

AN INTEGRATED ARCHITECTURAL ELEMENT APPROACH TO THREE-DIMENSIONAL GEOLOGIC MAPPING OF THE HUNTERTOWN AQUIFER SYSTEM IN NORTHEASTERN INDIANA

Shawn Naylor (snaylor@indiana.edu), Center for Geospatial Data Analysis, Indiana Geological Survey, Indiana University, Bloomington, Indiana. Greg Nelsón (nelsóng@indiana.edu), Department of Ġeological Sciences, Center for Geospatial Datá Analysis, Indiana Úniversity, Bloomington, Indiana. Andrew Gustin (angustin@indiana.edu), Department of Geological Sciences, Center for Geospatial Data Ánalysis, Indiana University, Bloomington, Indiana.





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A three-dimensional geologic model of the Huntertown glacial aquifer system is being developed. Permeable hydrostratigraphic units within the Huntertown Formation (Quaternary) comprise the principal ground-water resource for an expanding population in northern Allen County, Indiana. The Huntertown aquifer system lies predominantly between the less permeable Lagro and Trafalgar Formations. The Huntertown Formation and corresponding aquifer system are located in an interlobate setting characterized by complex glacial stratigraphy, consisting of coarse-grained proglacial sediments and loamy till intercalated with glaciofluvial and glaciolacustrine facies.

To construct the model, a database of more than 2,500 lithologic logs from public and private water supply wells and more than 200 down-hole natural gamma-ray logs was compiled for the study area (\sim 500 km²). The lithologic logs were plotted to construct 110 hand-drawn cross sections (total length of about 900 km) that were used to map the bounding surfaces of the three formations (high-order architectural elements) as well as to constrain the scale and geometry of intratill sand and gravel aquifer units. The base of the Lagro Formation was determined from well logs by a shift from massive clays to loam-textured sediments or by the presence of laterally and vertically extensive underlying sand and gravel units. A prominent shift toward higher counts in natural gamma-ray profiles was also used to determine the base of the Lagro. The top of the Trafalgar Formation was defined by a ubiquitously present overlying outwash package depicted in gamma-ray logs or by lithologic descriptions reflecting the Trafalgar's overconsolidated nature. Previously mapped areal extents of hydrogeologic facies are currently being used in conjunction with both lithologic and natural gamma-ray cross sections, rendered at varous orientations across the study area, to determine the geometry of individual morphosequences or lower-order architectural elements (e.g. ice marginal fans and outwash channels).

Research objective

Develop a three-dimensional framework for the aquifer facies with a longer-term goal of modeling groundwater flow in a fully three-dimensional model.

Available data for Allen County, IN

- -Approximately 2,500 well logs from public and private water supply wells
- -208 down-hole natural gamma-ray logs
- -Detailed geologic descriptions for approximately 100 of the gamma logged holes -Grain size analyses for approximately 10 boreholes

Previous work mapping the Huntertown aquifer system

Fleming (1994): The Hydrogeology of Allen County, Indiana

- -Developed existing conceptual framework for interlobate glacial stratigraphy in Allen Co.
- -Mapped glacial terrains of Allen Co. and aquifer facies in 2-D
- -Contoured the top of the Trafalgar Formation

Primary challenge associated with mapping heterogeneous glacial aquifer systems
-Building geostatistically constrained models is difficult due to sparsely distributed and uncertain data

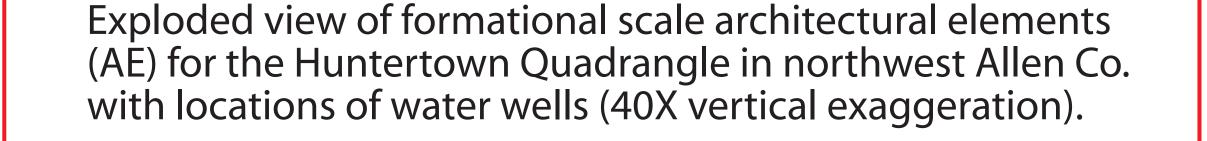
Initial approach used to process raw well log data

