Sedimentary Geology 223 (2010) 126–142

Contents lists available at ScienceDirect

Sedimentary Geology

journal homepage: www.elsevier.com/locate/sedgeo

Late Pleistocene glaciolacustrine sedimentation and paleogeography of southeastern Michigan, USA

Jeffrey L. Howard *

Department of Geology, Wayne State University, Detroit, Michigan 48202, United States

ARTICLE INFO

Article history:
Received 17 April 2009
Received in revised form 29 October 2009
Accepted 30 October 2009

Keywords:
Lacustrine
Pleistocene
Michigan
Mass flow
Proglacial
Laurentide ice sheet

ABSTRACT

The geomorphic, stratigraphic and sedimentological characteristics of glaciolacustrine sediments in the metropolitan Detroit, Michigan area were studied to determine environments of deposition and make paleogeographic reconstructions. Nine lithofacies were identified and paleoenvironments interpreted based on their morphostratigraphic relationships with relict landforms. The sediments studied are found southeast of the Defiance and Birmingham moraines lying beneath a lowland characterized by a low morainal swell (Detroit moraine) and a series of lacustrine terraces that descend progressively in elevation southeastward. The glaciolacustrine sediments were deposited approximately 14.3–12.4 kA BP during the Port Bruce and Port Huron glacial phases of late Wisconsinan time, and are related to proglacial paleolakes Maumee, Arkona, Whittlesey, Warren, Wayne, Grassmere, Lundy and Rouge. The glaciolacustrine section is typically 2–4 m thick and consists of a basal unit of wavy-bedded clayey diamicton overlain by a surficial deposit of stratified and cross-stratified sand and gravel. The basal unit is comprised of subaqueous debris flow deposits that accumulated as subaqueous moraine in paleolake Maumee along the retreating front of the Huron lobe. The surficial deposits of sand and gravel were formed by traction, resulting from lacustrine wave activity and fluvial processes, in lakebed plain, beach ridge and deltaic depositional settings. Much of the lake-margin sand and gravel was derived from clayey diamicton by lacustrine wave action and winnowing, and that associated with paleolakes of the Port Huron phase is largely reworked Port Bruce sediment. Paleogeographic reconstructions show that the Defiance, Birmingham and Detroit moraines, Defiance and Rochester channels, and the Rochester delta, were deposited penecontemporaneously as paleolake Maumee expanded northward across the map area. A unique type of wavy bedform is characteristic of clayey diamicton deposited by subaqueous mass flow in the study area that is useful for differentiating sediment: 1) deposited by mass flow in subaqueous vs. subaerial settings, and 2) deposited by subaqueous mass flow vs. basal till. These bedforms are a useful tool for identifying subglacial meltwater deposits, and facilitate the mapping and correlation of glacial sediments based on till sheets. The map area provides a continental record of ice sheet dynamics along the southern margin of the Laurentide ice sheet during Heinrich event H-1. The record reveals rapid glacial retreat (~0.8 km/yr) contemporaneous with the discharge of a large volume of meltwater. Evidence in the study area for subglacial meltwater is problematic, but indications that periglacial conditions persisted in the map area until ~12.7 kA BP, and extended for 200 km or more south of the ice front suggest that a frozen substrate may have contributed to instability of the LIS.

1. Introduction

Late Pleistocene glaciolacustrine sediments cover a wide lowland area in the southeastern Great Lakes region, extending across much of northern Ohio, southeastern Michigan and southwestern Ontario, Canada (Fig. 1). These sediments were deposited during the late Wisconsinan in a series of proglacial lakes (Leverett and Taylor, 1915; Teller, 1987) located along the advancing and retreating front of the Laurentide ice sheet (LIS). Previous studies have outlined the overall depositional history and paleogeography of these lakes (Leverett and Taylor, 1915; Hough, 1966; Chapman and Putnam, 1984; Eschman and Karrow, 1985; Calkin and Feenstra, 1985; Barnett, 1992; Larsen, 1999; Larson and Schaetzl, 2001). However, despite recent advances in the description and classification of glacial landsystems along the southern LIS (Colgan et al., 2003), little is known about the stratigraphy, geomorphology and depositional environments of glaciolacustrine sediments in some areas. Further study of these sediments is needed to provide data which can be compared with those from other parts of North America to better document the unstable behavior of the LIS in response to the rapid global climate changes that characterized the late Pleistocene.

In southeastern Michigan, the shorelines of glacial paleolakes and associated late Pleistocene lacustrine sediments have been mapped in a

* Fax: +1 313 577 0517.
E-mail address: jhoward@wayne.edu.

