Using The Fluvial-Lacustrine Interface In A Glaciodeltaic Deposit To Redefine The Valparaiso Moraine, Berrien County, Michigan, USA

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ABSTRACT

The Valparaiso morainic system in eastern Berrien County, southwestern Michigan, is a 10-18 km-wide continuous belt of collapsed glacial landforms. Previously, the composition of the moraine belt was inferred to be of unsorted materials, including coarse- to fine-textured tills, and some stratified deposits. The moraine boundary was defined primarily on classical geomorphic evidence of relative high elevation, "kettled" or "swell & sag" topography, presence of boulders at the surface, steep ice-contact face, etc. Recent mapping, which included well records, geophysics, and test drilling, revealed the moraine to be composed of glacial meltwater deposits, commonly 30 m thick. The deposits include >50 separate glaciodeltaic morphosequences, mostly ice-marginal deltas, graded to proglacial Lakes Madron (new name) and Dowagiac. Both Lake Madron and younger Lake Dowagiac were dammed to the south by the older Kalamazoo moraine and to the west by the retreating edge of the Michigan ice lobe. Each delta grades from ice-contact landforms underlain by coarse-grained facies at its head to non-collapsed landforms underlain distally by fine-grained facies. Proximal deltaic deposits are coarse grained, locally containing boulders and lenses of poorly sorted flowtill with zones of collapsed bedding along ice-contact slopes. A composite section of a delta, derived from a gravel pit exposure extended by a drillhole showed, from top to bottom: 6 m glaciofluvial sand and gravel; 4.5 m deltaic foreset sand, silt, and gravel, dipping 10º SSE; 9 m pebbly sand; 10.5 m ft coarse to medium sand; 8 m medium to very fine sand and silt at the base; overlying 1.7 m of gray silty diamicton.
Deltaic glaciofluvial plains of Lake Madron grade from 256 m altitude to distal distributary plains at 241 m, controlled by the lake level and spillway at 239 m. Lake Dowagiac deltas have fluvial plains as high as 250 m graded to distal plain altitudes of 225 m. The Lake Dowagiac spillway crossed older deposits south of Niles, MI. Both lakes discharged through the St. Joseph River valley south across the regional drainage divide. Wide heads of deltas trending ENE within the Valparaiso moraine belt document ice-margin retreat positions, similar to older ice margins within the outer Kalamazoo Moraine. Correlating the elevations of the heads of deltas and the fluvial/lacustrine interface allowed us to group glaciodeltaic morphosequences by outlet/proglacial lake level and therefore, infer the location of nine ice margins at various stages during construction of the Valparaiso Moraine. The resulting map shows shingled deposits from a highly undulating ice margin, rather than the single, linear margin shown on older maps.

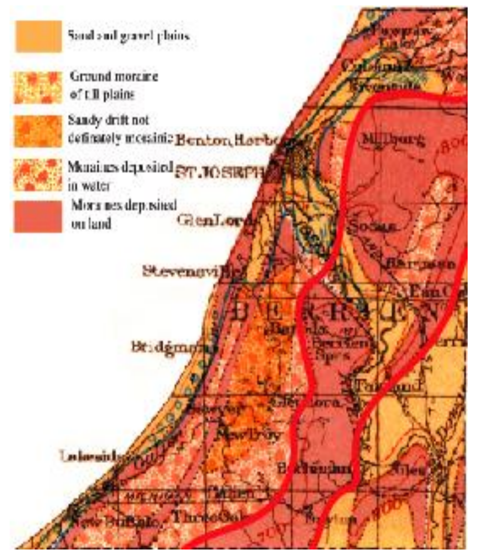
BACKGROUND

Mapping Pleistocene deposits has the advantage that, due to their recent deposition, they retain much of the original topography. Hence, morphology has played a role in the development of glacial theory. This has been a bane as well, since one of the problems plaguing glacial geology is our historic legacy of using morphology as a proxy for sedimentology. Leverett and Taylor (1915) described the internal characteristics of the glacial deposits of Michigan and Indiana only in the few areas where such data was available. Out of necessity, they relied on morphology to make conclusions about landform genesis. Based on his literature survey, Flint (1957) defined moraine as "an accumulation of drift having a constructional topographic expression … independent of the surface underneath it, and having been built by the direct action of the ice." The use of a largely topographic classification led Leverett and Taylor (1915) and many others to misclassify as moraines many landforms we now know to be composed of fluvial deposits.

