DIGITAL MAPPING TECHNIQUES 2023

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The contents of this document are provisional.

See Presentations and Proceedings from the DMT Meetings (1997-2023)

http://ngmdb.usgs.gov/info/dmt/
A fractured carbonate system comprises the Silurian-aged bedrock across eastern Wisconsin, USA, potentially acting as a conduit for contaminated surface water, such as manure-treated field effluent, to reach groundwater. Glacial deposits overlying the Silurian bedrock help filter contaminated surface water with thicker deposits having greater filtration potential. In light of revisions to state administrative codes ATCP 50 and NR 151 to regulate manure spreading, a current and timely mapping effort to derive a seamless depth-to-bedrock (DTB) map across the Silurian bedrock region in eastern Wisconsin is needed. The most recent DTB map and outline of the Silurian across eastern Wisconsin was created in 1979 at 1:250,000 scale. Advancement of geographic information system (GIS) technologies and 43 years of additional subsurface information are available to generate a more current and precise DTB map. We used Empirical Bayesian Kriging with Regression Prediction (EBKRP) in Esri ArcGIS Pro to first model a bedrock elevation surface, and then derive DTB by subtracting that surface from a ground-surface digital elevation model. We chose EBKRP over other interpolation methods because the calculation of an unknown value at a given location is dependent on the theoretical best fit of the variance of the known values over the interpolated area, rather than strictly distance. The theoretical best fit captures the spatial relationship across an area and provides the ability to coincidently generate a map of model error. Additionally, the map includes data from the novel application of airborne electromagnetic (AEM) data collected via SkyTEM Canada Inc. in collaboration with the United States Geological Survey and the Wisconsin Geological and Natural History Survey in 2021. AEM data was collected along helicopter flight lines and were inverted to produce electrical resistivity data at nearly 300 m depth with 1-2 m near-surface resolution. The resistivity transitions in the shallow subsurface were used to estimate DTB.
Abstract

Silurian-aged bedrock across eastern Wisconsin (WI) is a fractured carbonate bedrock system susceptible to surface water contamination. WI State statutes ATCP50 and NR151 are under current revision to regulate manure spreading over shallow fractured bedrock. The WGNHS is in collaboration with DATCP in generating a 12,000 sq. km depth-to-bedrock (DTB) model of the Silurian across eastern Wisconsin.

1. We applied the Empirical Bayesian Kriging with Regression Prediction (EBKRP) geostatistical Analyst Tool in ArcGIS Pro 3.1.0 to generate the DTB model by following these steps:

   1) Generate a 50x50 sq. meter raster bedrock elevation (BrElev) surface model with EBKRP with 170x BrElev points

   2) Subtract the generated BrElev surface model from a ground-surface digital elevation model (DEM) to calculate the DTB model deliverable surface.

We empirically investigated and iterated different EBKRP input model parameters, as well as, DTB point data source to maximize output quality. The map presented here includes data (Table 1, below) to manage its influence, or weight, in the model. Measurement error was assigned a priori along the south-side of the escarpment. The escarpment is located shallow (<5 ft) DTB escarpment (Fig. 1). The Waukesha Fault follows deposits and outwash plains.

Future Work

- Incorporate county-level external review comments and additional datasets, such as geoprobe and shallow bedrock fractures.
- Understand instances where the model output mismatches a priori geologic information. Improve geoclassification estimates with reliable DTB value.
- Collect field-pedigree seismic data to measure quality control output for DTB <20 ft.
- Generate 5’ and 20’ DTB contour feature class.
- Deliver seamless DTB raster, model error raster, and 5’, 20’ map contours as DATCP project deliverables.

Funding

- WI State grant funded contract between DATCP and the UW-WGNHS.
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References


Fig. 1 (left): DEM subtracted EBKRP BrElev surface modeling DTB across eastern Wisconsin. AEM measurements were circular for identifying buried Br valleys, namely in uniquinable areas where subsurface data exist. NRCS exposed Br and shallow soil depth datasets prevented overestimation of DTB. Bedrock holes datasets prevented undersaturation of DTB.

