CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: EarthVision® Users' Meeting (06002.01.292.541)

DATE/PLACE: February 18, 2005; Las Vegas, Nevada

AUTHOR: Shannon Colton

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PERSONS PRESENT:

Larry McKague and Shannon Colton of the Center for Nuclear Waste Regulatory Analyses (CNWRA) attended the EarthVision Users' Meeting held in Las Vegas, Nevada by Dynamic Graphics®, Inc. (DGI), February 18, 2005. The meeting had approximately 20 attendees who use EarthVision for geologic modeling, ranging from oil industry applications to environmental research.

BACKGROUND AND PURPOSE OF TRIP:

The EarthVision Users' Meeting held by DGI provides a forum for EarthVision users to share their projects and techniques with other users. In addition to presenting a recent EarthVision model from the CNWRA, we attended presentations by other EarthVision users and DGI staff to gain insight into modeling techniques and applications and recent software developments.

SUMMARY OF ACTIVITIES:

Presentations by EarthVision Users

Wanda Taylor (University of Nevada, Las Vegas) presented a talk entitled "Geologic and Shear Wave Models of the Las Vegas Basin." She and Jeff Wagoner of the Lawrence Livermore National Laboratory conducted a study to assess ground shaking hazards in the Las Vegas area. Their data sources included geologic and fault maps, 1,145 well logs, USGS gravity inversion results, USDA soil maps, and refraction studies in the area from which they created a 3D model of the basin with EarthVision. Well data was incorporated into well lithology profiles with RockWorks™ software, which was then displayed in 3D with layered cylinders representing the wells. While displaying and rotating the well data, Taylor pointed out the key material types relevant to shaking in this area: (1) coarse- and mixed-grain deposits in the western portion of the Las Vegas Basin that have faster shear waves and are relatively stiff resulting in less ground shaking, and (2) clay-rich deposits concentrated in the lower parts of the basin and approximately following the Las Vegas Wash that have the most potential for shaking in the model area. Fault interpretation was based on geologic maps and gridded gravity data. Faults were contemporaneous with basin development so thickness anomalies are present near the fault surfaces (e.g., coarser colluvial wedges). The EarthVision model was complex and included alluvial fans containing coarse- and mixed-grain material along with clay and alluvium interfingering. Due to discontinuous depositional environments in the shallow zones, it was not possible to model the clay and alluvium interfingering accurately with the standard method of

EarthVision zone modeling using 2D grids, which are limited to x, y, and z data coordinates. Skip Pack of DGI helped Taylor and Wagoner develop the model using 2D grids for the lower horizons, but 3D grids, which contain x, y, and z coordinates and additional property values, for the shallow zones. Shallow zones were displayed according to the property of shear wave velocity to visually distinguish the clay from coarse- and mixed-grain material. As part of this study, shear wave velocities of various material types were collected and charted. The study concluded that three- to nine- story buildings were posed the most dangerous shaking hazard in this area, and that buildings located above clay-rich zones will topple most easily. The model was calibrated with data from seismic measuring stations, of which two were located on bedrock and two were in the basin.

Stephen Smart (Subsurface Modeling Concepts) talked about the use of visualization centers to support multi-disciplinary operation decisions. Visualization centers are essentially meeting rooms with the technology to display data of several geologic disciplines simultaneously, thus allowing team members of diverse backgrounds to have their software applications and data at their fingertips while discussing a project with other team members. By showing everyone's models and work at the same time, collaboration is greatly enhanced. Each team member is able to visualize the others' works and each member's contributions are more quickly incorporated into project planning. EarthVision is an excellent tool for bringing together multiple geologic data types for visualization. For example, boreholes and geophysical logs can be displayed with a 3D structural geology model. Systematic review of all geologic data often reveals problems that would otherwise be missed when analyzed separately. Visualization centers can now be built at a cost of $80,000–$90,000 using multiple projectors and a Linux operating system. It takes patience for team members to adjust to the process, but the result is often a better product.

