Lake sediment erosional unconformities and possible lowered lake level at 7.6 ^{14}C ka in the Lake Simcoe basin, Ontario

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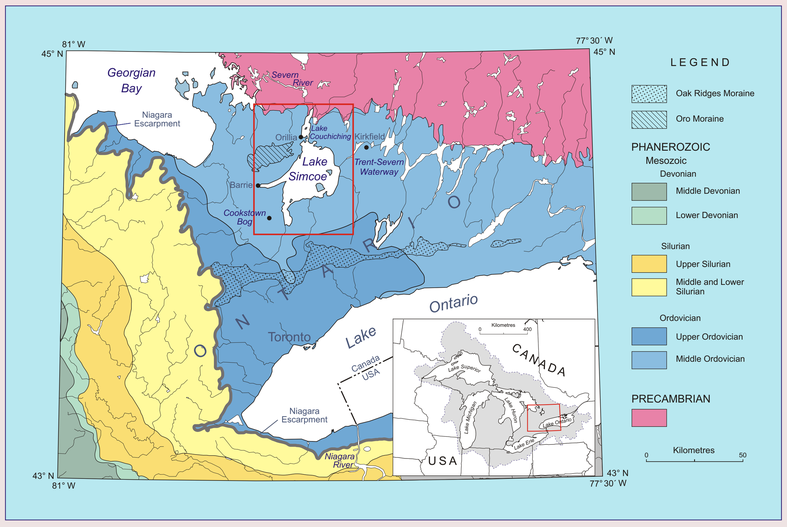
1. DRY CLIMATE AND LAKE LEVEL LOWSTANDS

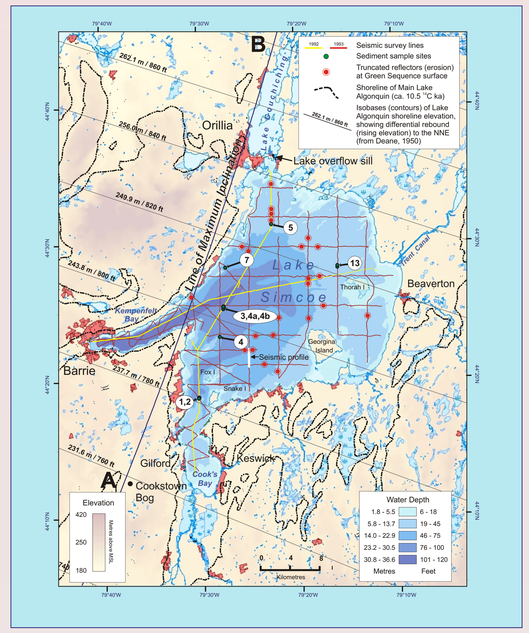
Recent studies show that climate-driven, hydrologically closed lake basins without overflow existed during lake level lowstands in the Michigan and Huron basins (see Great Lakes inset map on location map to right) at about 7.6 ^{14}C ka (Lewis et al., in press). Former interpretations of the evolution of these basins assumed that they were open, overflowing lakes with discharge to downstream rivers (Hough, 1962; Moore et al., 2000). Closed lake levels are driven below their outlets by a dry climate causing an excess of evaporation loss relative to inflow by precipitation, runoff and groundwater (Bengsston and Malm, 1997). A severe impact by an early Holocene dry climate generated the closed lowstands in the Michigan and Huron basins and may have affected, due to the broad scale of atmospheric circulation, other lakes in the Great Lakes basin (Lewis et al., in press). Here, we present geophysical observations of low water level in the Lake Simcoe basin which may be evidence to support an episode of severe dry climate impact in the Great Lakes basin about 7.6 ^{14}C ka (8320-8510 cal BP).

