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Otter-Eider Geochemical Production Allocation: 6+ Years of Continuous Monitoring to Provide Fiscal Measurements for Hydrocarbon Accounting

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Over a six-year period beginning in October 2002 weekly samples of commingled oil production from the Otter and Eider fields were analyzed using geochemical production allocation methods. What makes this case history unique is that this was the first time in the UK North Sea that geochemical results were accepted to be the Fiscal measurement for the allocation of oils between two fields. Approval to use oil fingerprinting for fiscal metering required agreements from both the UK Government DTI (Department of Trade and Industry) and the Joint Venture partners (Shell, Esso and Total) from both fields because of the potential impact on Tax and Royalty calculations. This case history demonstrates how to identify an opportunity, design and implement the correct program, adjust for changes, and most importantly provide your customer with timely results.

In 2002 plans were being made to use the existing Eider platform in the UK Northern North Sea as a tieback location for the subsea pipeline from a new 3 well development at the Otter Field. Due to space limitations and economics at that time ($18/bbl oil price), major renovations on the platform were not possible, so the pre existing facilities were the only option for fiscal metering of the production from both fields. There was a test separator with a 10 % metering accuracy, main separator, and one fiscal meter for export. Using the test separator for metering Otter and allocating by difference translated into a 60% uncertainty of Eider allocation over the life of the project. The uncertainty was large due to high Otter contribution, ~90%, to the commingled production and the 10% error of the test separator. Geochemistry was selected as the alternative method to calculate the dead oil split between Otter and Eider as this was expected to reduce the uncertainty to 25 % over the life of the project. To achieve this goal the geochemistry of the commingled fluid would have to be carefully monitored. The geochemistry results would also have to meet the monthly Hydrocarbon Accounting deadline.

The geochemical fingerprinting method chosen for production allocation was the Multi-Dimensional Gas Chromatography (MDGC) technique developed by Shell. This method quantitatively measures eleven aromatic compounds in the C8 – C10 carbon range with the results usually displayed in a star diagram using a standard set of 12 peak ratios to illustrate differences between oils (Ganz 1999 and Rowe et al 2001). Figure 1 shows the starplot of the end-member oils and one of the commingled samples from the Otter-Eider allocation project.

One advantage of the MDGC technique over the traditional whole-oil gas chromatographic techniques utilized in the industry is the long-term reproducibility of the Shell MDGC method. Variations in the starplot of the laboratory standard oil are less than 1% over several years, which eliminate the need to reanalyze end-member and laboratory mixture (calibration samples) each time a new sample is collected. For long-term production allocation projects such as Otter-Eider, where samples were collected once a week, the time and expense of running a project are thus greatly reduced.

The original sampling of the correct end-members and commingled samples is very important for a long-term allocation project. The Eider wells all had a high water cut (>90%) and were produced through a common manifold. Individual well samples were easy to obtain, but a representative Eider field only commingled sample was only possible from the main field separator when Otter was not on production. Otter production was through a subsea pipeline tied back to the Eider test separator. Individual Otter well sampling was only possible when the other two wells were shut-in. Otter-Eider commingled samples were obtained from a flow proportional sampler located at the Fiscal Meter. The flow proportional sampler was changed once a week, which always coincided with one of the Eider wells (EA-13) being cycled on and off. Representative end-member geochemical monitoring was a challenge on the project, while obtaining a representative commingled sample was routine.

The project began as a two end-member mixing model when Otter-P2 and P3 were the only producing wells from the Otter Field. Production from Eider was either with, or without, the EA-13 well. Since the EA-13 well had a different geochemical fingerprint from the other Eider wells, two different end-members for Eider were necessary to make accurate calculations. Allocation calculations using a two end-member mixing model were similar to the traditional mixing line methodology first described in Kaufmann et al 1990. One advantage with using MDGC data is that the ratio mixing lines can now be calculated without actually creating a series of laboratory mixtures. Using the ppm values for each aromatic compound in the end-member oils, a theoretical ppm value for any combination of the two end members can be calculated and therefore be used to create ratio values. Mixing lines of 100 points were used for making calculations and the accuracy of these lines was checked with a couple of lab mixtures of the end-members. Figure 1 highlights the eight ratios that were used to make the calculations for the commingled production samples.

After six months production the Otter P-1 well came on production and it had a different fingerprint from the other two Otter wells. This required the project to move from a two end-member mixing model to a three end-member mixing model. Three end-member models no longer used mixing lines but still utilized theoretical ratios for allocation calculations. Theoretical ratio values for all 12 MDGC ratios were compared to the ratio values for a produced commingled sample and the best statistical match was determined to allocate the % Eider in the weekly flow proportional sample. The statistical technique used to determine the best match is a Shell method called Similarity Index, which will be described in the presentation.