Art Ehrenberg (Southern Nevada Water Authority) presented a model of Lake Mead and the Las Vegas Wash. Approximately 80 percent of the drinking water of Las Vegas comes from Lake Mead, where water is extracted from the Saddle Island Intake Facility within the lake. The water in Lake Mead is currently down by 60 percent, affecting water quality in several ways. There is less distance for water to travel from the Las Vegas Wash before reaching the intake facility, so water from the Las Vegas Wash arrives at the extraction source more quickly and less mixing occurs between water from the Las Vegas Wash and Lake Mead. Ehrenberg stressed the importance of using GIS to consolidate data sources, and he modeled the bathymetry of Lake Mead and performed volumetric calculations with EarthVision.

Vivian Bust (Consulting Geologist) gave a presentation entitled "Using Subzone Production Data with a 3D Geologic Model," in which she modeled oil production rates within an oil field. Production was higher near the wells, and her model used a linear increase in production approaching each well as an approximation. Bust's primary challenge was finding low-cost solutions for a small oil company without the financial means to purchase expensive software commonly used by larger oil companies.

Tad Beard (Weston Solutions at Stoller-Navarro) presented one of five alternative models created of the Oasis Valley-Paiute Mesa. The model he presented was similar to a USGS model of the same area except for the northeast corner, where Beard and coworkers' model emphasized the importance of basin and range faulting and its influence on caldera formation. Whereas, the USGS model had a more typical caldera morphology, this model displayed a mixture of caldera collapse and basin and range faulting, where caldera collapse occurred primarily along pre-existing basin and range faults. They used the same source information as the USGS, but slightly different hydrostratigraphic layering. The model required approximately nine months to build. An additional three months were spent exporting the model to a finite element mesh. Steven Smart commented that displaying calculated flow paths in the 3D model is a nice way to see the flow paths once hydrology modeling is complete, and Tad Beard and several others agreed.

Leigh Justet (US Geological Survey) presented the results of her work in converting the Death Valley Regional Flow System (DVRFS) Hydrogeologic Framework Model (HFM) from a STRATA™ model to an EarthVision model. Her assignment was not to create a new interpretation of the area, but to reproduce the HFM as closely as possible with the more widely-used EarthVision software. Data was exported from the STRATA model and used to build the EarthVision model. Justet explained the challenges she faced and techniques used to solve technical problems. Especially problematic were the presence of artificial corrugations along steeply dipping planes and data gaps between horizons. Skip Pack helped Justet find solutions to these problems. They calculated distance grids which measured the distance of each grid node to the nearest data point. The distance grids then were used to create buffers around each horizon to fill in the gaps. Corrugations were addressed by making slightly shallowing the steep planes, and horizon "overshoots" were solved by adding control points below the lower boundary of the model. Justet presented cross-sections of both 3D models to show the level of similarity between the two models and to highlight some of the differences. In response to a question, she noted that any future calculations based on the HFM would use data exported from the original STRATA model rather than the new EarthVision model since, as mentioned earlier, the EarthVision model was intended not as a new interpretation but to reproduce the STRATA model as closely as possible.

Tim Voit (ISSI at Bechtel-SAIC) gave a presentation entitled "Recent Applications of the YMP Integrated Site Model and Related Investigations," in which he demonstrated his recent EarthVision use. Voit discussed his investigation of potential mega-ring structures at the Yucca Mountain area as an alternative way of interpreting the tectonic system. He also created a topographic base grid with EarthVision on which he draped several data sets from the USGS DVRFS, including aeromagnetic data and gravity data. Since the number of topography data points exceeded EarthVision's limit for 2D gridding, Voit decimated the topographic data with an EarthVision utility prior to gridding it. Voit also discussed tomography data from the University of Nevada at Reno, noting a fast zone under the Timber Mountain Caldera. Additionally, he pointed out that the 3D viewer can be used to display any data with three coordinate axes rather than only using it for spatial data, and as an example he displayed data with axes of distance, temperature, and time.

