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High-terrace chert-gravel deposits in the Toledo vicinity, Chase County, Kansas

James S. Aber
Emporia State University, Emporia, Kansas jaber@g.emporia.edu

This study examines high-terrace chert-gravel deposits preserved in several locations near and north of Toledo at the eastern edge of the Flint Hills in Chase County, Kansas. High-terrace gravel deposits are situated in ascending steps north of the Cottonwood River valley at three levels from approximately 90 to 150 feet (~28-45 m) above the Cottonwood River channel. All deposits contain exotic quartzite pebbles and represent the Old Osage River, which gradually shifted southward as it eroded into the modern valley. Assuming a late Pliocene age for the highest terrace gives a vertical incision rate of 1.5 cm/1000 years and a lateral migration rate of 2.2 m/1000 years. The Toledo vicinity provides confirmation for the asymmetric history of valley incision presumably due to regional crustal tilting downward to the south.

Keywords: Pliocene, quartzite, Flint Hills, Ogallala, exotic

Introduction

Toledo is a small community on the Emporia terrace on the northern side of the Cottonwood River valley in easternmost Chase County about halfway between Emporia and Strong City (Fig. 1). This study focuses on high-terrace chert-gravel deposits preserved in several locations in vicinity of and 2-3 km north of Toledo at the eastern edge of the Flint Hills. Moore et al. (1951) described the terrace deposits of Chase County. They identified and named the Emporia terrace, which is typically 10-20 feet (3-6 m) above the present flood plain of the Cottonwood River valley, and noted higher terrace deposits ranging "from 50 to 150 or more feet above the present flood plain."

High-terrace deposits are comprised mainly of chert pebbles and cobbles derived from chert-bearing limestones of the Flint Hills, namely the Wreford and Florence limestones (Kansas Geological Survey 2018). Moore et al. (1951) did note the presence of "sand grains of colorless quartz, mostly well rounded," but did not mention exotic pebbles. On the1951 geologic map of Chase County, these terraces were shown as a single stratigraphic unit identified as Quaternary terrace (Qt; Kansas Geological Survey 2006), although they considered the highest terraces possibly Pliocene in age.

Merriam and Harbaugh (2004) reviewed high-level chert-gravel deposits of the Osage Cuestas region of east-central Kansas. They likewise considered the age range to be Pliocene for the highest deposits and early/middle Pleistocene for lower deposits. Given the age and thorough weathering of these deposits, only the most resistant quartz and chert lithologies have survived, often with a reddish-brown paleosol preserved.

The high-terrace deposits north of the Cottonwood River are part of a trend that extends from Chase County eastward across Lyon, Coffey and Anderson counties, thence southeastward into Woodson and Allen counties and beyond (Aber 1985, 1988, 1997; Law 1986; Krueger 1993; Byerley 1995; Corley 2008). These upland alluvial gravel deposits contain scarce, exotic pebbles of quartz, varicolored quartzite, quartzose sandstone, dark chert, and rare granite. These high-terrace gravel deposits mark a paleodrainage that I have called the Old Osage

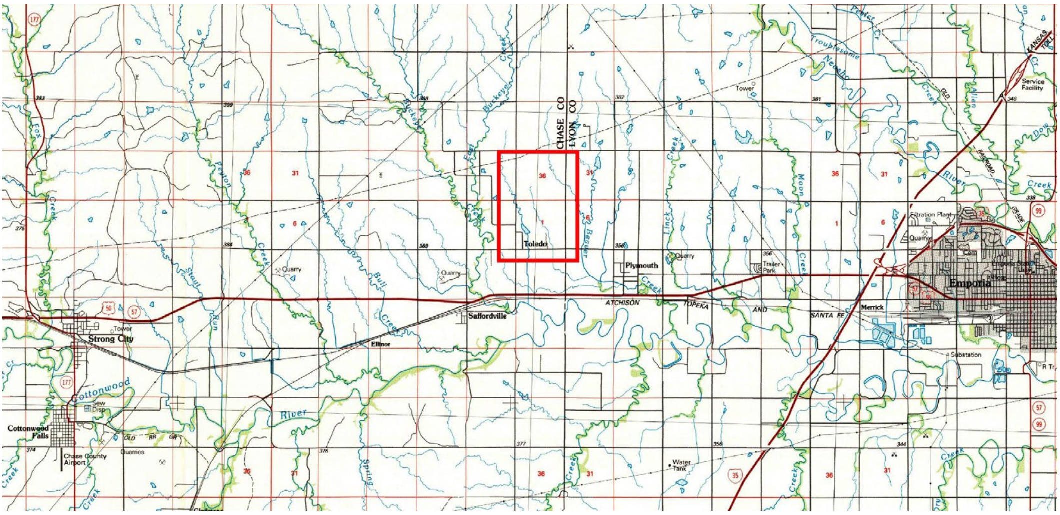

Figure 1. General locality map for Toledo (red box) in east-central Kansas. Adapted from Emporia, Kansas 1:100 000 planimetric map (1985); USGS topoView (2019).