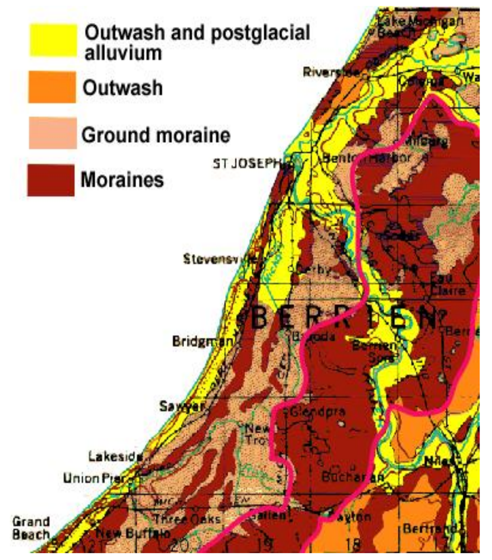
Jahns' (1941 and 1953) mapping efforts in Massachusetts led him to recognize that glacial landforms appeared associated together in a genetic series. Jahns called these associations of features "sequences" (Jahns, 1941, p. 1910), in the sense that landforms could be traced from sub-glacial to sub-aerial ice-contact to proglacial types. Ice-front positions were determined by mapping the locations of "…ice-contact meltwater deposits, such as eskers or ice-channels fillings, kames, kame terraces [and] kame plains…" (Koteff, 1974, p. 122). The terminology choice of "sequence" by Jahns (1941, p. 1910) was "unfortunate" (Koteff, 1974, p.122), due to the extant use of the word in a time-transgressive manner. Jahns intent was to use the term to mean deposits being formed contemporaneously. Koteff and Pessl (1981) subsequently renamed the term "morphosequence" (as a combination of morphologic and sequence) both to eliminate the confusion with the time connotation and to add the geomorphology component of the mapping technique. Morphosequence analysis is not just a morphologic examination of topography. It must also include the distribution of texture and sedimentary structures and reconstruct the grade and base level relationships of the entire depositional sequence.

