

Glacial Isostatic Adjustment and Predictions of the PaleoHydrology of the Great Lakes Region of North America

James A. Clark, Kevin M. Befus and Glenn Sharman

Department of Geology and Environmental Science, Wheaton College, Wheaton, Illinois,
USA 60187

james.a.clark@wheaton.edu

Over the last century geological studies of the ancestral Great Lakes have confirmed that the large surface load of the Laurentide Ice Sheet deformed the region causing tilting of ancient lake shorelines spanning the last 18,000 years. We have developed a method, utilizing a numerical model of glacial isostatic adjustment combined with GIS and high resolution digital elevation models to predict the paleo-topography at 1000-year intervals over this time period. GIS was then used to recreate the paleohydrology of the Great Lakes during the past 18,000 years. Predictions include the extent of late glacial, postglacial and Holocene lakes and their associated outlets and bathymetries. This predicted history of the Great Lakes is similar to that obtained from a century of detailed field studies but our method uses only the present digital elevation model, a prescribed ice sheet chronology and an assumed earth viscoelastic rheology. Predicted shorelines are readily downloaded into a portable GPS unit and used to assess predicted shoreline locations in the field. Predictions of the relative elevations of controlling outlets indicate how the isostatic adjustment process forced the change from one outlet to another. Furthermore the geometry of outlet channels and the predicted water level and lake volumes permit an estimation of the discharge that likely occurred during outburst floods as the retreating ice sheet uncovered lower outlets. Predicted water velocity from the outburst flood of a small proglacial lake in Wisconsin west of Lake Michigan is sufficiently large to explain transport of the 2-meter boulders found in the outlet channel. Because the paleo-topography, ice sheet thickness and lake levels are known it was possible to use a finite difference groundwater model to estimate groundwater flow during ice sheet retreat. A detailed analysis of the Wisconsin region indicates the groundwater hydrology is strongly affected by the changing ice loads and lake water stage, while the rebounding earth surface contributed to a lesser extent. Groundwater flow direction there is predicted to reverse direction during deglaciation. Using the predicted paleo-topographic surface it was possible to predict where changes in river drainage were caused by the isostatic adjustment process. GIS hydrology modeling software was used to predict Great Lakes river drainage patterns during the past 10,000 years and hundreds of regions where the patterns alter through time were highlighted for further study in the field.