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OXBOW LAKES AS GEOLOGICAL ARCHIVES OF HISTORICAL CHANGES IN CHANNEL SUBSTRATE; SWAN CREEK METROPARK, TOLEDO, OHIO

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Abstract

Urbanization significantly impacts hydrologic systems, including changes in flood magnitude and frequency, sediment input and channel storage, and channel morphology. As attempts are made to restore urban rivers, a complication is understanding human-caused changes in channel substrates. This study looks at the sedimentary record in oxbow lakes as an archive of historical changes in channel substrates. The study area is a focused on approximately 3.5 km reach of Swan Creek (a tributary of the Maumee River in NW Ohio) that contains 4 oxbow lakes of various ages and in-fill histories. The study area has changed over historical times from swamp forest to agricultural fields to suburban housing tracts and light industry. Photographs from 1963 and 2005 and topographic maps from 1935, 1951, 1964, and 1994 were collected from the USGS. These were georeferenced using ground control points, input into ArcGIS, and the RMS error was calculated to be 5.7 meters when comparing each historical image to the 1994 image acquired from the USGS and used as a base map. It was determined that one of the oxbows formed during a channel avulsion event in 1963, based on both the historical aerial photos and historical flood records. Trenches in this oxbow show the pre-1963 channel consisted of coarse-grained sand and fine pebbles. The sediment fill also contained anthropogenic materials, which may be used to date stratigraphic layers. The other 3 oxbows represent channel switching events older than the available historical aerial photos and topographic maps (pre-1930s), which indicate they formed before this period, possibly from the historic 500-year flood of 1913. The channel substrates in these oxbows are appreciable finer-grained (fine- to medium-grained sand). In contrast, the modern channel contains coarse gravel, some of it anthropogenic materials (bricks, etc.), shell debris, and significant submerged wood loads. Trenches were dug near the pre-1963 oxbow and a large pre-1930 oxbow. Depth extended to the water table, which ranged from 2-3m. On-going work will include calculating changes in channel path length and sinuosity resulting from avulsions and cut-offs, match each avulsion to historical flood data, characterize the sedimentary record of each in-filled oxbow sequence, and relate these changes to historical changes in land-use.

Study Area

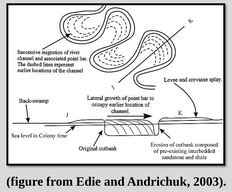
Swan Creek flows thru the city of Toledo, before joining the Maumee River shortly before flowing into Lake Erie. This study focuses on a 5,200 m reach flowing through Swan Creek Metropark.

Left: image shows the field area (2011) with sampled oxbow lakes outlined in red. Modern channel samples are thanks to an ongoing project investigating grainsize changes throughout a meander bend.

Left: image shows the field area in 1940, before designation as a metropark. Note the visible channel changes in the sample locations (boxes) as above.

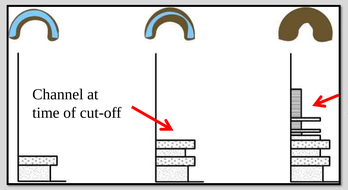
Meandering River Behavior

Rivers meander due to bank erosion and resulting channel shifts. Lateral accretion deposits form at the bends, as shown below. The characteristic fining-upwards sequence can be used to identify these point bar deposits. In contrast, channel cutoffs, produce deposits which have a channel base, but are then filled in by lake deposits.



(figure from Edie and Andrichuk, 2003).

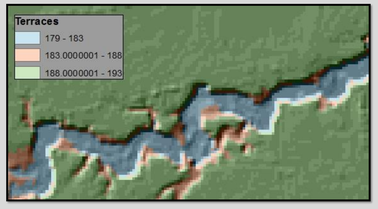
Oxbow Lake Stratigraphy



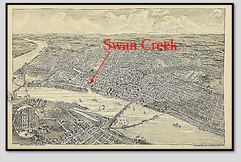
Above: In contrast to the fining-upward sequence seen in point bars, cut-offs show an abrupt transition to fine-grained lake and wetland deposits interbedded with occasional coarser-grained flood deposits (sourced from the adjacent active channel).

The channel substrate at the time of the cut-off is a geological archive of historical channel conditions. The age of the cut-off may be determined from historical accounts, the historical aerial photographs, or the ages of flood horizons in the lacustrine sequence overlying the previous channel.

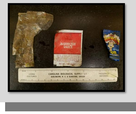
Anthropogenic Activity & Landuse



Post-glacial meltwater terraces and a lower "fill terrace" probably related to anthropogenic changes in sediment budgets.



Within the past 150 years, the region has changed from forested wetlands to agricultural fields and (post-1950) to urbanized areas (historical image from Clark Waggoner). These land-use changes had major impacts on sediment and water budgets, presumably affecting channel migration and cut-offs.



