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Reconstructing the age of coastal sand dunes along the northwestern shore of Lake Huron in Lower Michigan: Paleoenvironmental implications and regional comparisons

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ABSTRACT

Coastal sand dunes are very common in Lower Michigan, especially along Lake Michigan due to prevailing westerlies and high sand supply. These western dunes have been the focus of numerous geomorphic investigations that demonstrate a history for the past 5000 years. Coastal dunes on Lower Michigan's shore with Lake Huron are far less common and have yet to be examined. They have the potential to yield important information about regional wind patterns and their response to lake-level fluctuations. This study is the first to investigate such dunes and focuses on Manitou Beach in northeastern Lower Michigan. The chronology was reconstructed through optical dating of eolian sands.

Three dune groups were examined. The *Algonquin group* contains low-relief dunes on the Algonquin lake plain that apparently formed about 6 ka, perhaps due to a warmer/drier climate. The extensive *Manitou group* contains prominent ridges between the shore and a bluff eroded during the Nipissing high lake stand about 5.5 ka. Most ridges apparently formed shortly after the lake regressed and about 4 ka. A large, easterly oriented parabolic dune developed about 2.8 ka on the eastern side of the dune field. The *Hammond group* consists of a dunes perched on the Nipissing bluff on the west side of the study area. These dunes also formed between about 5 and 4 ka. This study demonstrates that (1) dunes here are generally older than those on the west coast of Lower Michigan, and (2) unusually strong easterly winds apparently occurred around 2.8 ka.

1. Introduction

Sand dunes are very common along the shores of Michigan (Fig. 1). These landforms are especially numerous along the eastern shore of Lake Michigan where they range from large parabolic dunes up to 60-m high (e.g., Arbogast et al., 2002a) to much smaller foredunes only a few meters tall (Olson, 1958; Van Dijk, 2004). In many places extensive dune fields line the shore for many kilometers. As a result, these landscapes collectively have a very high public profile in the state, with numerous national, state, and local parks located along the shore.

Since the middle 1990s, dunes along the west coast of Lower Michigan have been the focus of intensive geomorphic research that has centered on reconstructing the history of eolian sand deposition. The dynamics of west coast dunes (activation and stabilization) have been determined primarily by analyzing stratigraphic relationships in conjunction with radiocarbon dating and optical stimulated luminescence dating (e.g., Arbogast and Loope, 1999; Van Oort et al., 2001; Arbogast et al., 2002a; Hansen et al., 2002; Cordoba-Lepczyk and Arbogast, 2005; Fisher and Loope, 2005). The general goal of this research has been to assess the temporal relationship of growth intervals and stability with lake-level fluctuations (e.g., Baedke and Thompson, 2000; Thompson et al., 2004).

These studies demonstrate that coastal dunes along the eastern shore of Lake Michigan have a very complex history. Dune fields along the southeastern shore of the lake line much of the coast, mantle pro-glacial lacustrine plains from ancestral Lake Michigan, and contain numerous large parabolic dunes. Research indicates that most of these dunes apparently began to grow about 5000 years ago (Arbogast et al., 2002a, 2004; Hansen et al., 2002) during the Nipissing high stand (Hansel et al., 1985; Monaghan et al., 1986; Larson and Schaetzl, 2001). They subsequently grew rapidly, but in an episodic fashion, until about 2000 years ago when they stabilized for about 1500 years, resulting in the formation of the prominent Holland Paleosol (Arbogast et al., 2004; Hansen et al., 2010). This soil was buried locally between about 900 and 500