Previous maps of Moraines in Berrien County

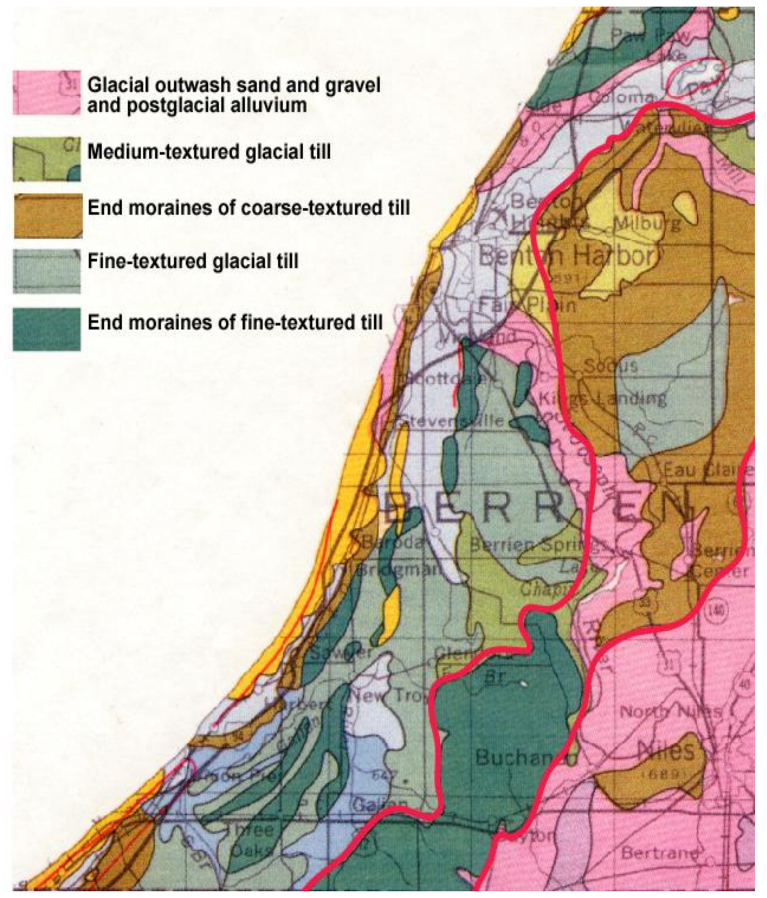
Valparaiso Moraine outlined in red



Leverett, 1912



Martin, 1955



Farrand, 1982

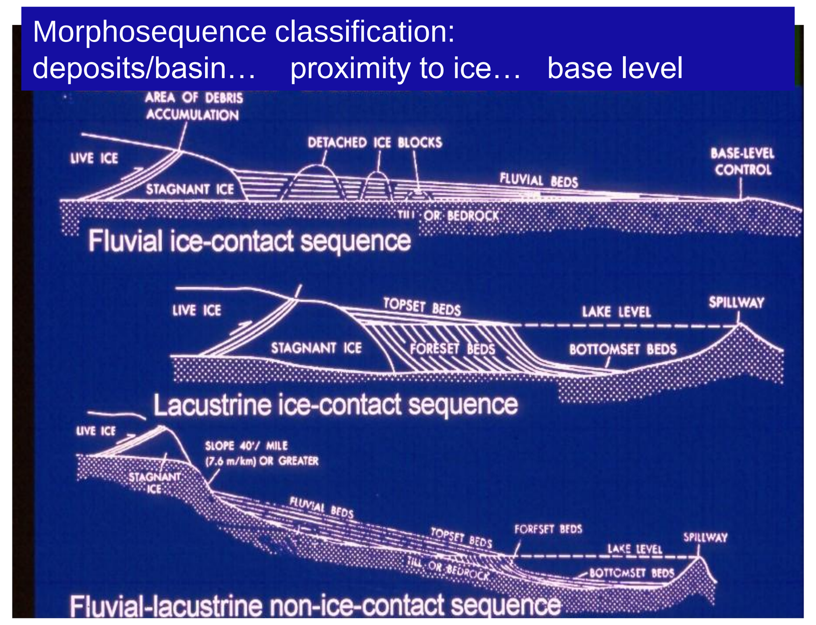
MORPHOSEQUENCE CONCEPT

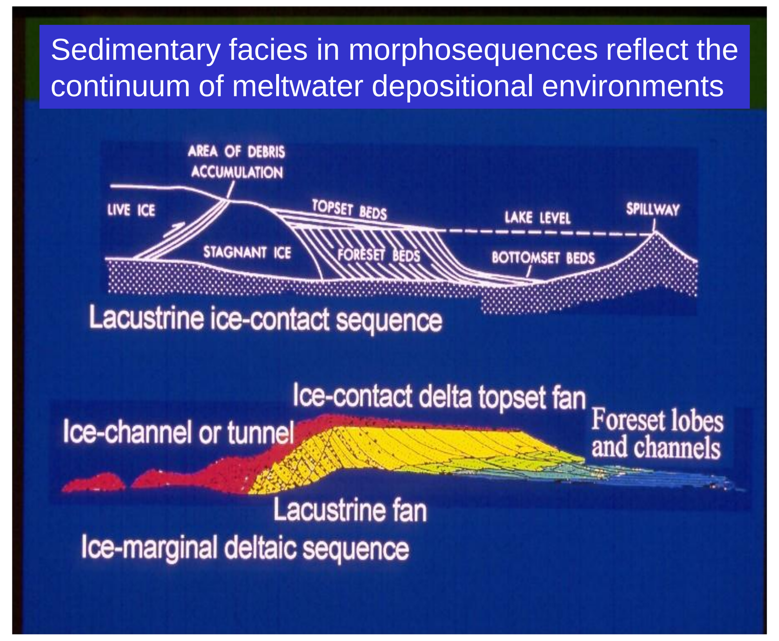
DEFINITION – A body of meltwater deposits composed of a continuum of land forms, grading from ice-contact forms (eskers, kames) to non-ice-contact forms (flat valley terrace, delta plains), that were deposited simultaneously at and beyond the margin of a glacier, graded to a specific base level.