Nat Voorhies (SAIC) emphasized efficiency in his talk entitled "Streamlining the Update of a Water Table Model with Semi-Annual Resampling." He noted that data from monitoring wells alone is not enough for gridding a potentiometric surface. Control points need to be added, then contours and the grid should be edited as necessary. Sometimes, one must resort to hand-contouring, but since it is highly labor-intensive it should be a last resort. He assisted EarthVision users who had up to that point been completely hand-contouring the water table each time it was resampled. Voorhies created a template with which they could base future semi-annual grids. A template was appropriate in this case because the potentiometric surface had the same shape over time, including drawdown at each well. At each resampling event, the elevation of the potentiometric surface was adjusted based on new measurements but the template controlled the shape of the potentiometric surface. This method dramatically reduced the amount of labor required by the organization to update potentiometric surface grids. Voorhies noted that a numerical groundwater model, when available, is ideal for a potentiometric surface template.

Skip Pack (Dynamic Graphics, Inc.) presented a geologic framework model of the Edwards Aquifer developed by Mike Pantea and Jim Cole of the USGS in Denver, who were unable to attend the meeting. Pack displayed the model and highly complimented the packaging and delivery of the model. The model is an Open File Report and is available via CD-ROM. DGI offers a free version of their 3D viewer so that clients without an EarthVision license can view EarthVision models built for them by licensed EarthVision users. The free version requires faces files (i.e., EarthVision model files) to be encrypted. Mike Pantea and Jim Cole included with their report an encrypted faces file of the model, a demonstration script, and a folder with installation software and instructions for the free version of the 3D Viewer for each available operating system. They also included a quick help guide that describes how to perform common tasks in the 3D Viewer. In response to questions, Art Paradis and Skip Pack of DGI noted that it costs $350 to create up to three encrypted faces files that can be viewed with the demonstration version of their 3D Viewer.

Shannon Colton (CNWRA, Southwest Research Institute®) presented a model of the Edwards Aquifer in the Camp Bullis quadrangle by David Ferrill, Nathan Franklin, Darrell Sims, Deborah Waiting, and Alan Morris. This model is a subset of the area covered by the USGS model and offers a different interpretation of the area than the USGS model. The Edwards aquifer is a major water supply for much of western Texas, the San Antonio metropolitan area, and springs at San Marcos. Recent contamination to the Trinity aquifer, which underlies the Edwards aquifer, from the army bases Camp Stanley and Camp Bullis and noted southward migration of the contaminants has sparked interest into whether these two aquifers might communicate. If communication occurs, the recharge area of the Edwards aquifer would need to be expanded to include the Trinity aquifer as well. Thus, they have been characterizing the structural architecture of the Edwards and Trinity aquifers, and analyzing potential communication between them. Although this presentation focused on the Camp Bullis quadrangle, they have completed similar studies of the Castle Hills and Helotes quadrangles. To meet their goal, the team measured strikes, dips, slickenline rakes, and displacements along faults at numerous field locations in the region. They found that faults had slickenline rakes of nearly 90° degrees in most locations and faults in the Edwards aquifer averaged 75° dip while faults in the Trinity aquifer had average dips of 60°. Lower dip angles in the Trinity units are explained by less mechanical strength due to the presence of clay layers within the limestone. Field data was used in conjunction with pre-existing fault maps to create an EarthVision model of the area. The team exported fault cutoffs and created fault throw maps to assess potential aquifer juxtaposition. They noted that fault displacement was spread over many faults rather than being concentrated along one or two major faults. Although in some cases within the Castle Hills and Camp Bullis quadrangles the Edwards and Trinity aquifers are juxtaposed, communication depends on additional factors such as whether the fault acts as a barrier or conduit to across-fault flow, thus field work was necessary to characterize faulting styles. Colton noted that faults in this area have a complex effect on hydrology even within short distances. A photograph was shown with springs, then flowing water with interspersed ponds, then a sinking stream within a short distance along a single fault trace. They concluded that fault damage zones and karst conduit formation provide likely communication pathways between the Trinity and Edwards Aquifers.