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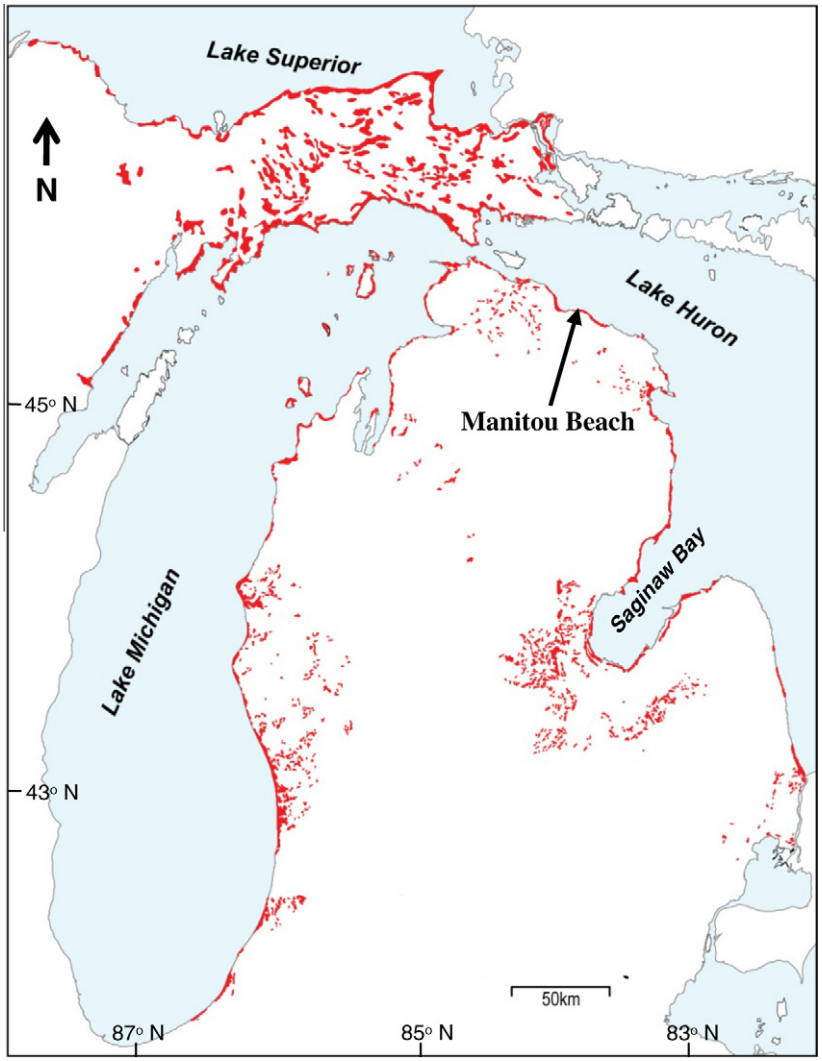

Fig. 1. Dune fields of Michigan's Lower and Upper Peninsulas (modified from Schaetzl et al., 2009).

years ago, with further episodic dune activation since that time (e.g., Arbogast et al., 2004; Fisher and Loope, 2005; Hansen et al., 2010). In general, periods of dune stability and soil formation along the southeastern shore tend to align temporally with low lake stages, whereas episodes of dune growth generally appear to have most often occurred during high lake phases when beach erosion was common and landscapes were geomorphically active.

In contrast to dunes along the southeastern shore of Lake Michigan, dunes along the northwestern coast of Lower Michigan appear to have a somewhat different geomorphic history. At a fundamental level, the landscape position of most dune fields differs from the more southerly dune fields. Most of these dune fields occur in isolated embayments (e.g., Cordoba-Lepczyk and Arbogast, 2005; Arbogast et al., 2009a,b), rather than along an entire reach of coastline. In these settings, dunes mantle lacustrine surfaces that have been raised isostatically above the water line since the Nipissing stage (Scott, 1942). Most dunes consist of individual ridges that sometimes contain imbedded parabolic forms. Other isolated dune fields, such as at Sleeping Bear National Lakeshore (Snyder, 1985) and Arcadia (Blumer, 2008) are perched high on glacial headlands.

In addition to their different landscape position, it appears that most northerly dunes began forming somewhat later in time than the dunes farther south. According to Arbogast et al. (2009a), the earliest period of intensive dune growth in this part of Michigan began about 3500–3300 years ago when dunes that are now the most inland developed. Instead of growing upward, as many dunes along the southeastern shore have through time (e.g., Arbogast et al., 2002a), dunes in northwestern Lower Michigan are progradational with progressively younger dunes found towards the modern lake. Most of the more lakeward dunes began to form about 1000 years ago, with some additional deposits accumulating in the past few hundred years (Cordoba-Lepczyk and Arbogast, 2005). In general, the oldest dune ridges are the largest (up to ~30 m high). Progressively younger dunes tend to also be systematically smaller (Arbogast et al., 2009a), suggesting a reduction in sand supply over time.

In addition to the extensive dune fields on the western coast of Lower Michigan, some dune landscapes are also found on the east coast of the peninsula (Fig. 1). These dune fields are far less extensive than those on the peninsula's west coast, are much more widely scattered, and contain a fraction of the eolian sand. Given their very low profile in Michigan, their depositional and geomorphic histories have yet to be reconstructed. These dune fields may be informative geomorphic features, however, because they might shed light on regional wind histories as they relate to the timing of eolian sand supply and dune formation. As a result, dunes on the eastern coast of Lower Michigan likely preserve a different record of eolian sand mobilization than their western counterparts and thus will contribute to our understanding of paleoenvironmental