Koteff's (1974) fieldwork as well as a review of his colleagues' mapping led him to recognize eight morphosequence types:

A. Fluvial ice-contact sequence
B. Fluvial non-ice-contact sequence
C. Lacustrine ice-contact sequence
D. Fluvial-lacustrine ice-contact sequence
E. Fluvial-lacustrine non-ice-contact sequence
F. Lacustrine-fluvial ice-contact sequence
G. End moraine and associated outwash
H. Glaciomarine

As can be deduced from the nomenclature, the key features of the idealized sequences (examples below) are whether it begins in contact with the ice and the existence and distribution of fluvial and lacustrine units. Of lesser importance are moraines and coastal influences. Jahns (1941) suggested that drawing profiles of outwash plains at a vertical exaggeration of 20x would readily illustrate the form of the sequences and show the position of former ice margins. These can then aid in restoring the collapsed outwash plain to its original form.
It should be noted that Koteff (1974) and Koteff and Pessl (1981) believed that basal shearing was responsible for sediment transfer from ice entrainment to the fluvial system. Gustafson and Boothroyd (1987) and Bjornsson (1998) showed this to be incorrect. The main source of water and sediment transfer out of the glacier is from subglacial drainage. However, this does not alter the utility of the morphosequence concept.





APPLICATION TO BERRIEN COUNTY

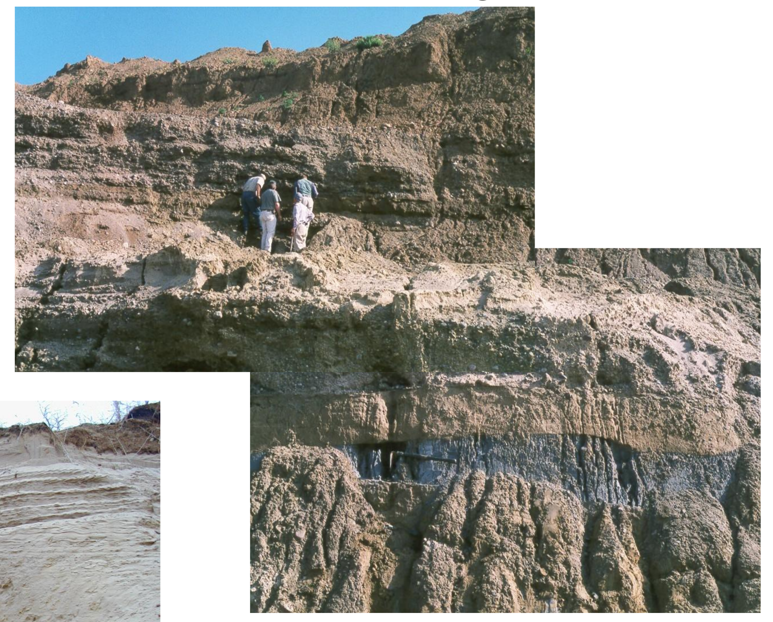
SURFACE DEPOSITS AND GLACIODELTAIC SEDIMENTARY FACIES

Fine sandy silt eolian loess deposit
Sand and gravel glaciofluvial topset facies

Fluvial-lacustrine interface

Sand and gravel deltaic-foreset facies

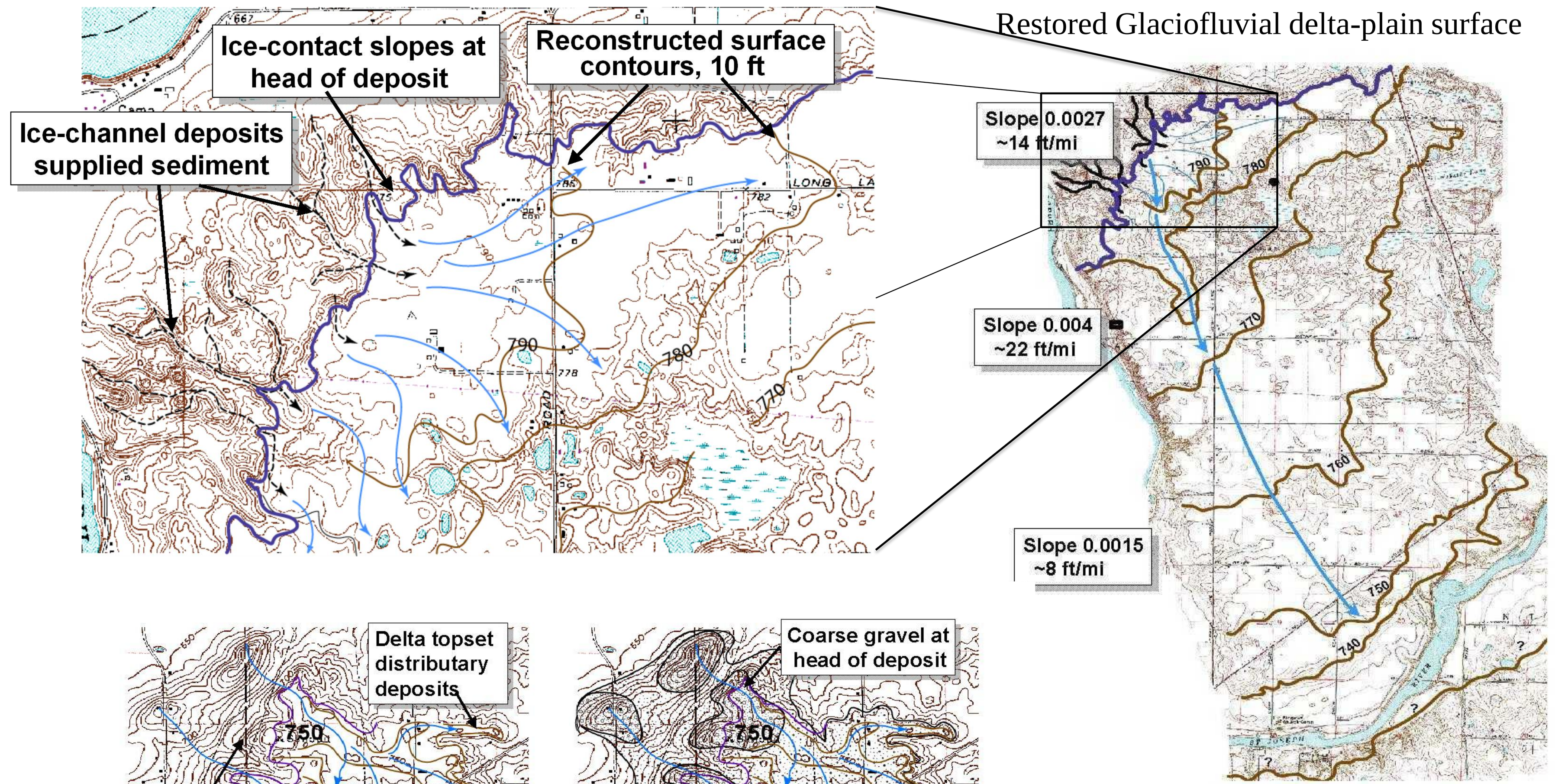
Foreset bed exceeded 4 m thickness at this location.