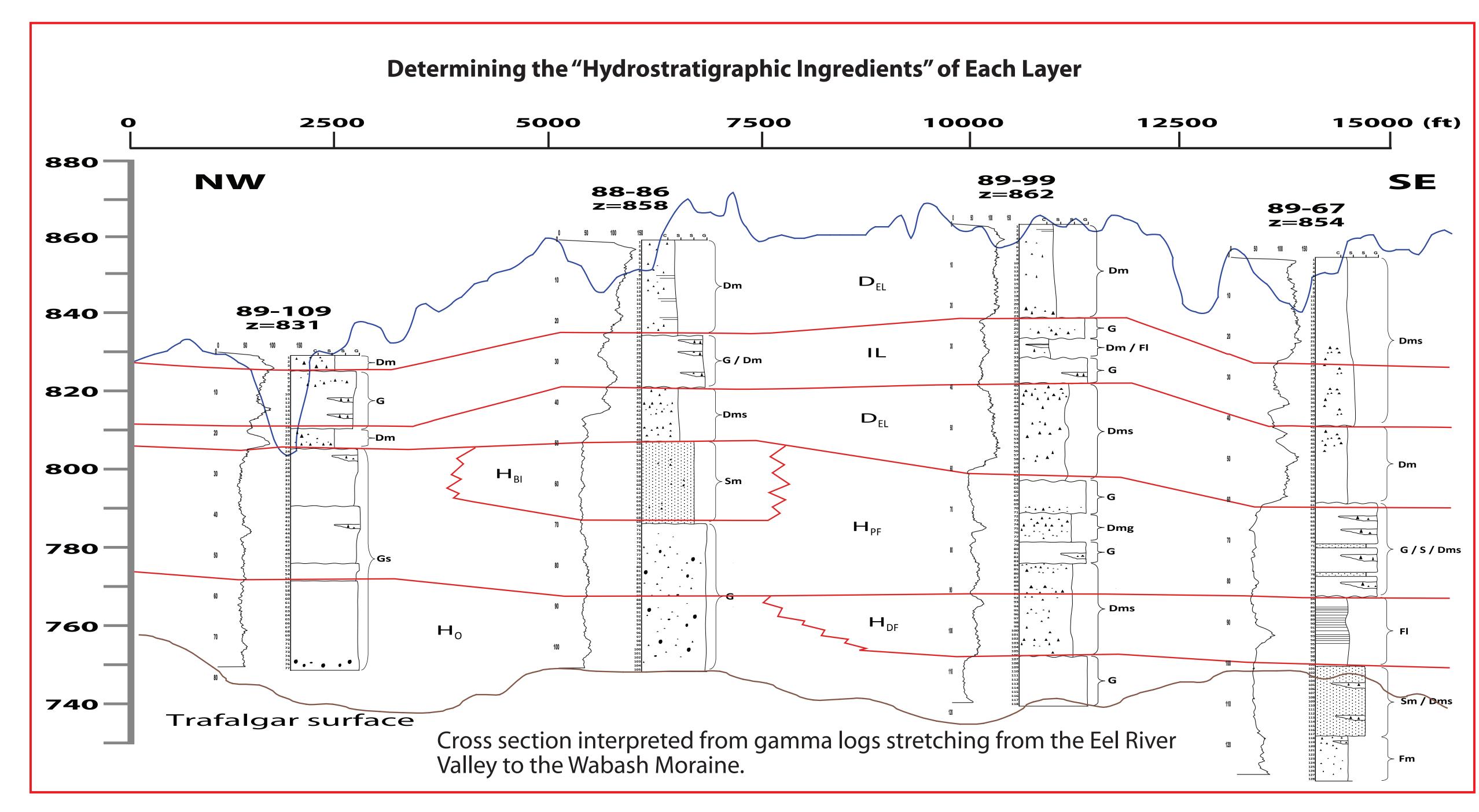
-Use Fleming's (1994) 2-dimensional conceptualizations (terrain maps and cross sections) to code the well logs with respect to the 3 primary Wisconsin-aged formations in Allen Co.