River (Aber 1985), which had its headwaters in central or western Kansas from which Ogallala-type exotic pebbles were derived.

Study area

The study area includes section 36 and the eastern one-third of section 35, T18S, R9E, as well as the NE¼ section 2, T19S, R9E. Chert gravel is exposed in several locations at multiple topographic levels in the landscape (Fig. 2). To the south, the Emporia terrace is conspicuous along the northern margin of the Cottonwood River valley. The lower edge of the terrace is marked by the 1150-foot contour line, and its upper limit is approximately 1180 feet (~360 m; all elevations in feet are taken from Plymouth, Kansas 1:24 000 topographic map 2018; USGS topoView 2019; approximate metric values are given). The flood plain is ~1140 feet elevation, and the Cottonwood River channel is just below 1120 feet (~340 m). The flood plain is inundated frequently, as happened in May 2019, but the Emporia terrace remains above flood level.

Upland chert-gravel deposits are mostly associated with the Olpe-Smolan soil complex; whereas, the Emporia terrace is marked by Ladysmith and Labette soil series (Neill 1974). Underlying bedrock consists of the Grenola Limestone, Roca Shale, Red Eagle Limestone, and Johnson Shale of the Council Grove Group (Moore et al. 1951). Gravel deposits are best seen in early spring immediately following prescribed prairie burning.

Site descriptions

This vicinity was first investigated in 1983 (Aber 1985). At that time an old gravel pit still was recognizable (Site e), and I found one dozen exotic pebbles in only one hour of searching (Fig. 3). Today this site is merely a grassy depression used for cattle pasture with poor exposures along back slopes of the adjacent county road. Renewed field study has revealed additional nearby sites at three distinct elevation levels.

- 1210-1220 feet (~369-372 m) – Site (c) is a road bank exposure resting on the Red Eagle Limestone. Site (d) is the hill top in the Hillside Cemetery, and Site (e) is the old gravel pit noted above.
- 1230-1240 feet (~375-378 m) – Site (b) is a road bank exposure and former gravel pit now used as pasture. One brownish gray (5YR 4/1), well-rounded quartzite pebble was discovered here (Fig. 4; colors based on Rock-Color Chart Committee (1991)).

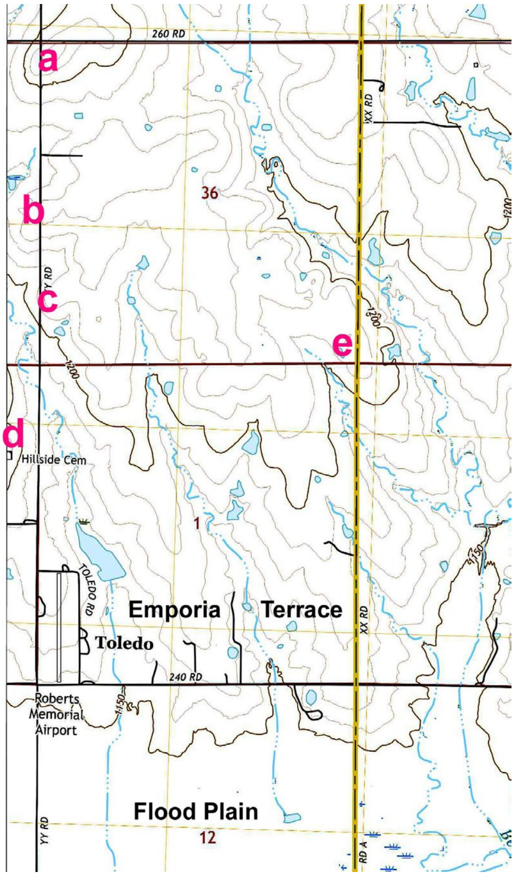

Figure 2. Study area in the Toledo vicinity. High-terrace chert-gravel deposits identified by letter (a-e) on each site. Adapted from Plymouth, Kansas 1:24 000 topographic map (2018); USGS topoView (2019).

- 1270-1275 feet (~387-389 m) – Site (a) caps a small hill and rests on the Neva Limestone Member of the Grenola Limestone (Fig. 5). One very pale orange (10YR 8/2), well-rounded quartzite pebble was discovered at Site (a).

