DIGITAL MAPPING TECHNIQUES 2013

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# 3D Sand Modeling for Characterizing Aquifer and Aggregate Resources

Jacqueline D. Hamilton, R. S. Lively, Robert Tipping and Alan Knaebel
Minnesota Geological Survey, University of Minnesota, Saint Paul, Minnesota 55114

## Introduction

Establishing the distribution and thickness of sand and gravel deposits in an essential step toward the use and protection of groundwater resources. Also, near-surface sand and gravel bodies may be important in supporting surface water systems. The resolution and accuracy of the models are crucial in defining problems in delineating discrete stratigraphic units at the county level. Glacial terrain, multiple events of glacial deposition and erosion create unique problems in defining discrete stratigraphic units at the county level (19x64 scale of mapping). The model results display a distribution of sands and gravels both at the surface and in the subsurface. These models form the geologic framework that the Minnesota Geological Survey and other public and private entities use to identify and monitor aquifer and aggregate resources.

## Materials and methods

The creation of Minnesota’s sand model stratigraphy is implemented through ESRI’s ArcGIS. In order to model the stratigraphic, descriptive and sample data from water well records, rotary sonic core, scientific cutting, and auger borings 2(a) are collected from the County Well Index (CWI) database. Closed spaced cross section lines are then generated in a west-east direction 2(b). The geologists provide the original geologic materials that occur in the areas between wells or at depths not penetrated by wells, based primarily on their understanding of the glacial processes (2c). The distribution of data greatly affects the accuracy of the models.

## Results

As our 3D modeling processes have evolved we have tried to improve gridding efficiency and accuracy for Minnesota’s Wright County 2(d). Specific sand and gravel units were pulled out for additional analysis. Glacial terrain of sand bodies typically display variable thickness and can be discontinuous in many locations. The following steps yielded significant improvement in gridding accuracy relative to the geologists interpretation of the geologic structure of subsurface sand and gravel deposits.

1. The geologist digitizes each unit based upon the CWI data. Locations, either from borehole or wells, are included if within 500 meters of each cross section location. The CWI locations are then digitized from the cross section.

2. Stratigraphic layers are created by a geologist along each cross section. Python scripts are used to extract the figure and plot these projections onto a map. Additional elevation points from each cross section layer are used to aid in visualization of the cross section line to provide additional elevations for the gridding process.

3. A geographer then draws a boundary (mask) around the points delineating the extent of the stratigraphic unit.

4. Creating Working Surfaces

   (a.) CWI Wall Log & Cross Sections

   (b.) Geologic Cross Section

   (c.) CWI Wall Locations & Cross Sections

   (d.) Geologic Cross Section

   (e.) Geologic Cross Section

   (f.) Cross sections along the original geologic cross section (plan view).

   (g.) Cross sections along the original geologic cross section (plan view).

   (h.) A model created in a west-east direction.

   (i.) Geologic cross section. Specific sand and gravel units were pulled out for additional analysis. Glacial terrain of sand bodies typically display variable thickness and can be discontinuous in many locations. The following steps yielded significant improvement in gridding accuracy relative to the geologists interpretation of the geologic structure of subsurface sand and gravel deposits.

   (j.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (k.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (l.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (m.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (n.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (o.) Creating Final Surfaces

   (p.) With the use of ESRI’s Spatial Analyst, 3D Analyst and Python scripts we can begin to create grids for each individual stratigraphic unit.

   (q.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

   (r.) This displays the initial data (CWI) locations and cross section location. The geologist noted the farthest cross section from the cross section.

## Conclusions

The use of 3D technology for geologic mapping is on the rise. The efficiency and cost effectiveness of these methods have increased the rate at which we can produce subsurface models. Minnesota is one of many states that contain glacial terrain which provide a unique set of problems and complexities when it comes to mapping individual stratigraphic units. Many of the mapping technologies today allow the geologist to construct 3D models that closely match their particular geologic interpretation of the subsurface. The Minnesota Geological Survey has been using ESRI’s ArcMap software to model the glacial terrain at a county scale. Individual stratigraphic units can be modeled separately. The addition of randomized points, as well as additional points along the outline, increases the accuracy of the grid and locates the grid for each unit. For Wright County, the modeling results display a distribution of imappable sand and gravel units, both at the surface and sub-surface.

Increasing the accuracy of 3D modeling improves the understanding of our geologic resources. These refined 3D models form the geologic framework that the Minnesota Geological Survey and other public and private entities use to identify and monitor aquifer and aggregate resources.

## References Sited


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## For further information

Please contact: Ashleigh Bowman. More information on this and related projects can be obtained at www.mngs.umn.edu.