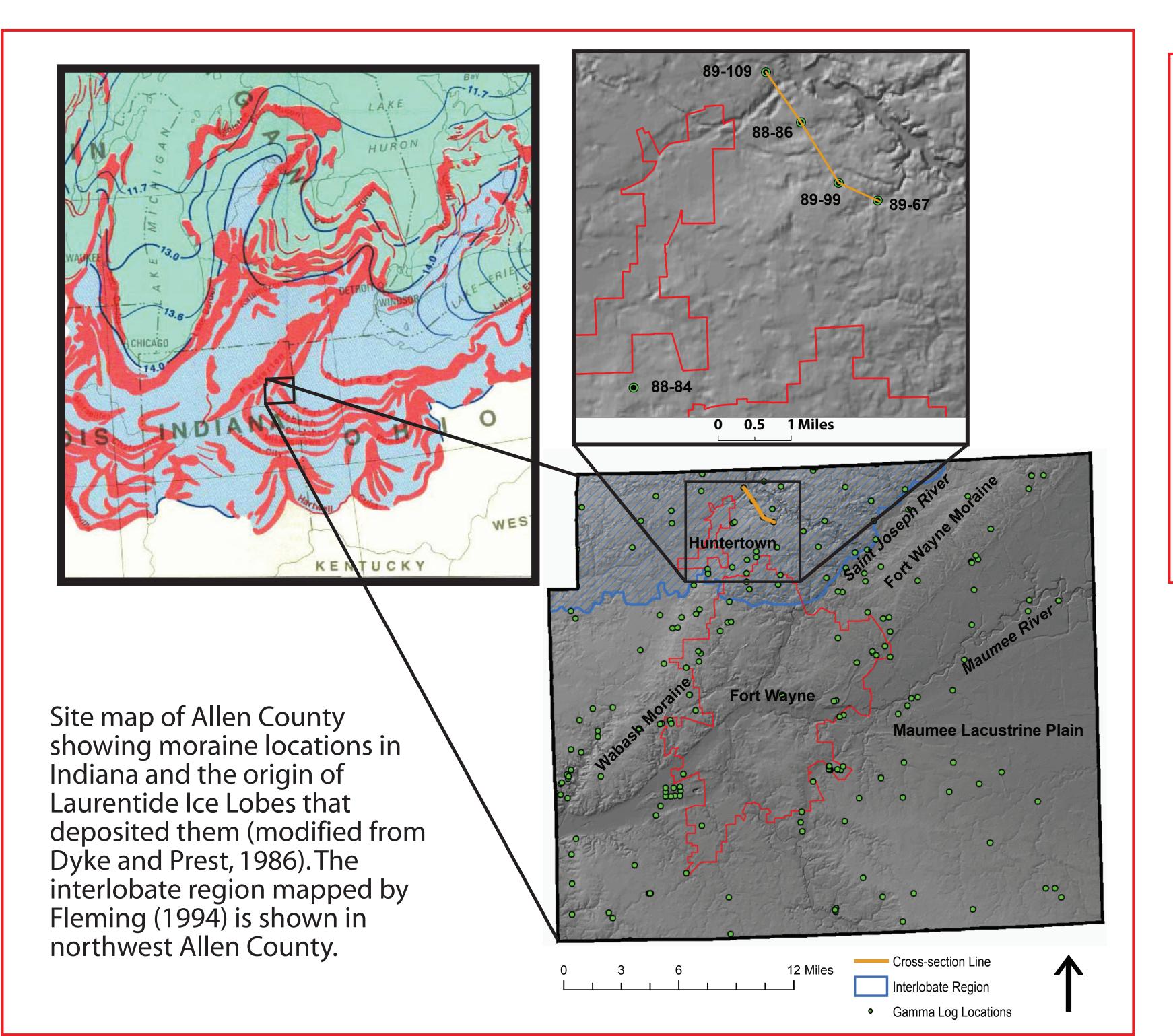
-The Lagro, Huntertown, and Trafalgar Formations are the equivalent of 5th or 6th order diamict architectural elements (DE) used in the work of Boyce and Eyles (2000)

-Formational elements were successfully mapped in three dimensions using the method. However, the method proved unsuccessful for mapping lower-order aquifer facies due to geostatistical and data quality limitations.