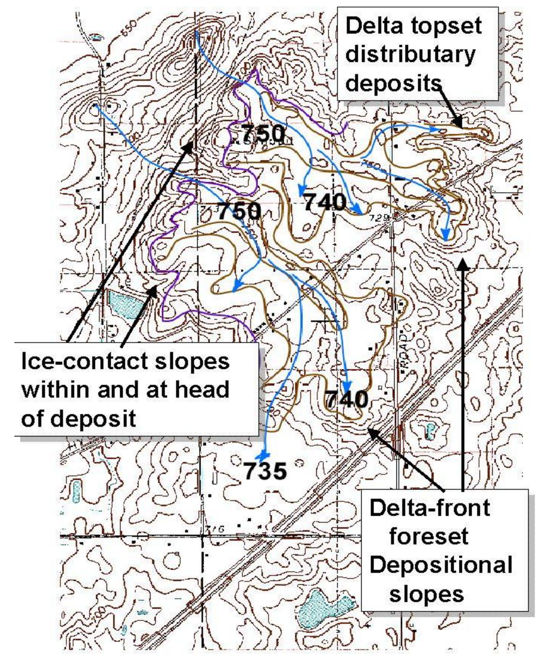


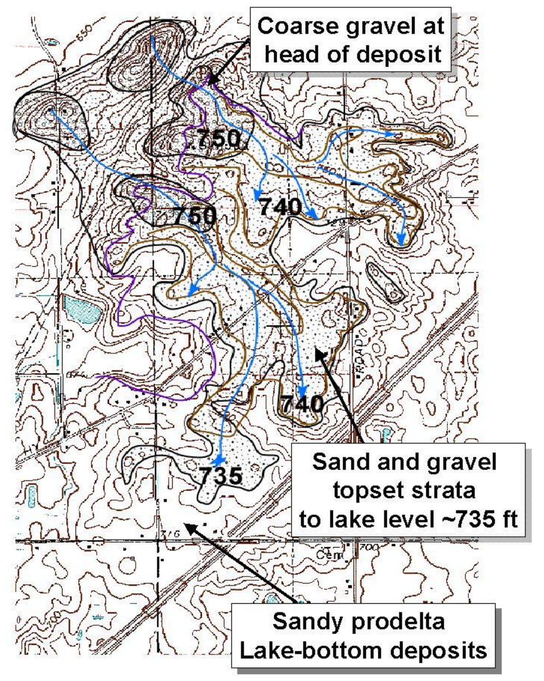
Topset sand and gravel lying unconformably above bottomset lacustrine silt. Yields minimum lake level.

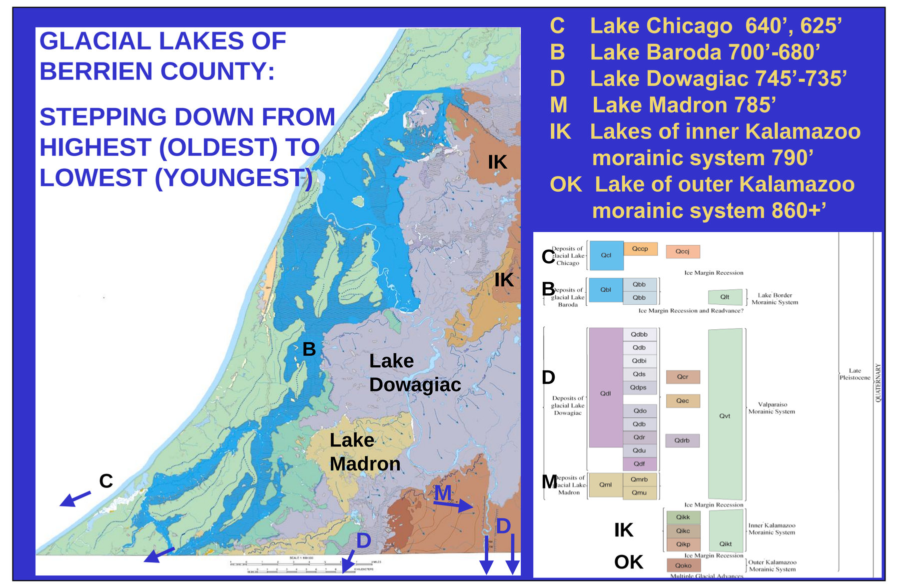
Prodelta laminated fine sand with occasional pockets of ice-rafted stones