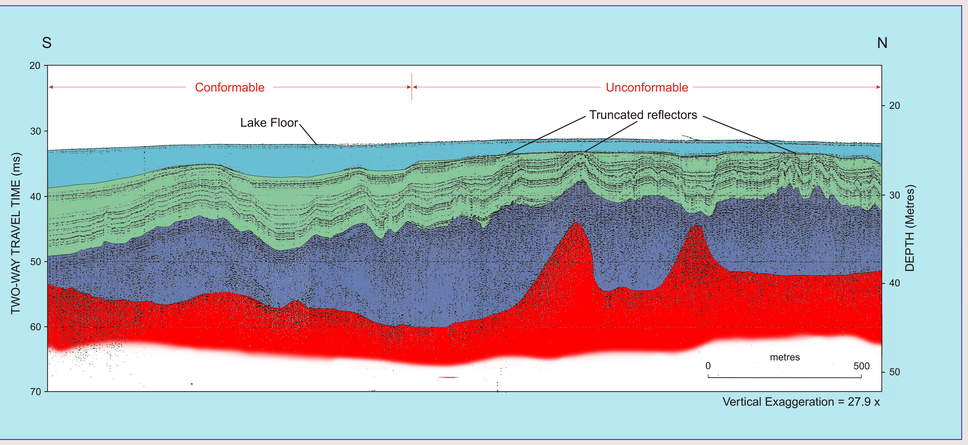
From 1992 to 1998, the Geological Survey of Canada undertook geophysical surveys and sediment sampling in Lake Simcoe, the largest lake (726 km^2) within southern Ontario (Todd et al., 2003; Todd et al., 2004). Lake Simcoe contains a record of sedimentation, and therefore climate, in late-glacial and postglacial time. Because of the lake's proximity to the Huron basin (see location map to right), Lake Simcoe may also have been impacted by the early Holocene dry climate registered in that basin. In this poster we present evidence of an unconformable surface, which truncates underlying sedimentary units, discovered in seismic reflection profiles in Lake Simcoe. The unconformity is interpreted as evidence of wave abrasion in a possibly closed lake at 7600 ^{14}C BP caused by early Holocene dry climate.



2. SURVEY AND SAMPLING

Geophysical survey lines on Lake Simcoe were undertaken on a 4 kilometer grid with a zigzig pattern employed in Cook's Bay and Kempenfelt Bay (see map at right). A single-channel boomer system (1800 Hz to 6-8 kHz) and a multichannel airgun system (400-600 Hz) were deployed to image the subsurface up to 40 m in depth. Based on interpretation of seismic reflection profiles, geological targets were identified and sediments were sampled where targets were at the lakebed using a mini van Veen grab and Benthos gravity corer (green circles on map). Samples from these short cores were analyzed for tree, shrub and herb pollen.





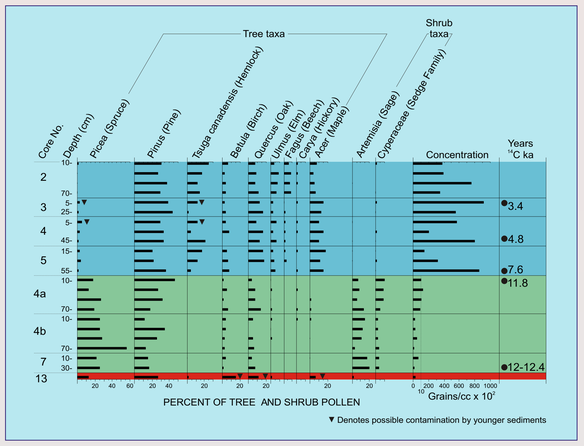
3. LAKE SIMCOE SEISMOSTRATIGRAPHY REVEALS UNCONFORMITIES

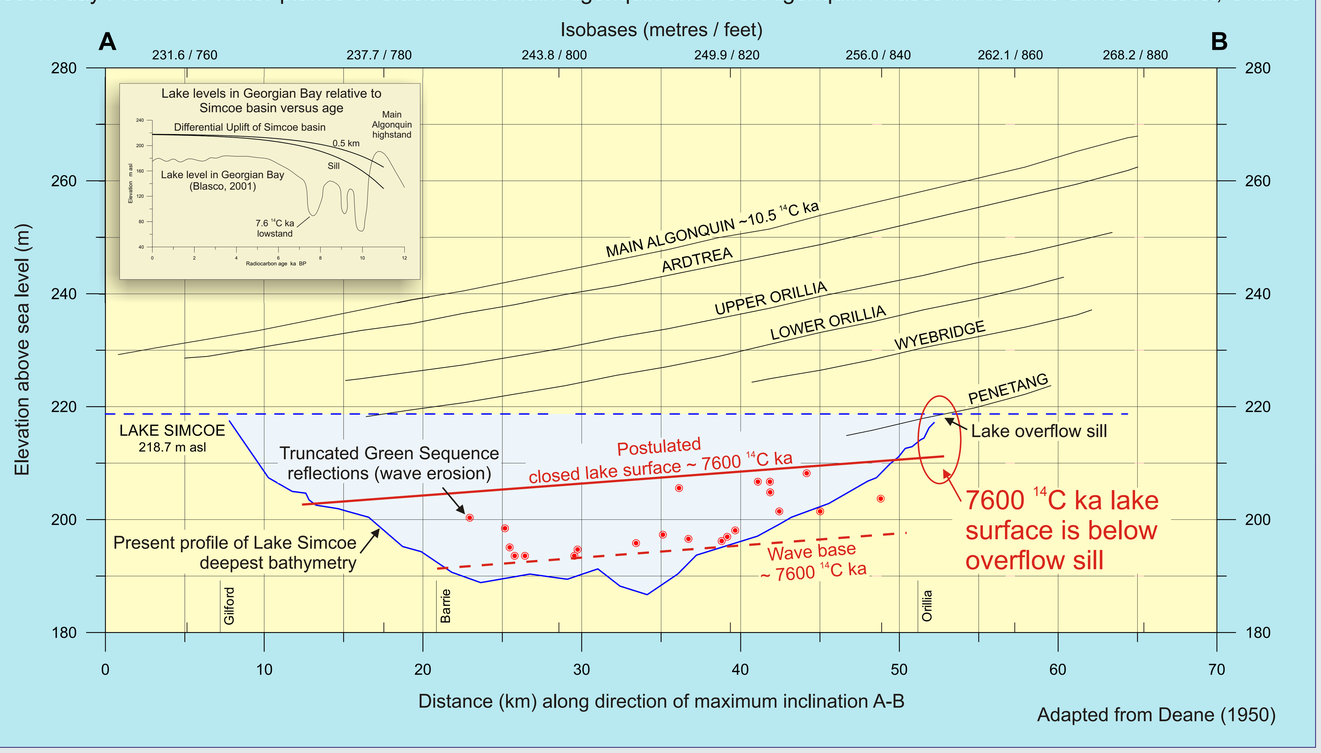
To the left is a high-resolution seismic reflection profile from Lake Simcoe (profile location shown by white line on survey line map at upper right). Acoustic basement Red Sequence sediments are interpreted as till or subglacial sediments and are unconformably overlain by Purple Sequence sediments interpreted as Newmarket Till. The overlying Green Sequence exhibits a conformable drape reflection configuration and is interpreted as glaciolacustrine fine sand, silt and clay of Late Wisconsinan age (about 11.9–10.4 ^{14}C ka; mostly sediments of glacial Lake Algonquin). Truncated Green Sequence reflections, as illustrated on the right half of the seismic profile, are widespread throughout Lake Simcoe and identify parts of the Green Reflector sequence boundary as an erosional unconformity. Sediments of the Blue Sequence overlie the top of the Green Sequence and are interpreted as mud deposited during Holocene (post-glacial) time in Lake Simcoe.