Traditional "Layer-cake" Hydrostratigraphic Model

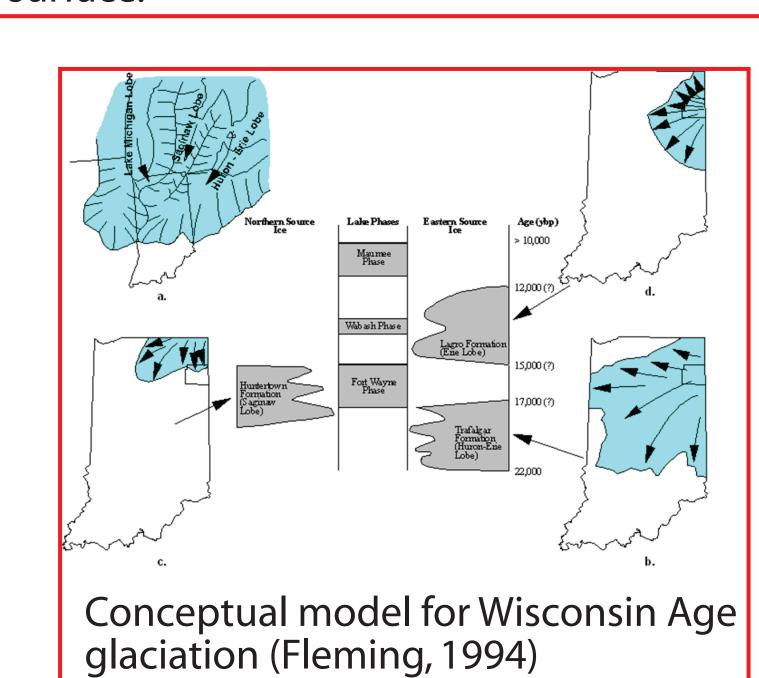


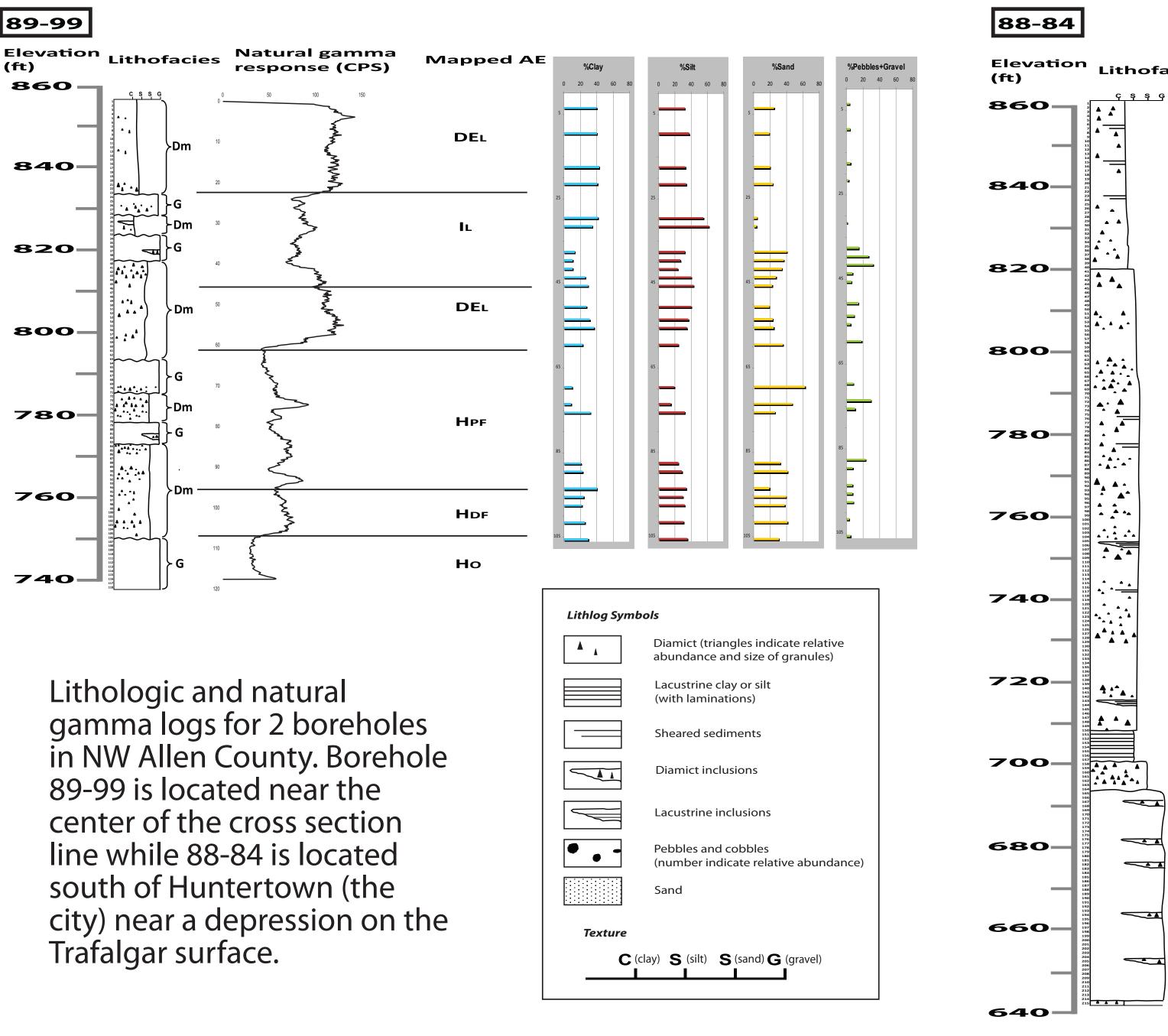


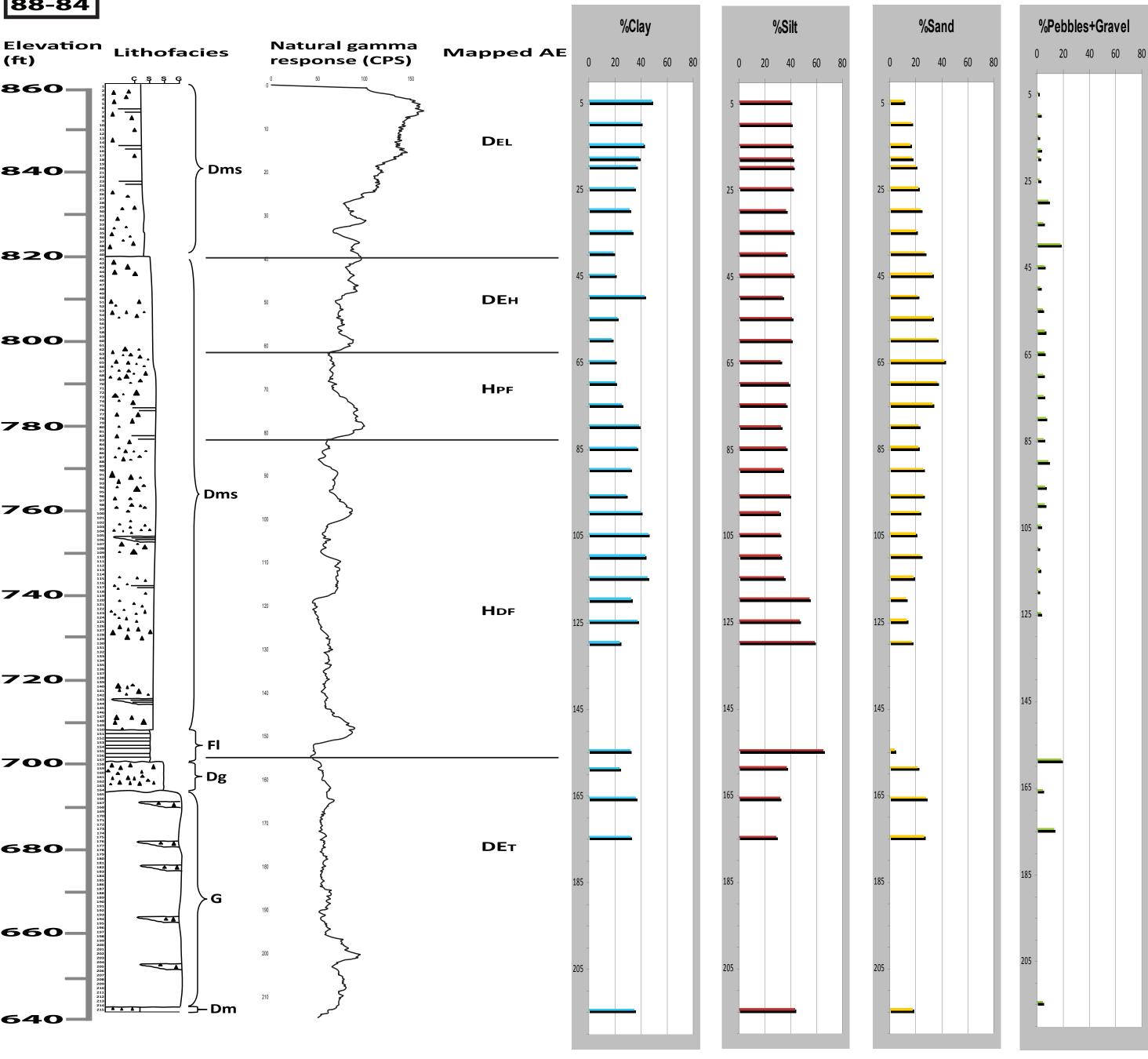


Recent efforts focusing on gamma logs and detailed lithologic descriptions -Gamma logs are compaired to detailed

- lithologic descriptions and grain size analyses to determine the gamma signature of aquifer
- -These higher quality borehole data are currently being used to render cross sections at various orientations to depressions that Fleming (1994) contoured on the Trafalgar
- -A basin analysis approach (similar to that used by Stanford and Ashley, 1998) is now being
- implemented in the central portion of the aguifer system to examine if the geometries of lower-order elements within the Huntertown Formation are controlled by the Trafalgar surface.







Architectural Elements

