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Kame deltas provide evidence for a new glacial lake and suggest early glacial retreat from central Lower Michigan, USA

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ABSTRACT

In association with an undergraduate Honors Seminar at Michigan State University, we studied two small kame deltas in north-central Lower Michigan. These recently identified deltas provide clear evidence for a previously unknown proglacial lake (Glacial Lake Roscommon) in this large basin located in an interlobate upland. Our first goal was to document and characterize the geomorphology of these deltas. Because both deltas are tied to ice-contact ridges that mark the former position of the retreating ice margin within the lake, our second goal was to establish the age of one of the deltas, thereby constraining the timing of ice retreat in this part of Michigan, for which little information currently exists. Both deltas are composed of well-sorted fine and medium sands with little gravel, and have broad, nearly flat surfaces and comparatively steep fronts. Samples taken from the upper 1.5 m of the deltas show little spatial variation in texture, aside from a general fining toward their outer margins. Gullies on the outer margins of both deltas probably postdate the formation of the deltas proper; we suggest that they formed by runoff during a permafrost period, subsequent to lake drawdown. We named the ice lobe that once covered this area the Mackinac Lobe, because it had likely advanced into the region across the Mackinac Straits area. Five of six optically stimulated luminescence (OSL) ages from one of the deltas had minimal scatter and were within ± 1000 years of one another, with a mean age of 23.1 ± 0.4 ka. These ages suggest that the Mackinac Lobe had started to retreat from the region considerably earlier than previously thought, even while ice was near its maximum extent in Illinois and Indiana, and the remainder of Michigan was ice-covered. This early retreat, which appears to coincide with a short-lived warm period indicated from the Greenland ice core, formed an "opening" that was at least occasionally flooded. Thick and deep, fine-textured deposits, which underlie much of the region, probably date to this time. Our work provides the first evidence of this extremely early ice retreat from central Lower Michigan, occurring almost 4000 years before the southern margin of the ice (Saginaw Lobe) had started its retreat from the state.

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1. Introduction

Deltas can form where rivers deposit more sediment into a standing body of water than can be carried away by the erosive forces of currents, waves, and tides. These forces act on the deltaic sediment, eventually determining the form, shape, extent, and sedimentology of the delta. As a result, information about conditions at the time of delta formation can often be determined from various physical characteristics of the delta (Wright and Coleman, 1972, 1973; Galloway, 1975, Bhattacharya and Giosan, 2003; Howard, 2010; Ashton and Giosan, 2011; Vader et al., 2012; Anthony, 2015). Key to our study is the dating of sandy, fluvio-deltaic sediment by luminescence techniques (Roberts et al., 2009; Wallinga and Bos, 2010; Schirrmeister et al., 2011; Shen and Mauz, 2011; Tamura et al., 2012), thereby constraining the period of delta formation.

Using GIS techniques, Luehmann (2015) developed an inventory of the Pleistocene deltas of southern Michigan but did not study any of them in detail. In our study, we focused on two small kame deltas in north-central Lower Michigan, USA, first identified by Luehmann. Both deltas formed in close association with large, sandy, ice-contact ridges that mark a stationary position of the Laurentide Ice Sheet as it retreated from the uplands of central Lower Michigan during Marine Isotope Stage (MIS) 2. Together, the two deltas also provide clear evidence for a previously unknown, high-elevation, proglacial lake, which we here informally name *Glacial Lake Roscommon*. Therefore, this study not only is the first to confirm the existence of this lake, but also constrains its age by reporting optically stimulated luminescence (OSL) ages from

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one of the deltas associated with the lake. These deltas formed as the ice margin was subaqueously grounded, and are associated with ice-contact ridges.

To that end, the purpose of this study is to examine the physical characteristics of two kame deltas on the high, sandy plains of north-central Lower Michigan. OSL data from one of the deltas were used to constrain the age of both the delta and its associated ice margin. Additionally, physical characteristics of the deltas were used to provide insight into the paleoclimate and sedimentological processes at work during their formation. This study represents the first significant research on the glacial geomorphology of this key interlobate area between the Saginaw and Lake Michigan Lobes.

2. Study area

The deltas are part of a large, sandy upland known locally as Michigan's "High Plains" (Davis, 1935; Fig. 1). The High Plains is a large interlobate area of the Laurentide Ice Sheet (Rieck and Winters, 1993), bounded in part by the Cadillac Morainic Uplands associated with the Lake Michigan Lobe to the west, and the West Branch moraine of the Saginaw Lobe to the southeast (Fig. 1; Leverett and Taylor, 1915; Mickelson et al., 1983, Blewett et al., 2009). Burgis (1977) and Schaetzl (2001) suggested that the ice that entered this region moved as a discrete lobe, rather than as part of the Saginaw Lobe to the south. Both authors argued that this ice entered the region generally from the northeast. Burgis (1977) referred to this ice as the "northwestern sublobe". For reasons that we will elaborate on later, we are naming the ice that advanced into the study area from the north and northeast during MIS 2 the *Mackinac Lobe*.