4. POLLEN ASSEMBLAGES IN LAKE SIMCOE GRAVITY CORES

Pollen assemblages in the Lake Simcoe cores were correlated to a ^{14}C-dated pollen diagram from the Cookstown Bog (see location map at upper right) to provide estimates of sediment age. The correlation for Core 5 (see pollen diagram at right) suggests an age of about 7600 ^{14}C (8.3-8.5 cal ka BP) for the base of Blue Sequence mud overlying the eroded surface of Green Sequence glaciolacustrine sediment. Thus, it is possible that the erosion which preceded mud deposition is also about 7.6 ^{14}C ka.

In the pollen assemblage diagram, there is a change in scale for the pollen concentration profile for cores 4a, 4b, 7 and 13. The background pollen assemblage colours (red, green, blue) correspond to assigned seismostratigraphic sequence colours (see seismic profile at far left).





5. LOW LAKE LEVEL EVIDENCE OF POSSIBLE DRY CLIMATE IMPACT

The truncation of Green Sequence sediments is interpreted as evidence of wave abrasion in a low-level lake. The diagram at left is adapted from the strand line diagram of the Lake Simcoe area compiled by Deane (1950) showing the present elevation of differentially uplifted shorelines projected along isobases to AB, the line of maximum inclination (see Lake Simcoe survey map top right). The locations of Green Sequence unconformities (see seismic profile above left) were projected to line AB using Deane's isobases. Recent research indicates that the adjacent Lake Huron basin has been impacted by dry climate and levels have dropped below outlets at 7600 ^{14}C BP in a closed lake condition (Blasco, 2001; Lewis et al., in press).

As sediments overlying the Green Sequence erosion surface appear to be younger than about 7600 ^{14}C BP, it is possible that waves of a low-stand lake of similar age caused this erosion in the Simcoe basin. Assuming that strong winds and wave generation at 7600 ^{14}C BP were similar to present conditions in the Great Lakes, we compute the wave base to be 13.4 m below lake level for 90 km hr^{-1} extreme winds with 20 km fetch using the approach of Gilbert (1999) for eastern Lake Ontario. The water plane (surface) for this hypothesized lake (see diagram at left) intersects the outlet area 7.5 m below its sill. The lake would have thus been hydrologically closed, a condition that results only from excessive evaporation in a dry climate.

RECOMMENDATION

We recommend that a coring program be undertaken in Lake Simcoe to recover and compare complete sediment sequences in deeper water and through the unconformity between the Blue and Green sequences to validate and establish the timing and duration of the lowstand postulated here. Additional cores through the Blue-Green sequence boundary in progressively shallower water should be studied to document the range of low Holocene water levels that occurred in the Lake Simcoe basin.

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