This photograph shows evidence of human impact on the area through litter. The debris from this image may prove useful when examining the stratigraphy of the younger trenches. Because labels and marketing changes, certain products can help relatively date the sediment layers containing them.

Methods

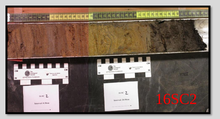
This project involves three main research components: field work, analytical work and laboratory work. The field work will consist of the data collection process, which includes trenches, push cores, and vibracores. The laboratory analysis will mainly take place at Bowling Green State University, excluding carbon dating, which will be contracted out to a laboratory. Finally, analytical work includes work done using historical imagery and ArcGIS software.

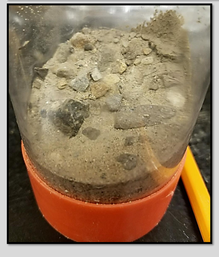
The image on the right is an example of a sample sent off for carbon dating. The data collected will aid in stratigraphic conclusions. Other carbon samples include large pieces of buried wood.

Sediment Budget

It is important to consider sediment budget when studying the impact of human activity on fluvial deposits. Changes in landuse often contribute to changes in sediment erosion and deposition. An additional factor is storage. Sediments need a basin to be stored in, in order to leave a deposit. As a result, changes in sediment input and output will cause changes in storage, leading to depositional events.

Results





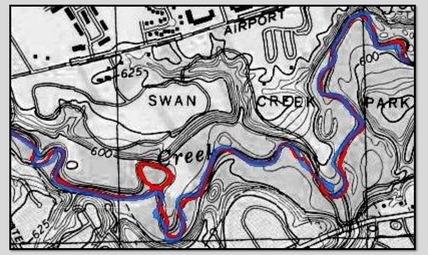
16SC1: This pushcore has a muddy lake layer, overlying light brown sand layers.
16SC2: This pushcore also is characterized by a muddy brown layer at the top of the core. Below this layer is an orange sand layer.
16SC3: This pushcore exhibits a change from underlying orange sands to overlying light brown silty muds.
16SC5: This pushcore consists of a range of layers. There are muds to fine sands. There is also a layer of gravel and shell debris at the top of this push core, indicated with a large red arrow. There are a few gravel clasts at the base as well.
16SC8: This pushcore consists of a gray sand with wood debris at the base of the core. This wood has been sampled for dating.

The above image is a small pushcore, consisting of a sample of a fluvial pavement. This channel substrate consists of sand mixed with gravel. There are also many clams in the channel. The modern channel appears to have mixed substrate. Many locations have an armored pavement; however there are patches of modern channel consisting of a muddy channel substrate.

Historic image analysis shows that there has been minor shifting in the river over the past few decades. Most of this movement is lateral shifting, without major abandonment events. In addition, historic image analysis has shown that the oxbow lakes in the park predate the available aerial photography. Historical topographic maps are available, but they do come with some degree of uncertainty as they are different mediums. There is one oxbow, South of the Brown Trail in the park that was shown as part of the channel in 1934 and seems to be largely cut off in 1940. This is likely the youngest oxbow in the park with an age sometime between 1934 and 1940.

The other oxbow lakes in the park that precede the youngest oxbow in age have yielded trench and core data with what appears to be finer grain sizes. In contrast, a trench along the youngest oxbow in the study area yielded 16SC5. This core has grain sizes much larger than the visible clasts in the rest of the cores. The largest sizes are gravel, and shell debris can be found. This is comparable to that of the visible channel substrate in the modern channel.

Results



Left: This image shows the 2011 positon of Swan Creek (Blue), as compared to 1940 Swan Creek (Red).

Ongoing Work

Grainsize data for this project, as well as another project have yet to be measured. In addition, there is one more planned day to collect vibracore data.

It is expected that within the coming weeks, geochronology data will arrive from the laboratory. Vibracores and trench data will be compiled into stratigraphic sections.

Preliminary Results

- **The impacts of urbanization can be recognized through the differences between the oxbow lakes. Pre-Urbanization oxbow lakes appear to be characterized by fine grained channel substrate, while post-urbanization oxbow lakes appear to have an armored pavement.**
- **There is an asymmetric distribution of oxbow lakes within the Park. All oxbow lakes within the metropark are located along the North side. There are oxbow lakes along the South, but not within the reach that runs through the park.**
- **Much of the modern migration of Swan Creek includes lateral shifts.**
- **The ages of the oxbow lakes are older than initially suspected, which may correlate to major land use changes in its history.**
- **Major land use changes would have changed the sediment budget, potentially influencing the channel abandonment events.**