Rieck and Winters (1993), who called the High Plains region the "North-Central Interlobate," reported on the extreme thickness of the glacial deposits in this part of Lower Michigan. Glacial deposits exceed 200 m in thickness across the High Plains, and are commonly well in excess of 250 m thick (Schaetzl and Weisenborn, 2004; Schaetzl et al., 2013). Soil and sediment textures across the High Plains are almost uniformly sandy, but with Histosols in the many swamps (Schaetzl, 2002). Much of the coarse-textured, stratified sediment is not directly glacigenic, but is more commonly associated with glaciofluvial and, as we suggest below, glaciolacustrine processes (Blewett and Winters, 1995; Schaetzl et al., 2006).

Much of the High Plains north of the Au Sable and Manistee Rivers are large, broad outwash plains (sandur) of the Port Huron readvance (Leverett and Taylor, 1915; Blewett, 1991, 1995; Blewett and Winters, 1995; Schaetzl et al., 2006; Fig. 2), which reached its maximum extent between 12.7 and 13.5 ^{14}C yrs. BP (Blewett et al., 1993). The Port Huron advance ended with widespread stagnation, forming large heads of outwash that transition into flat outwash plains or sandurs. The Port Huron's head of outwash has a conspicuous ice-contact face/escarpment, forming most of the northern margins of the High Plains; its broad sandur extends far into the Plains proper (Fig. 2). Set within the northern-middle section of the High Plains are the Grayling Fingers (Schaetzl and Weisenborn, 2004). They are the highest part of this northern Michigan landscape, and serve as the drainage divide for the lower peninsula. Two of the larger rivers in Michigan - the Au Sable and Manistee - head here, where elevations are highest, and flow within large valleys through the High Plains, eventually draining into modern-day Lakes Huron and Michigan, respectively (Fig. 1).

The High Plains area has a significant amount of relief; local relief often exceeds 50–80 m. Much of the relief derives from the deeply incised river valleys and from the large morainic systems that ring the southern and western margins of the Plains (Fig. 1). Notable, however, is the large, broad basin that occupies the south-central part of the High Plains (Figs. 2, 3), which is today drained primarily by the Muskegon River (Figs. 1, 2). We name this basin the Houghton Lake basin, for modern-day Houghton Lake, which occupies its central section (Figs. 2, 3). Houghton Lake, which forms the headwaters of the Muskegon River, is not a kettle, but instead is a shallow lake that essentially fills the lowermost part of the Houghton Lake basin. The lake – the largest in Michigan – has an average depth of ≈2.3 m, with only a few small areas deeper than 5 m.

As the ice was retreating from the Houghton Lake basin, we believe that the area was variously inundated by proglacial waters, and large areas of it became infilled with sandy and clayey sediment. Burgis (1977) referred to the large areas of flat, sandy topography that lie between the ridges as the St. Helen Plain (Fig. 3). The St. Helen Plain is likely a combination of flat, sandy, glaciolacustrine plains, along with

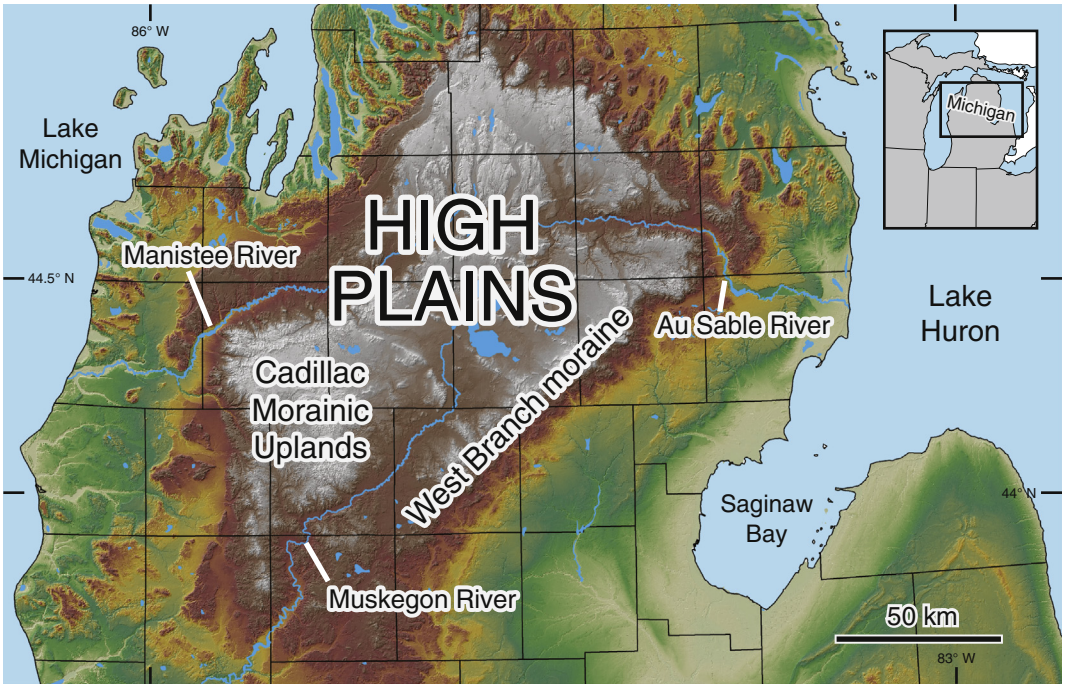

Fig. 1. Topography of central Lower Michigan on a color elevation base, showing the area known as the High Plains, and other important physical features.

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