Chert gravel exposed at these sites is generally ½ to 1 m in thickness, but may be up to 2 m thick in former gravel pits. Sites (b-e) are included in the Qt map unit of Moore et al. (1951); these sites are likewise denoted by the Olpe-Smolan soil complex (Neill 1974). However, Site (a) is not shown on the Moore et al. map, nor is it identified as an Olpe soil. Site (a) represents a newly described high-terrace, exotic-pebble-bearing, chert-gravel locality.

Figure 3. Exotic quartzite pebbles collected in 1983 at Site (e); U.S. penny for scale.

Figure 4. Small quartzite pebble found at Site (b) in 2019, just right of center (<). The pebble is well rounded, highly polished, and ~2.3 cm long.

Figure 5. Thin layer of chert gravel exposed by a recent prescribed prairie burn at Site (a). The gravel caps a small hill and rests on Neva Limestone. Contact between the gravel and limestone is highly irregular.

Figure 6. Two largest chert cobbles collected from Site (a). U.S. dollar coin for scale; ~2.6 cm in diameter.

At all sites, searches also were conducted for large chert cobbles. Site (a) yielded the two largest cobbles (Fig. 6). These cobbles are partially rounded and smoothed. They bear percussion fractures and pits of various sizes, which are typical of alluvial transport. Furthermore, they demonstrate the relatively light color (pale yellowish orange, 10YR 8/6) that is typical of the Toledo vicinity.

Discussion

Site (a) is situated some 150 feet (~45 m) above the Cottonwood River channel and ~4 miles (~6.5 km) north of the current Cottonwood River, which flows against bedrock bluffs along the south side of its valley in the Toledo-Saffordville vicinity. No other high-terrace chert-gravel deposits have been found higher or farther north than Site (a) in this vicinity. Assuming a Late Pliocene age of 3 million years for deposition of chert gravel at Site (a), this gives a vertical incision rate of 1.5

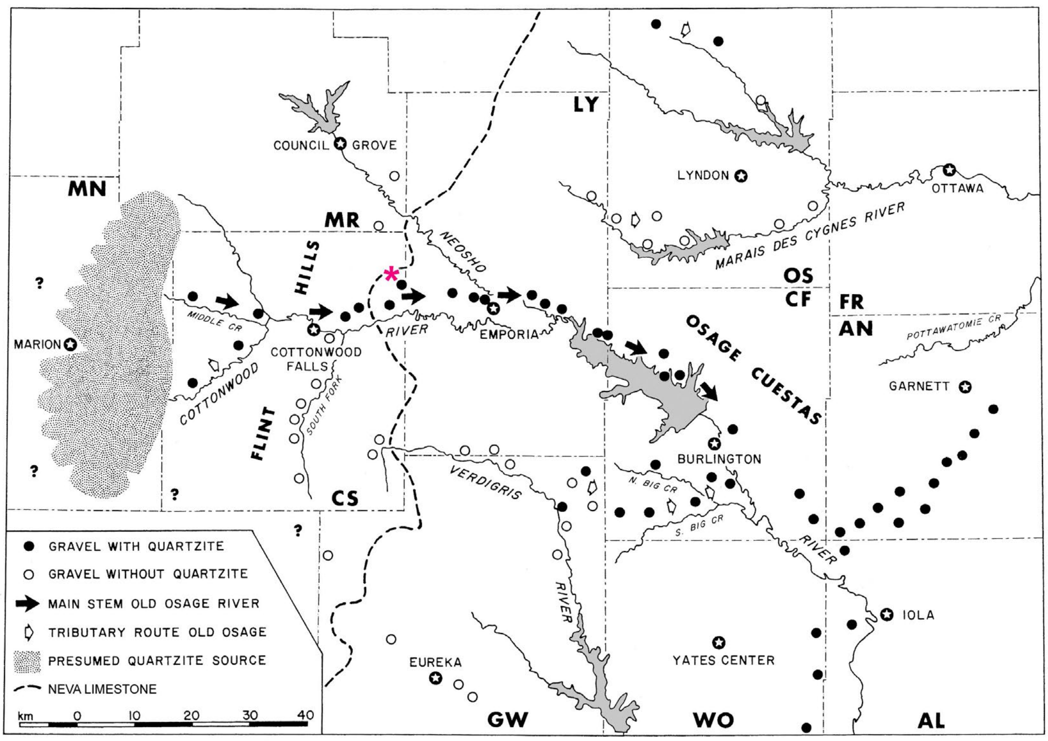

Figure 7. Sketch map of high-terrace chert-gravel deposits of east-central Kansas. Location of Toledo Site (a) indicated by red asterisk (*). Eastern limit of Flint Hills marked approximately by the Neva Limestone (dashed line); large reservoirs shown in gray. County abbreviations: MN, Marion; MR, Morris; CS, Chase; LY, Lyon; GW, Greenwood; OS, Osage; CF, Coffey; WO, Woodson; FR, Franklin; AN, Anderson; AL, Allen. Adapted from Aber (2018, fig. 6).

