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Reservoir Modeling and Production Characteristics of the Cusiana Field, Llanos Foothills, Eastern Colombia

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The Cusiana Field (BP, Ecopetrol, Total, and Triton) is one of the few giant oil discoveries of the 1990s. The field is located on the eastern edge of the Eastern Cordillera of the Andean mountain chain and at the western limit of the Llanos Basin, eastern Colombia. The structural configuration of Cusiana is a large (25 x 5 kms) hanging-wall anticline on a leading thrust structure of the Eastern Cordillera. Drilling depths to the reservoirs range from 12,000 to over 15,000 feet. Appraisal, development, and implementation of production facilities have been executed at a rapid pace despite many operational and environmental constraints posed by the deep burial of the reservoirs in an active thrust belt and the relatively remote location of the field. Over the past 18 months, average daily production has been close to 180,00 bopd, and by mid-1997 new facilities and pipeline upgrades will allow peak production exceeding 300,000 bopd. It is expected that primary drilling will be concluded by yearend 1998 at close to 640-acre spacing.

Effective reservoir management in an environment of high single well and high fieldwide production rates is now one of the biggest challenges to the continued success of the Cusiana Field. This presentation examines the sedimentological and stratigraphic fabrics of the Cusiana reservoirs and compares the evolving geological understanding of the reservoirs to dynamic data and full field modeling results. A focus on the key lessons learned during the past three to fours years and the changing nature of geological uncertainties during appraisal and early production will be a key component of the Cusiana story presented.

The Cusiana stratigraphy comprises three reservoirs that range from late Cretaceous (Santonian Campanian) to early Tertiary (earliest Oligocene) in age. The Eocene Mirador Formation is the principal reservoir containing >60% of the reserves and is currently providing nearly all of the Cusiana production. Stratigraphic evaluation of the Mirador Formation has recognized sandy incised valley fill deposits as the key reservoir components. The interpretation of incised valleys is based on an extensive core data set and biostratigraphic analyses. Valleys comprise 50% of the Mirador stratigraphy and contribute the bulk of a moderately high net-to-gross ratio of 60%. Average porosity in the deeply buried Mirador Formation is only 8% but remains effective because of the nearly pure-quartz nature of the sandstones. Reservoir pressure data prior to and after the onset of production have all indicated that valley sandstones are well connected across the Cusiana Field. However, dynamic data have also indicated that the Mirador reservoir comprises two major compartments, and that single incised valleys behave as strongly layered systems. Both of these features of the reservoir owe their origin to textural characteristics of the incised valley sandstones that are stratigraphic in nature.

Reservoir layers for the static full field model are constrained by the sequence stratigraphic interpretation of each reservoir. In the Mirador reservoir, this deterministic approach allows the general connectivity of valley sandstones to be strongly controlled in the modeling process and also makes the most of the valuable vertical data provided by the wells. Stochastic techniques, allied to empirical field data and analog information, are used to model reservoir parameters such as sandstone body widths and orientations that are incompletely understood. Results from upscaled static descriptions in the dynamic simulator are providing valuable insights into the prediction of the sizes and orientation of sandstone bodies and are being used iteratively to better understand the reservoir geology.

Biographical Sketch

Andy Pulham is a Research Associate in Reservoir Geology at the Energy and Minerals Applied Research Center (EMARC), Department of Geological Sciences, University of Colorado at Boulder. Andy previously worked as a petroleum sedimentologist for British Petroleum and has worked in the North Sea, Gulf of Mexico, and South America. Andy obtained his B.Sc. in geology and geography from Liverpool University and his Ph.D. in geology from the University of Wales at Swansea. His current research interests are the recognition and evaluation of stratigraphic surfaces and fabrics in producing reservoirs and their importance in understanding production characteristics ■