Project Summary

Title:	Coupled Modeling of Gravity and Aeromagnetic Data For Analysis of the Waukesha Fault, Southeastern Wisconsin
Project ID:	R/UW-HDG-007 (WR03R003)
Investigator:	John D. Skalbeck, Assistant Professor, Department of Geosciences, University of Wisconsin-Parkside
Period of Contract:	July 01, 2003 – June 30, 2004
Background/Need:	Increased concerns about groundwater resources in Wisconsin have brought about the need for better understanding of the subsurface geologic structure that lead to developing conceptual hydrogeologic models for numerical simulation of groundwater flow. Models are often based on sparse data from well logs usually located large distances apart and limited in depth. Model assumptions based on limited spatial data typically requires simplification that may add uncertainty to the simulation results and the accuracy of a groundwater model. This research provides another tool for the groundwater modeler to better constrain the conceptual model of a hydrogeologic system. The area near the Waukesha Fault in southeastern Wisconsin provides an excellent research opportunity for our proposed approach because of the strong gravity and aeromagnetic anomalies associated with the fault, the apparent complexity in fault geometry, and uncertainty in Precambrian basement depth and structure.
Objectives:	The objectives of this research are to improve the current understanding of the subsurface geometry (offset and fault dip) of the Waukesha Fault in southeastern Wisconsin, to improve the current understanding of the Precambrian bedrock topography of the down-thrown area southeast of the Waukesha Fault, and to demonstrate the effectiveness of coupled modeling of gravity and aeromagnetic data for delineating the hydrogeologic settings in other areas of Wisconsin. This fault appears to exhibit complex geometry that is variable along its trend. Better definition of the fault subsurface geometry obtained from this research will allow for a better understanding of the effects of this fault on the hydrogeologic system. A better-constrained estimate of the Precambrian bedrock topography will provide needed information for a regional groundwater flow model. Results from this study can be used to demonstrate the effectiveness for delineating the hydrogeologic settings in other areas of Wisconsin.

Methods:

Coupled 2.75-dimensional modeling of existing gravity and aeromagnetic data was performed along seven northwest-southeast profiles, perpendicular to the trend of the Waukesha Fault and one north-south profile (Tie Line), using the commercially-available software program GM-Sys^{R}. Cross-sections of the geologic subsurface were constructed from existing surface and subsurface geologic information and assigned initial density and magnetic properties from literature. Adjustment to structure and properties were made to yield acceptable fits between observed and model calculated gravity and aeromagnetic anomalies. Elevations from these model sections and from well logs were used to generate a 3-dimensional representation of the top of Precambrian bedrock.

Results and Discussion:

Acceptable fits between observed and model calculated gravity and aeromagnetic anomalies were obtained from the geologic models constructed for the eight profiles in the study area. A single well reaching bedrock on the down-thrown block provided excellent vertical control for initial model calibration. Profile model data yields a 3-D representation of the Precambrian bedrock top surface with elevations that range from 168 m above mean sea level (msl) on the up-thrown block to –1318 m msl on the down-thrown block. The prominent southwest-northeast trending drop in bedrock surface elevation is interpreted as the Waukesha Fault scarp.

Conclusions/ Implications/ Recommendations:

The results from this study show the Waukesha Fault as a high angle normal fault dipping to the southeast. Model topography of the Precambrian bedrock surface appears complex on both sides of the fault with a maximum vertical displacement of 560 m. A reasonable estimate of top of bedrock elevations southeast of the fault has been obtained from this study. Further model refinement will be conducted to improve structure interpretations for southeast Wisconsin. Results from this study have direct application to the groundwater flow model for southeast Wisconsin (Feinstein et al., 2004). These researchers now have an additional data set for the Precambrian basement configuration that can be utilized in the flow model. Coupled modeling of gravity and aeromagnetic data can be applied to other areas in Wisconsin with groundwater management issues such as arsenic contamination and excessive drawdown.

Key Words:

Aeromagnetic, Gravity, Coupled Modeling, Waukesha Fault, Precambrian Basement, Ground Water, Wisconsin

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