) at Schramm Park. PLF-Plattsburg Limestone Formation. Transgressive South Bend Limestone (not shown) overlies Rock Lake Shale (from Pabian, 1977).

64.0 Entrance to Iron Horse development.

64.6 Lincoln Municipal Water Plant. Between 1883 and 1930, wells were drilled in many parts of what is now central Lincoln. Many of these wells were abandoned when the water turned salty. In the late 1920's, water use was severely curtailed through water conservation practices when the city faced a major water crisis. The persistent problem of salt water wells, combined with Lincoln's growth and growing need for more water, meant the city had to find another water source. Although it was an ambitious undertaking, the city established a well field site along the Platte River, 25 miles northeast of Lincoln, near Ashland. The aquifer consists of alluvial sand and gravels. The Ashland Water Treatment Plant was constructed in 1935. To meet projected demands, major improvements to the production facilities began in the early 1990's. The city had previously purchased additional land for a new wellfield, including a Platte River island. Test wells were drilled, and Lincoln now has two new wells, each capable of producing 25 million gallons of water a day. The Lincoln Water System serves more than 230,000 people, who use an average of 40 million gallons of water every day.

65.0 Junction with Nebraska Highway 66.

66.0 Junction with Nebraska Highway 63; turn left.

69.0 Turn onto Interstate 80 West; return to Lincoln.

89.4 + Embassy Suites

References

Brenner, R.L., Ludvigson, G.A., Witzke, B.J., Zawistoski, A.N., Kvale, E.P., Ravn, R.L., and Joeckel, R.M., 2000, Late Albian Kiowa-Skull Creek marine transgression, lower Dakota Formation, eastern margin of western interior seaway, U.S.A.: Journal of Sedimentary Research, v. 70, p. 868-878.

Gosselin, D.C., Harvey, F.E., and Frost, C.D., 2001. Geochemical evolution of groundwater in the Great Plains (Dakota) aquifer of Nebraska: Implications for the management of a regional aquifer system. Ground Water v. 39, p. 98-108.

Gosselin, D.C., Harvey, F.E., and Frost, C.D, Stotler, R. and Macfarlane, P.A., in press (2003), Strontium isotope geochemistry of groundwater in the central part of the Dakota (Great Plains) Aquifer, U.S.A., Applied Geochemistry.

Joeckel, R.M., Ludvigson, G.A., Witze, B.J., Kvale, E.P., Phillips, P.L., Brenner, R.L., Thomas, S.G. and Howard, L.M., in press, Palaeogeography and fluvial to estuarine architecture of the Dakota Formation (Cretaceous, Albian), Eastern Nebraska, USA, *in* Blum, M.D. and Marriott, S.B., eds., Fluvial Sedimentology VII, International Association of Sedimentologists, Blackwell, Oxford.

Joeckel, R.M., 1989, Paleogeomorphology of a Pennsylvanian land surface: the Rock Lake Shale in Nebraska: Journal of Sedimentary Petrology, v. 59, p. 469-481.

Joeckel, R.M., and Ang Clement, B.J., 1999, Surface features of the Salt Basin of Lancaster County, Nebraska: Reconnaissance of inland sabkhas at the subhumid eastern margin of the Great Plains, USA: Catena, v. 34, p. 243-275.

Joeckel, R.M., 1994, Virgilian (Upper Pennsylvanian) Paleosols in the Upper Lawrence Formation (Douglas Group) and in the Snyderville Shale Member (Shawnee Group, Oread Formation) of the Northern Midcontinent, U.S.A.: Pedologic Contrasts in a Cyclothem Sequence: Journal of Sedimentary Research, v. A64, p. 853-866.

Mandel, R.D., and Bettis, E.A., III, 1995, Late Quaternary landscape evolution and stratigraphy in eastern Nebraska, *in* Diffendal, R.F., and Flowerday, C.A., eds., Geologic Field Trips in Nebraska and Adjacent Part of Kansas and South Dakota, Guidebook No. 10, Field Trip 7, p. 77-90, University of Nebraska-Lincoln, Conservation and Survey Division.

Pabian, R.K., 1977, Field guide – Sarpy County, Gretna State Fish Hatchery area: University of Nebraska-Lincoln, Conservation and Survey Division, Field Guide 3, 5 p.