0037-0738/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.sedgeo.2009.10.006

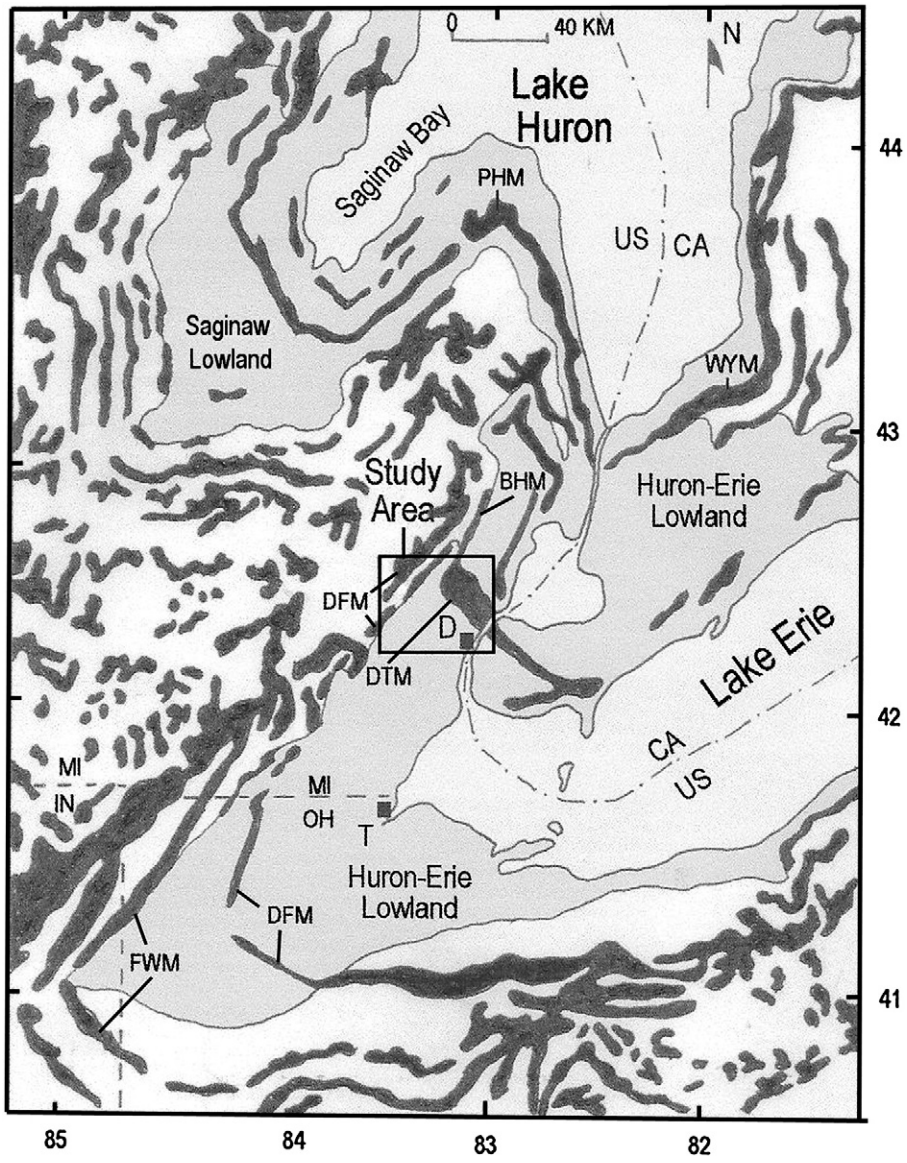

Fig. 1. Location of the study area in southeastern Michigan, and geographic distribution of late Pleistocene glaciolacustrine sediments in lowlands (shaded). Uplands include outwash (unshaded) and moraines (solid). Moraines: FWM, Ft. Wayne; DFM, Defiance; DTM, Detroit; BHM, Birmingham; PHM, Port Huron; WYM, Wyoming. Cities: D, Detroit, Michigan; T, Toledo, Ohio. Modified from Flint et al. (1959).

general way based on geomorphology or texture (Leverett and Taylor, 1915; Scherzer, 1916; Bay, 1938; Farrand and Bell, 1982; Fullerton et al., 1991; Soller, 1998). Previous studies reported the presence of beach ridges, deltaic deposits and "water-laid moraine" (Leverett and Taylor, 1915; Scherzer, 1916; Bay, 1937, 1938; Bergquist and MacLachlan, 1951), but otherwise the sedimentological characteristics of glaciolacustrine sediments are poorly known. Several geomorphic features of unknown origin are also present near Detroit, including a striking change in the trend of paleoshorelines, and the enigmatic "Detroit interlobate moraine" of Leverett and Taylor (1915). The purpose of this study was to document the geomorphic, stratigraphic and sedimentological characteristics of glaciolacustrine sediments in a representative part of southeastern Michigan, and to determine their geologic significance. The objectives were to: 1) characterize and determine the origin of glaciolacustrine landforms near Detroit, Michigan, 2) document lithofacies and interpret depositional environments, 3) develop a depositional model and make paleogeographic reconstructions, and 4) examine possible correlation with Heinrich event H-1 and evaluate implications for deglaciation of the LIS. Analysis of the sedimentary sequence composing the Defiance moraine, and other nearby glacial landforms, is beyond the scope of this study.

2. Geologic setting and study area

The study area (Fig. 1) is part of an extensive late Pleistocene glacial landscape that was formed by successive advances of the LIS that became progressively more lobate and less extensive geographically over time. The ice sheet covered all of the Great Lakes when it reached its maximum extent about 20 kA BP (Farrand and Eschman, 1974; Mickelson et al., 1983). During subsequent maxima, at about 15, 13 and 11 kA BP, the region was affected by three distinct glacial lobes (Saginaw, Huron and Erie) that deposited the lobe-shaped pattern of moraines surrounding each respective modern lake (Fig. 1). Proglacial lakes developed primarily along the front of the Huron and Erie lobes, and fluctuated in size and shape as the ice sheet advanced and retreated over the course of late Wisconsinan time (Calkin and Feenstra, 1985; Eschman and Karrow, 1985; Teller, 1987).