



# A near synthesis of pre-Illinoian till stratigraphy in the central United States: Iowa, Nebraska and Missouri



C.W. Rovey II<sup>\*</sup>, Trevor McLouth<sup>1</sup>

Department of Geography, Geology and Planning, Missouri State University, 901 S. National, Springfield, MO 65897, USA

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## ABSTRACT

Nearly identical sequences of pre-Illinoian glacial till are present throughout the north–central United States in Iowa, Nebraska and Missouri. In each of these states three tills with normal magnetic remanence have been found above two – three tills with reversed remanence, and the lithologic differences among successive tills are nearly the same. Each till is capped by a mature paleosol, except for the two youngest reversed-polarity tills, which are nearly identical in lithology and separated by immature weathering profiles. These results seem to indicate that deposits from five major pre-Illinoian glaciations are present throughout this entire region.

Cosmogenic-nuclide burial ages provide relatively precise ages for the three earliest glaciations that reached northeast Missouri: ca. 2.4, 1.3 and 0.76 Ma. Ages of the youngest two glaciations in this area are less precise, but both are between –0.2 and 0.4 Ma. The tills in Nebraska and western Iowa have not been dated directly, but are constrained by the ages of interbedded tephra, and these limits are consistent with the burial ages in Missouri for tills in the same relative stratigraphic positions, with one exception. Two of the three normal-polarity tills in Nebraska/western Iowa are present below the 0.64 Ma Lava Creek B tephra, and thus should be between 0.64 and 0.78 Ma in age. However, only one of the normal-polarity tills in northeast Missouri is within this range. This discrepancy indicates either a problem with the age constraints or that the till sequence is more complex than yet recognized.

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## 1. Introduction

Three pre-Illinoian (pre-MIS 6) glacial tills with normal remanent magnetization overlie two or more tills with reverse magnetization throughout much of Iowa, eastern Nebraska and northern Missouri (Figs. 1 and 2). Over this region the lithology of the tills appears to present an identical stratigraphic sequence. Nevertheless, the available age constraints are not always consistent with a one-to-one correlation of these tills between the different areas. Two of the three normal-polarity tills in Nebraska and eastern Iowa are overlain by tephra dated at ~0.6 Ma (Boellstorff, 1978a,b), whereas cosmogenic-nuclide burial dates indicate that only one of the normal-polarity tills in northeast Missouri is older than this age (Balco and Rovey, 2010). In this paper we summarize the stratigraphy and lithology of pre-Illinoian tills in Iowa, eastern Nebraska, and northeast Missouri and then present similar data for a new

study area in northwest Missouri midway between the two areas with the best chronologic control. The results reinforce the view that the same tills generally span much of this region and suggest several hypotheses explaining the age discrepancy among the normal-polarity tills.