Fig. 2 (above): Modelled DTB of the Silurian carbonate in Kewaunee Co., located in northeastern portion of the study area. Note the mile-scaled <5 ft DTB knolls, and ledges observed throughout county. Modelled interpolation error provided in inset map (above, right).

Fig. 3 (left): Modelled DTB of the Silurian carbonate in portions of Fond du Lac, Sheboygan, Dodge, Washington and surrounding counties located in w-s dominant portion of the study area. Note the sub-km-scaled hummocky drumlins and km-scale continuous NE-SW trending ribbons of marly deposits modeled as deeper DTB. Interpolation error provided in inset map (above).

Model Output Observations

- The current EBKRP model parameters and input DTB point dataset with measurement error generated a reasonable BrElev model (not shown).
- The BrElev model raster subtracted from the USGS 2017 DEM generated a reasonable DTB model of the Silurian carbonate bedrock across eastern Wisconsin (Fig. 1).
- Point measurement error, based on DTB field collection method and geoclassification confidence, minimized erroneous ‘bullseye’ or ‘hitting’ features in the model output.
- Applying a DEM as an explanatory raster to guide the EBKRP interpolation improved the model output across Br plateaus, cuestas, and escarpments. These features are prominent along the study area’s western boundary.

Bedrock fractures in aerial photos

Generalized Geologic Cross Section of Eastern Wisconsin

- Northern end of the study area is modeled predominantly very shallow (<5 ft) DTB (Fig. 1), consistent with traditional DTB mapping efforts (Carson et al., 2016). Zones within this area of greater DTB are consistent with previously mapped glacial map deposits and outwash plains.
- Continuous south, instnaces of shallow DTB are more common as isolated or grouped km-scale knobs, escarpments, or cuestas (Figs. 1, 2, and 3).
- South-central portion of the study area modeled a NE-SW trending shallow DTB escarpment (Fig. 1). The Waukesha Fault follows along the south-side of the escarpment. The escarpment is located on the uplifted block of the Waukesha Fault (Braschayko, 2005).

Focus Extents

- Search Neighborhood Parameters - Standard circular
- Sector Type - 8
- Radius - 341 ft (104 m)

EBKRP Parameter Models

ArcGIS Pro 3.1.0, geostatistical analyst tool Empirical Bayesian Kriging with Regression Prediction (EBKRP)

- Raster size - 50 x 50 m  •  Max/Min Neighbors - 8
- Sector Type - 8   •  Radius - 341 ft (104 m)
- Search Neighborhood Parameters - Standard circular
- Measurement error was uniquely assigned to each data point to manage its influence, or weight, in the model. Measurement error was calculated by multiplying the length of geoclassification confidence radius by an estimated land surface slope of 2% (Table 1, below).

Table 1: Bedrock borehole quality control on geologic events. Data source, geoclassification error [feet (m)], and measurement error [feet (m)].

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Geoclassification [feet (m)]</th>
<th>Measurement Error [feet (m)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreholes</td>
<td>50-3750 (15-1140)</td>
<td>1.75 (0.52)</td>
</tr>
<tr>
<td>USGS AEM</td>
<td>750 (229)</td>
<td>15 (4.5)</td>
</tr>
<tr>
<td>NSRSC</td>
<td>300 (91)</td>
<td>6 (1.8)</td>
</tr>
<tr>
<td>National Resources</td>
<td>300 (91)</td>
<td>6 (1.8)</td>
</tr>
<tr>
<td>Conservation Services</td>
<td>150-1000 (45-305)</td>
<td>3.20 (0.96)</td>
</tr>
<tr>
<td>County Range Outcrop</td>
<td>50 (15)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Quay Pits</td>
<td>300 (91)</td>
<td>6 (1.8)</td>
</tr>
</tbody>
</table>

Note: This dataset is accessed by the general public, but the actual data are not disclosed. The data are intended for use in spatial modeling and geoclassification of land surface events. The data are intended for use in spatial modeling and geoclassification of land surface events.