Presentation by DGI Staff

Graham Brew (Dynamic Graphics, Inc.) discussed recent developments planned for the EarthVision 7.5.3. release. He emphasized the new 3D Viewer (3D Viewer +) that has an interface more similar to Windows, including drop-down menus. New covisualization tools included with 3D Viewer will provide powerful opportunities to incorporate multiple data types into one model, including structure, properties, cellular grids, seismic attributes, well logs, and production data. Users will have the option of opening two "volume spaces" (i.e., views) of the same faces file simultaneously with one displayed above the other. For example, one volume space could show a structural model with wells while another displays seismic data for the same model. Menu options can be applied to one or both volume spaces, and both volume spaces can be saved in a single vue file. For example, users can rotate or slice both views at the same time, or use the 3D cursor while it appears at the same point in both volume spaces. This will be tremendously useful for visualizing a large number of data types and interpretations in 3D. New advancements in animation have also been made. Users will be able to define views as key frames and specify the number of frames from which to linearly transition from one key frame to another. Animations can be created directly from the 3D Viewer, whereas before they required shell scripting and a separate software application to convert still images to animations. Time-step animations can also be created, but will require using a series of restart files. Brew showed as an example a simulation of water content in a cellular grid over time. The viewer has an enhanced point query tool that accommodates a number of output possibilities, including surveillance tools used by the petroleum industry and direct excel queries. For example users can set up the 3D Viewer so that clicking on a well will display an image or automatically open a Microsoft® Excel or Word file containing data, such as a daily production log. Screen annotation capability has been added and can be saved in vue files, but Brew notes that each screen annotation is valid for only one orientation. Annotations will disappear, for example, if one rotates the model. Immediate rendering of faces files is now possible (up to individual hardware limitations), so that one can view a structural model or seismic data as they slice through it by simply dragging the slider bar. It is possible to quickly make animations that can be played in the 3D Viewer, referred to as "group animations" by using a text file that refers to vue files. These group animations provide an alternative to the time-consuming process of creating an animation for use outside of EarthVision (e.g., avi or MPEG files). The group animations capability has been extended to view multiple scenarios within the same model. For example, one can specify that a fault's location uncertainty is ±100 meters, and EarthVision will calculate several possible permutations based on that uncertainty. Each permutation can then be listed in a text file as a new vue and the series of possible fault locations will be displayed as an animation of the model with the fault moving through those permutations. Tad Beard encouraged DGI to add a weighting mechanism to each image so that users can assign probabilities of the fault being located in various places rather than giving equal weight to each location within a specified error amount. Other 3D Viewer advancements include volumetrics calculations on the fly and cellular grids with multiple properties. EarthVision will also provide a tool for importing cellular grids.

SUMMARY OF PERTINENT POINTS:

The presenters at this meeting built a number of complex EarthVision models and overcame complex technical challenges, often with the assistance of DGI staff, especially Skip Pack. Among the challenges presented at this meeting were representing thin layers of interfingering clay and alluvium by utilizing property grids and converting a pre-existing model made with another software application to an EarthVision model. More broad-ranging discussions included the interaction of teams of geologists with different specialities and how EarthVision can help team members visualize each other's data and work, the importance of sharing EarthVision capabilities with technical staff who might not otherwise be aware, and efficiency when handling repetitive tasks. DGI presented new software developments that will provide exciting opportunities for geologists to visualize a multitude of data with 3D models and diminish the time required to complete other EarthVision tasks.

CONCLUSIONS:

When building a model, it is important to understand the intricacies of the EarthVision gridding process. Although DGI's minimum tension gridding algorithm is proprietary, certain gridding behavior becomes apparent over extended use, such as artificial corrugations along steeply dipping planes. A user who understands why these problems occur is well equipped to solve them. This knowledge is obtained through training, experience and exposure to a variety of problems, which is one reason that these meetings are so valuable to EarthVision users. They provide an opportunity to learn from each other and from DGI staff the high-level modeling techniques to which many users would otherwise not be exposed. In addition to providing insight into the ways geologists are using EarthVision, the meeting offers an opportunity to discuss and lobby for software development interests with DGI staff.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

Skip Pack of DGI is planning an upcoming visit to the CNWRA and will present recent software developments to interested technical staff.

RECOMMENDATIONS:

None.

SIGNATURES:

Shannon L. Colton (signature) — Mar 21, 2005
Shannon Colton
Scientist
Date

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