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PREDICTING PRODUCTION BEHAVIOR OF LOW NET TO GROSS WASHOVER FANS USING MODERN GEOMETRIES AND HISTORIC DYNAMIC PRODUCTION DATA FROM LOW NET TO GROSS COASTAL PLAIN ANALOGS

Project Summary

The goal of this research is to use observed geometries and historic dynamic production data from low net to gross washover fans in ancient and modern strata, including those deposited in fluvial and wave/tide-dominated deltaic and coastal plain depositional environments, to create a model of fluid flow through a subsurface washover fan. The model will allow for a better understanding about production behavior of low net to gross washover fans with the objective of being able to make an intelligent prediction of potential hydrocarbon production, design of developments and economic viability for these ancient reservoirs. Production data specifically for washover fans is fairly limited across the public domain, which requires us to use observed modern geometries, coupled with any data from former reservoir studies to construct our model to anticipate fluid flow through a washover fan. This model will attempt to portray more accurate fluid flow in a washover fan, which will enhance economic predictions of future reservoirs with washover fan systems.

Ongoing work will include: 1) data-mining Bureau of Economic Geology State Geological Survey publications of clastic reservoir studies, data mining AAPG, SEG and other societal publications, and data mining theses and dissertations, that contain pertinent data, 2) accessing volumetric and production well data on pertinent fields and units of interest from the Texas Railroad Commission; 3) creation of a database for historic low net to gross strata, including identification and classification of depositional environment, descriptions of shale and sand body architecture and volumetric data; and 4) simulation of fluid flow through a model

generated washover fan architecture, and comparing modeled production across the database for similar washover fan systems to try and reduce uncertainty in future production.

Motivation for the Study

Net to gross is a statistic used to quantify the volume of reservoir space in a given unit, measuring the net sand thickness in relation to the gross interval. Sandstone connectivity is highly dependent on net to gross values and is defined by the ratio of the reservoir that is connected. In studies using simulations of channel geometry, percolation theory defines a threshold of up to 28% net to gross, at which sandstone connectivity is extremely low and effective permeabilities are closer to a mudstone. As net to gross increases from 28%, sandstone connectivity begins to approach 100% and is considered highly connective (King, 1990; Jackson et al., 2005; Larue and Hovadik, 2006). Low net to gross facies, like washover fans, are dominated by generally thinner sandstone packages interbedded with muds and clays that complicate the flow units and facies architecture, isolating sandy reservoir intervals (Beaubouef, 2004; Jackson et al., 2005).

These low net to gross systems have the potential to contribute to global hydrocarbon production, but hydrocarbon exploration companies are hesitant to commit to low net to gross targets, especially in offshore settings where the cost of each well poses significant economic risk, until there is a better understanding of how they perform in the subsurface (Portella, 2003). Due to the expected lower yields from low net to gross systems (Higgs, 2010), an improved understanding of the nature of low net to gross character in various depositional settings and how it acts to create or destroy connectivity will improve recovery efficiency. Understanding performance behavior will enable companies to keep these targets as a realistic option for development in the future.

Methods

The collection of data is the initial, and critical, component of this study and is currently being carried out by reviewing publications of coastal plain reservoir studies that include low net to gross facies. Depositional elements, such as washover fans and deltaic distributary channel-levee architecture, are examples of these types of deposits. Table I shows the types of deposits documented so far from literature. Issues of terminology will not be discussed here, but need to be reconciled for the final publication. Currently our focus is on publications from the Bureau of Economic Geology at the University of Texas at Austin, which also serves as the state geologic survey. The other sources being utilized are the individual well records maintained by the Texas Railroad Commission that include hydrocarbon production. Examples of statistics being collected include, but are not limited to,

- Deposit type, in terms of environment of deposition
- recovery efficiency,

- porosity,
- permeability,
- water saturation,
- original hydrocarbons in place,
- decline rate,
- well spacing,
- production rate,
- trap type, and
- drive mechanism.

The actual design of the database and the data that we chose to populate in it are other fundamental elements of this study. Input has been sought from industry engineers and geoscientists regarding relevant data and architecture of the database. The key is to isolate the most important variables of reservoir character and performance, to be able to collect data on these variables that is as similar from one study to the other as possible in terms of collection and reporting techniques, and thereby to ensure a useful database that is also statistically accurate. Great effort has been put forth to try and standardize data from multiple sources and create a user-friendly data repository.

The next level of this project involves increasing the resolution of architectural understanding in washover fan deposits. This study seeks to incorporate observations from both modern and ancient washover fans in order to model expected fluid flow through this type of low net to gross facies. To generate expected heterogeneities in the model, we hope to utilize core studies and wireline logs from available publications and the Core Research Center. Fields will be searched for core taken from intervals identified as washover fan facies, and the feasibility of a modern systems study of washover fans along the Texas coast is under consideration. All of these data will be utilized in Petrel to build the architectural framework for initial and possibly alternative washover fan geometries to test fluid pathways and assess any regions for potentially unswept hydrocarbons.

Lastly, once the model and database are complete, the goal is to extrapolate any trends by attempting to standardize the quantitative data, while maintaining a link to its associated qualitative data, as well. The quantitative data from similar types of deposits will be cross-correlated to determine if any trends are apparent that will enable us to predict future performance in current low net to gross reservoirs as well as those yet to initiate development.

Relevance of the Study

The reality facing the hydrocarbon exploration industry is that many of the high net to gross targets with high recovery efficiencies have already been identified and produced, and the low net to gross reservoirs have been left unutilized due to poor understanding of production behavior in these systems compounded by the economic risk associated with this uncertainty. In addition, enormous unconventional (liquid and gas) resources reside in low net to gross reservoirs (for example, the Athabasca Oil Sands, Canada; the Ugnu reservoirs, North Slope Alaska, U.S.A.). Using analogs to predict reservoir performance is not a new concept, but in the case of low net to gross systems, a comprehensive study of low net to gross production will allow a greater understanding of how these systems have historically behaved and provide the end-members of what to expect for future low net to gross targets (Dronamraju and Finol, 2005). This research will improve our understanding of production behavior of low net to gross systems according to depositional system and facies associations.

Table 1: Depositional Facies Included in Database
Strand plain
Barrier Island
Wash over Fan
Tidal-Dominated Delta
Wave-Dominated Delta
Distributary Channel
Crevasse Splay
Point Bar
Tidal Inlet Channel

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