Architectural Element	Code	Description
Lagro Diamict	DEL	Clayey diamicts of the Lagro Formation. Typically massive and matrix supported with trace fine granules.
Lagro Intrasequence	lι	Coarser-grained, laterally continuous facies that lie within the Lagro Diamict.
Huntertown Diamict	DE _H	Loamy tills that typically display signs of being deposited directly by ice.
Huntertown Proximal Fan	H _{PF}	Ice proximal fan facies displaying coarsening upward sand and gravel sequences with fine grained diamict interbeds and occasional mudflows.
Huntertown Distal Fan	H_{DF}	Distal fan facies that show coarsening upward gamma signatures similar to H _{PF} but are dominated by fine sands and silt and contain lacustrine sediments within or adjacent to them.
Huntertown Ice Contact Features	H _{BI}	Fleming (1994) described these as predominantly stratified sands overlying the basal outwash unit. They are most likely associated with buried ice blocks and ice-walled lakes.
Huntertown Basal Outwash	Ho	Laterally ubiquitous outwash sediments that overly the Trafalgar Formation and represent the base of the Huntertown Aquifer System.
Trafalgar Diamict (Undifferentiated)	DE⊤	Overconsolidated loamy and gravelly loam diamicts with isolated gravel bodies. Pre-Wisconsin deposits underlying the Trafalgar





References

Boyce, J. I., and Eyles, N. (2000). "Architectural element analysis applied to glacial deposits: internal geometry of a late Pleistocene till sheet, Ontario, Canada." GSA Bulletin 112(1): 98-118.

Dyke, A. S., and Prest, V. K. (1986). Late Wisconsinan and Holocene retreat of the Laurentide Ice Sheet, The Geological Survey of Canada: Map 1702A.

Formation are not currently differentiated from this element.

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