## 2. Background and lithostratigraphy

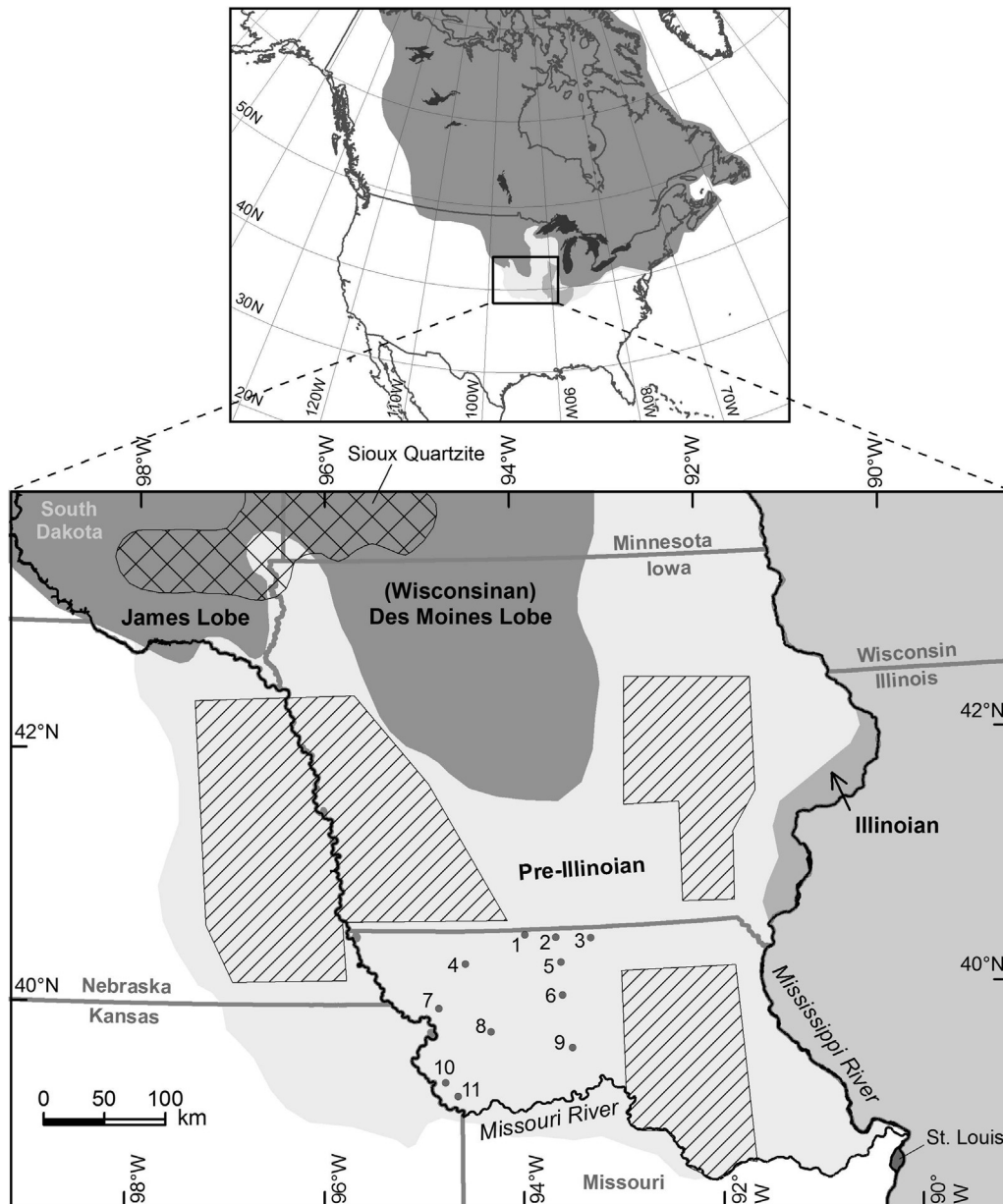
### 2.1. Nebraska and western Iowa

Prior to the 1970s the pre-Illinoian (pre MIS 6) portion of the Pleistocene in North America was limited conceptually to two stages of glaciation, Nebraskan followed by Kansan, each represented by one main till body (Kay and Apfel, 1929; Hallberg, 1980a, 1986). This simplification prevailed from the late 1800s up to the 1970s due to two main reasons. First, most early exposures were quite shallow, so the entire till sequence at any given site was rarely exposed. Secondly, terminal positions of these old tills are not preserved as distinct landforms, so regional correlation was based almost entirely on local superposition without considering

<sup>\*</sup> Corresponding author.

E-mail address: [charlesrovey@missouristate.edu](mailto:charlesrovey@missouristate.edu) (C.W. Rovey).

<sup>1</sup> Present address: Luckstone, Inc., PO Box 29682, Richmond, VA 23242, USA.



**Fig. 1.** Location map. Numerals in northwest Missouri are new sections listed in Table 3. General ages of surficial tills are given for locations west of the Mississippi River. The unglaciated area in portions of Illinois and Iowa is not shown. Cross hatching shows previous study areas discussed in text: the area in Nebraska and western Iowa shows the approximate study area of Boellstorff (1978a,b) and Roy et al. (2004), that in eastern Iowa is for Hallberg (1978a,b), and that in northeast Missouri is for Rovey and Kean (1996). Illinoian till also extends a few kilometers into Missouri just north of St. Louis. The checkered area shows the distribution (outcrop and subcrop) of the Sioux Quartzite as discussed in the text.

lithology; an upper till was assigned to the Kansan and any till observed or inferred to be below that was considered to be Nebraskan. This consensus began to dissolve in the 1960s, however, as various state geological surveys began subsurface investigations and to treat individual tills as lithostratigraphic units (e.g. Willman and Frye, 1970). Reed and Dreeszen (1965), for example, defined seven different till formations in eastern Nebraska and showed that at least four of these may be preserved in direct superposition in the subsurface. As these tills are present far beyond the borders of the younger Illinoian (MIS 6) and Wisconsinan (MIS 2) glaciations (Fig. 1), and they preserve deep weathering profiles, this sequence presented a major problem for the classical two-fold division (Nebraskan followed by Kansan) for all pre-Illinoian glacial deposits. Nevertheless, they assigned four of these tills to expanded

Nebraskan and Kansan Stages by interpreting some of the weathering profiles as interstadial. They also assigned three of these tills to the Illinoian and Wisconsin Stages despite being beyond the well-defined borders of these glaciations, because they are present above the “Pearlette Volcanic Ash”, which was thought to be restricted to the Kansan Stage or the following interglacial. Although the younger assignments proved to be incorrect (they are all pre-Illinoian), this study, in particular, demonstrated greater complexity within the pre-Illinoian and led to the next phase of investigations discussed below.

By the early 1970s geologists realized that the “Pearlette Volcanic Ash” actually consists of multiple tephras spanning a wide range in age (Izett et al., 1970; Izett, 1981; Boellstorff, 1976). Boellstorff (1978a,b) found different tephras interbedded within

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