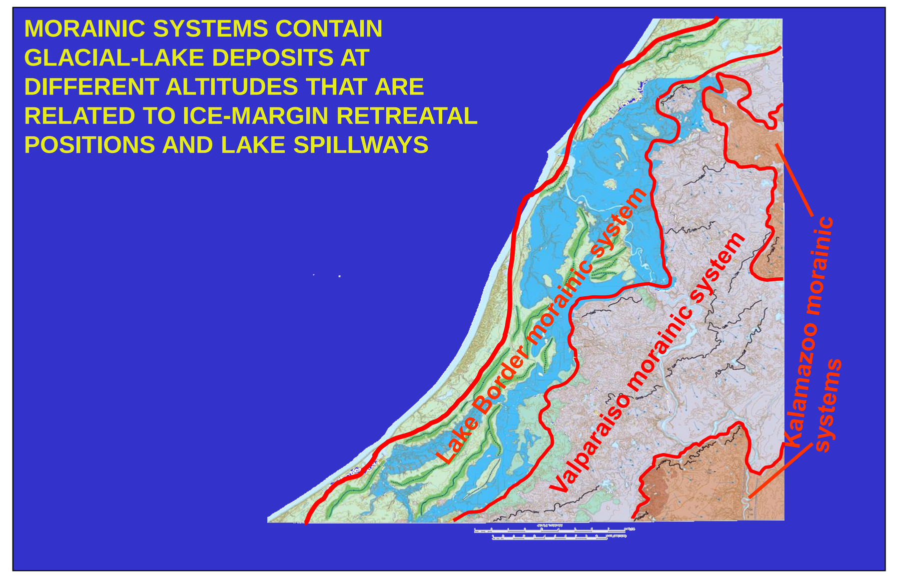
Horizontal laminated lacustrine silt eroded and overlain by ripple-drift set fine sand. Traction currents from approaching delta front.

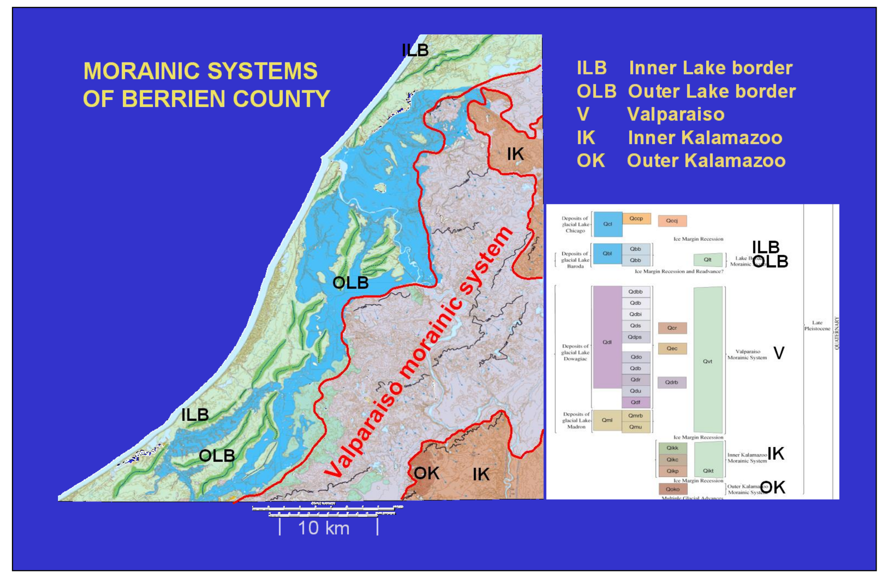












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