

# INTRODUCTION - THREE-DIMENSIONAL GEOLOGIC MAPPING FOR GROUNDWATER APPLICATIONS

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## INTRODUCTION

This fifth workshop, discussing three-dimensional (3D) geological mapping for groundwater applications, is part of an ongoing series that began in 2001. A focus of all the workshops has been the development of techniques to optimize internal consistency and to fully integrate 3-D stratigraphic with hydrostratigraphic models that can be used directly for hydrogeologic modeling. Workshops have emphasized the need for high-quality data, the procedures for reconciling often disparate and plentiful archival data, and the obvious realization that the better the geological model, the greater the probability that subsequently derived groundwater flow models will be as accurate as possible.

Studies focused on the generation of 3D geologic models of the near surface have dominated the previous four workshop proceedings, as the workshop organizers strove to maintain this as a central focus. In addition, there has been an attempt to maintain connection with the needs of the groundwater community. Therefore, several groundwater modeling presentations have emphasized informational needs for producing viable groundwater flow models.

Very importantly, each successive workshop has adapted to and reported on continually evolving and newly emerging software applications for basic mapping and visualization, as well as innovations in data management strategies. There has also been a conscious effort to continually include perspectives that allow workshop participants to expand their horizons and consider other, perhaps less traditional, methods and applications for their mapping and modeling efforts. Along these lines, an increasing number of Europeans involved in 3D modeling have become regular workshop participants, and have shared their often unique experiences that have direct application to North American issues. Workshop presenters dealing with 3D mapping of bedrock, and supporting energy developments, have provided insight regarding their model building techniques and applicable interpretive uses. Finally, although workshop focus has been on 3D geologic modeling for groundwater applications, we continually have sought other applications and interpretive uses of geological models, as well as mechanisms to improve the understandability and accessibility of geological information. We realize that communicating the results of geological mapping must go beyond the technical level, and that geological work must be relevant and understandable by the general public, particularly if we expect to receive continued and increased funding for mapping activities.

## CURRENT WORKSHOP

There are 19 talks in this workshop, the first 15 of which follow the format of the four previous workshops, and discuss various aspects of 3D model development and applications, including case study examples. The first nine talks discuss overarching issues that affect and improve the ability of geologists to interpret data and produce 3D geologic conceptual models and derivative products.

A specific objective of all workshops, including this one, is providing the opportunity for participants to share ideas with people from other jurisdictions who have experienced a sustained and urgent need for developing optimal mapping and modeling methods by (1) experimenting with new ways to deal with large data sets, (2) developing ways of integrating data of variable quality with high-quality data, and (3) developing methods to construct 3D geological models of appropriate detail that can be used for various land and water applications. While building on the previous four workshops (Berg and Thorleifson, 2001; Thorleifson and Berg, 2002; Berg et al., 2004; and Russell et al., 2005), this workshop maintains its central focus, but expands outward to include a large user community of engineers. It will also enhance our familiarity with the expanding applications of web mapping, web accessibility of geo-information, visualization, and other trends in geoscience information management and delivery.

Three-dimensional geological mapping data are as important for groundwater applications as they are for addressing engineering and other environmental geology issues. Because we wish to expand the sharing of 3D mapping expertise to the engineering community, the first talk by Turner presents an overview of geological modeling as it applies to site investigations and projects. It includes a discussion on innovations

in model creation, interfaces with design tools and process model applications, visualization, and data sharing and dissemination.

Following the presentation by Turner, workshop presentations return to traditional roots. Rivera provides an overview discussion about the intricacies of groundwater modeling as it applies to both geology and hydrogeology. This talk is followed by two presentations on general mapping and data issues. Soller discusses the need for 3D mapping standards, and how much standardization is really necessary, and Keefer focuses on methods for characterizing uncertainty in geologic maps.

Discussions then proceed to specific applications of integrating geophysics and geochemistry into modeling, with Knight focusing on the usefulness of ground-penetrating radar to develop hydrogeologic models, and Moran talking about chemical and isotopic tracers for characterizing groundwater systems. Interfacing between hydrogeology and geology are then presented by (1) Bradbury, who discusses a bedrock aquitard and its affect on groundwater flow at various scales, (2) Kessler, who talks about systematic 3D geological modeling as the foundation for regional groundwater flow models in the United Kingdom, and (3) Gunnink, who focuses on 3D modeling of geology for groundwater applications in The Netherlands.

Additional presentations on specific modeling techniques and interfacing between geology and hydrogeology, mainly as case-study examples, are then made by: (1) Venteris, who discusses water-well data, geostatistics, and 3D modeling, (2) Tremblay, who presents a Quaternary grid-based hydrostratigraphic 3D modeling approach; (3) Troost, who provides an update on her Puget Sound 3D investigations by focusing on geodatabases and high-resolution geologic mapping, (4) Burt, who discusses new mapping products and 3D modeling advancements based on studies of thick drift areas in Ontario, Canada, (5) Ross, who provides insights about 3D geological modeling as it applies to environmental impact assessments of Canadian military training ranges, and finally (6) Macfarlane, who discusses a realistic evaluation of groundwater availability in heterogeneous aquifers in the High Plains aquifer of southwest Kansas.

The final four talks of the workshop represent new directions, not only for 3D mapping and modeling, but for the discipline of geology as a whole. Morin discusses new visualization techniques that provide geologists with ways to improve the understandability of their information, thereby allowing users and the lay public to better visualize the subsurface and understand its complexity. Sharpe and Russell talk about exhibiting 3D information on the web, and providing various interactive map applications, based upon recent mapping in Ontario. Allison continues the theme of web accessibility of geologic information by discussing geoinformatics, which is the science that develops and uses informational infrastructure to address various problems of the geosciences via development and integration of computer hardware and software for building and managing geologic databases and for analyzing and modeling geologic data, mainly through GIS platforms or decision support systems. Finally, Jackson reports on modeling, visualization, and future trends in geoscience information management and delivery. He particularly discusses the OneGeology concept and the Brighton Accord, which is a worldwide effort to improve the accessibility of global, regional, and national geologic map data, and in so doing, provide better solutions for mitigating environmental hazards, ensuring a sustainable supply of energy, minerals, and water, and addressing climate change scenarios. An ultimate objective is the production of an internet-accessible "best possible" worldwide geologic map, initially at a scale of about 1:1 million.

## **CONCLUSION**

The need is increasing drastically to provide new, improved, and detailed 3D geological information for addressing issues of conflicting land use, water quality and water resource allocations, site characterization, dwindling aggregate resources, industrial agriculture, and alternative energy supplies. Providing this much needed geological information requires plentiful and accurate data, presented in understandable formats and accessible in as many venues as possible. This is indeed a daunting task, particularly in the face of limited financial resources. It is only through cooperative efforts, open sharing of expertise, and learning from the successes and failures of others - all part of this fifth workshop - that technical problems can be minimized and overcome, and efficient and cost-effective solutions to mapping, modeling, visualization, and delivery of information can be attained.

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