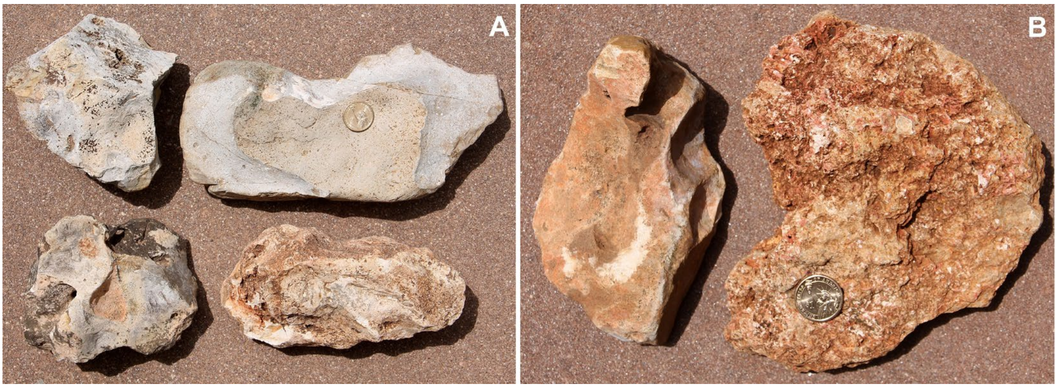

Figure 8. Large specimens from high-terrace gravel deposits. A – chert cobbles in central and western Chase County. Exotic pebbles are relatively common at these sites. B – oddly shaped chert cobble (left) and mass of milky and rose quartz crystals (right) from southeastern Morris County. The latter is derived from the same source formations as the chert. The reddish-brown color is from oxidized iron in the paleosol of the high terrace. No exotic pebbles have been found at these sites. U.S. dollar coin for scale; ~2.6 cm in diameter. Compare with Fig. 6.

cm per 1000 years. Dethier (2001) determined that stream incision in the Neosho drainage basin is <5 cm per 1000 years during the past 600,000 years.

The rate of southward migration of the Cottonwood River would be ~2.2 m per 1000 years. These results are quite similar to those of the highest chert gravel deposits on the drainage divide between the Cottonwood and Neosho rivers, ~14 km downstream in northwestern Emporia (Aber 2018). The downstream gradient from the Toledo Site (a) to the highest chert gravels in Emporia is ~1.1 m/km. The modern Cottonwood valley (flood plain) gradient is slightly less at 0.9 m/km.

The high-terrace chert-gravel deposits of the Toledo vicinity are situated along the main stem of the Old Osage River across Chase and Lyon counties (Fig. 7). Exotic pebbles are found in all high-terrace levels in the Toledo vicinity, which further strengthens the connection to the through drainage that transported exotics from Ogallala-type sources in central and western Kansas (Aber 1985, 1997).

Site (a) is particularly important given its high topographic position and distance from the modern river (see Fig. 7). Upon flowing across the Flint Hills, the Old Osage River received a large influx of chert clasts from numerous local tributaries, such as the South Fork Cottonwood River, along which chert-gravel terraces are abundant (Krueger 1993). Exotic pebbles have never been found in terrace deposits of the South Fork Cottonwood River valley, however.

From southeastern Chase County, a trend of high-terrace chert-gravel deposits extends eastward across southern Lyon, northern Greenwood, and southern Coffey counties (see Fig. 7). This trend is associated with the Verdigris River and tributaries of Big Creek. Exotic pebbles have been found in some, but not all, of these deposits (Aber 1985). This trend may depict a tributary that joined the Old Osage River just south of Burlington, but the westward path and headwater of this drainage route are unknown.

The largest cobbles (Site a) show evidence of alluvial modification and transportation from the source bedrock formations. In contrast, the largest chert cobbles from high terraces in central and western Chase County as well as southeastern Morris County, closer to bedrock sources, are typically larger, unsmoothed, and more angular or irregular in shape (Fig. 8). The characteristics of large cobbles suggest that chert gravel at Toledo was transported by streams some distance, perhaps >10 km, and not derived from nearby bedrock sources.

The Toledo vicinity provides a nearly ideal example for the asymmetric history of valley downcutting. All terraces are preserved in ascending steps north of the Cottonwood River valley (see Fig. 2), while the modern river is eroding into bedrock bluffs along the southern side of the valley. This is a typical and long-lived condition for nearly all east-west oriented valleys in east-central Kansas, regardless of direction of stream flow or other local circumstances (Aber 2018). I earlier concluded that regional crustal warping downward to the south is the only explanation that could account for the timespan involved and widespread distribution of asymmetric drainage (Aber 1992).

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