Small County: Development of a Virtual Environment for Instruction in Geological Characterization of Petroleum Reservoirs ED53A-0579 Bryan Banz, Dept. of Electrical Engineering and Computer Science, University of Kansas KANSAS GEOLOGICAL SURVEY The University of Kan. Geoffrey C. Bohling, Kansas Geological Survey, University of Kansas **KU** SCHOOL OF ENGINEERING John H. Doveton, Kansas Geological Survey, University of Kansas



Abstract

Traditional programs of geological education continue to be focused primarily on the evaluation of surface or near-surface geology accessed at outcrops and shallow boreholes. However, most students who graduate to careers in geology work almost entirely on subsurface problems, interpreting drilling records and petrophysical logs from exploration and production wells. Thus, college graduates commonly find themselves ill-prepared when they enter the petroleum industry and require specialized training in drilling and petrophysical log interpretation. To aid in this training process, we are developing an environment for interactive instruction in the geological aspects of petroleum reservoir characterization employing a virtual subsurface closely reflecting the geology of the US mid-continent, in the fictional setting of Small County, Kansas. Stochastic simulation techniques are used to generate the subsurface characteristics, including the overall geological structure, distributions of facies, porosity, and fluid saturations, and petrophysical logs. The student then explores this subsurface by siting exploratory wells and examining drilling and petrophysical log records obtained from those wells. We are developing the application using the Eclipse Rich Client Platform, which allows for the rapid development of a platform-agnostic application while providing an immersive graphical interface. The application provides an array of views to enable relevant data display and student interaction. One such view is an interactive map of the county allowing the student to view the locations of existing well bores and select pertinent data overlays such as a contour map of the elevation of an interesting interval. Additionally, from this view a student may choose the site of a new well. Another view emulates a drilling log, complete with drilling rate plot and iconic representation of examined drill cuttings. From here, students are directed to stipulate subsurface lithology and interval tops as they progress through the drilling operation. Once the interpretation process is complete, the student is guided through an exercise emulating a drill stem test and then is prompted to decide on perforation intervals. The application provides a graphical framework by which the student is guided through well site selection, drilling data interpretation, and well completion or dry-hole abandonment, creating a tight feedback loop by which the student gains an over-arching view of drilling logistics and the subsurface data evaluation process.

Subsurface Simulation

The subsurface is generated using a stochastic property generator whose model parameters are defined in an exercise configuration file defined by a facilitator. First the elevations of the major intervals are determined. These surfaces are generated to exhibit reasonably realistic variability and continuity across the county. In the current version of the application, the lithologies and geophysical properties are simulated on demand when the student sites a well, rather than being simulated in advance over the entire subsurface grid.



Figure 1 - County Overview View showing the elevations of the Quivira Dolomite. An existing well is selected and the elevations at that location are shown on the right.

http://www.kgs.ku.edu/Hydro/SmallCounty

User Experience

Upon launching the application, the student is presented with a welcome screen and is prompted for session parameters such as where to store the saved session. After the subsurface has been generated and saved to the session file, the student is presented with an overview map of the county (Figure 1). From here, the student can view contour plots of either the elevations or thicknesses of the major intervals. The data for these plots is interpolated from the known elevation/thickness values found in the existing wells.

The user may also view data associated with an existing well. Clicking on a well's icon populates the Well Summary View with elevations and relative thicknesses of the intervals for the selected well's location. Double-clicking a well provides a dialog with more detailed information about the well.

To site a new well, the student selects a toolbar button and then clicks the desired location on the map. An intent to drill dialog is presented (Figure 2) with information about the new hole, including its name, location, and prognosis depths for each interval.

WELL: Thunder Oil Pfannenstiel 1 LOCATION: T13S R13W S11 NW ELEVATION: Ground 1999; KB 2011 ASL		
Drill Depth (FT sub KB)	Elevation (FASL)	
1126	885	
1298	713	
1904	107	
1981	30	
2827	-816	
2951	-940	
2952	-941	
3437	-1426	
3454	-1443	
	Thunder Oil Pfannenstiel 1 T13S R13W S11 NW Ground 1999; KB 2011 ASL Drill Depth (FT sub KB) Image: I	

Figure 2 - Intent to Drill/Well Prognosis Dialog Box

If the student elects to continue with the drilling operation, the lithology sequence and the properties at each depth are simulated at this time. When the simulation process completes, the user is presented with the Well Log View (Figure 3).

Here the student's task is to interpret the presented data and determine the correct lithology at each depth as well as mark the tops of the major intervals. Additionally the student may select promising ("pay") zones to perforate for production upon completion of the well.



Figure 3 - Well Log View. In this image the lithologies and interval tops have been defined by the user.

After labeling lithologies and the tops of all applicable intervals are marked, the student indicates he has finished by selecting a toolbar button. An interpretation "score card" is presented summarizing the student's performance (Figure 4). A table depicting the difference between the actual interval tops and the student's picks is shown at the top of the window. This is followed by a summary of the picked and missed pay zones.

	for Thunder Oil Lang	g 1		<u>×</u>
Francisco Shale	206	205	1	
CARBONIFEROUS				
Westport Limestone	151	149	2	
Possum Trot Shale	-707	-709	2	
Morn Sandstone	-823			
ORDOVICIAN				
Ozark Dolomite	-823	-825	2	
CAMBRIAN				
Sawyer Sandstone	-1308			
PRECAMBRIAN				
Precambrian	-1308	-1309	1	
		Total Difference	11	
Percent correct int	erpreted Lith	ology: 84.8%		
Pay Identification Total feet of actual pay:	74 186			
Pay Identification Total feet of actual pay: Total feet perforated:	74 186			
Pay Identification Total feet of actual pay: Total feet perforated: Feet of pay perforated:	74 186 26			
Pay Identification Total feet of actual pay: Total feet perforated: Feet of pay perforated: Feet of non-pay perforated:	74 186 26 160			

The Small County application is based on the Eclipse Rich Client Platform (RCP) (http://www.eclipse.org/rcp). This enables for rapid development of an application that runs on multiple operating platforms (Win32, OSX, Linux/GTK) while retaining the feel of the native operating environment. The RCP provides a framework of application, UI, and modeling tools that allow the developers to focus on the applications domain without much concern for lowlevel implementation details. Another benefit of the RCP is that the application is based on sets of plugins. The application is therefore easily extended and its components are reusable.

Figure 4 - Interpretation Evaluation

Currently the application has no means for reviewing performance, so if the student wants to review this information at a later time, the report may be printed.

After dismissing the Interpretation Evaluation, the student is returned to the County Overview View, which has been updated to include data from the newly completed well. At this time the student may begin the process of choosing the site for the next well and continuing the site well/interpret well process until the exercise requirements have been met.

Help System

The application is shipped with a set of documentation that provides:

- Background geological information
- Exploration and development steps
- A usage guide for the application

The documentation is accessed through the application's built-in help system and is implemented as a set of HTML/XML files.



Figure 5 - Help / Background Information





The Platform

Facilitator Tools

Work has begun on a set of tools to enable a facilitator to tailor the behavior of the Small County application. Currently there is an editor for viewing and modifying the parameters defining the county environment, the sub-surface properties and geological elements.



Figure 6 - Environment Editor

Future enhancements include the ability to tailor the "storyboard" of the exercise, allowing a facilitator to specify which elements of the application will be presented to a student and to customize the exercise goals and evaluation criterion.

Future Developments

 Server-based user management Reconfigurable exercises Multi-player game

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