Over a six-year period weekly calculations of the commingled production samples were performed using the two or three end-member models depending on which wells were on production at the time. Each weekly geochemical result was compared to a Flow Estimator calculation of the % Eider contribution. Flow Estimator is a model-based calculation of the daily flow from each of the Eider wells utilizing recent well tests, flowing tubing pressures and temperatures and historical decline curves. Figure 2 shows a comparison of the geochemical allocation values and the Flow Estimator values for 2005. The 2005 comparisons agree very well except when periodical chemical additives were injected into the Otter flow lines. Some of these chemicals contained aromatic compounds (xylenes), which interfered (contaminated) with the MDGC analysis. The results from these samples were deemed invalid and not used for allocation reporting. As a result of the close correlation between the Flow Estimator and Geochemistry calculations, whenever there was a suspect geochemistry value the Flow Estimator value was used for the Fiscal allocation.

References

Ganz, H.H., Hempton, M., Knowles, W., van der Veen, F., and Kreulen, R.,: 1999, Integrated Reservoir Geochemistry: Finding Oil by Reconstructing Migration Pathways and Paleo Oil-Water-Contacts, Society of Petroleum Engineers, SPE 56896, Aberdeen, Scotland 7-9 September

Rowe, R., B. Elsinger, and B. Hutton, 2001, Implementation of a Multiphase Meter on Anasuria, in Proceedings of 19th International North Sea Flow Measurement Workshop, Kristiansand, Norway 22-25 October.

Kaufman, R. L., A. S. Ahmed, and R. J. Elsinger, 1990, Gas Chromatography as a development and production tool for fingerprinting oils from individual reservoirs: applications in the Gulf of Mexico, in D. Schumaker, and B. F. Perkins, eds., Proceedings of the 9th Annual Research Conference of the Society of Economic Paleontologists and Mineralogists, October 1, 1990: New Orleans, p. 263-282.

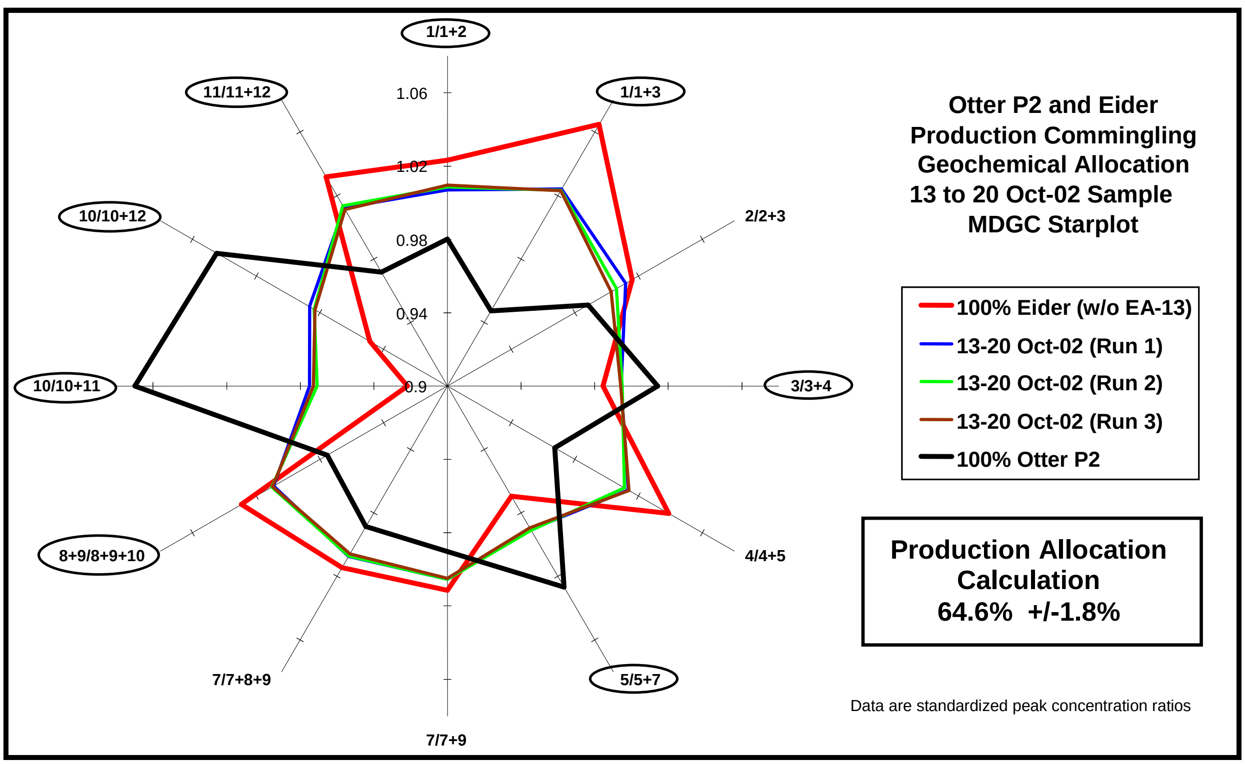

Figure 1. MDGC Starplots for the triplicate analyses of the 13 to 20 Oct-02 commingled sample and the end-member oils. The ratios that are circled were used to create the eight mixing lines used to calculate the % Eider in the commingled sample. The uncertainty in the allocation result is the standard deviation of the average of eight mixing lines and triplicate analysis of the commingled sample.

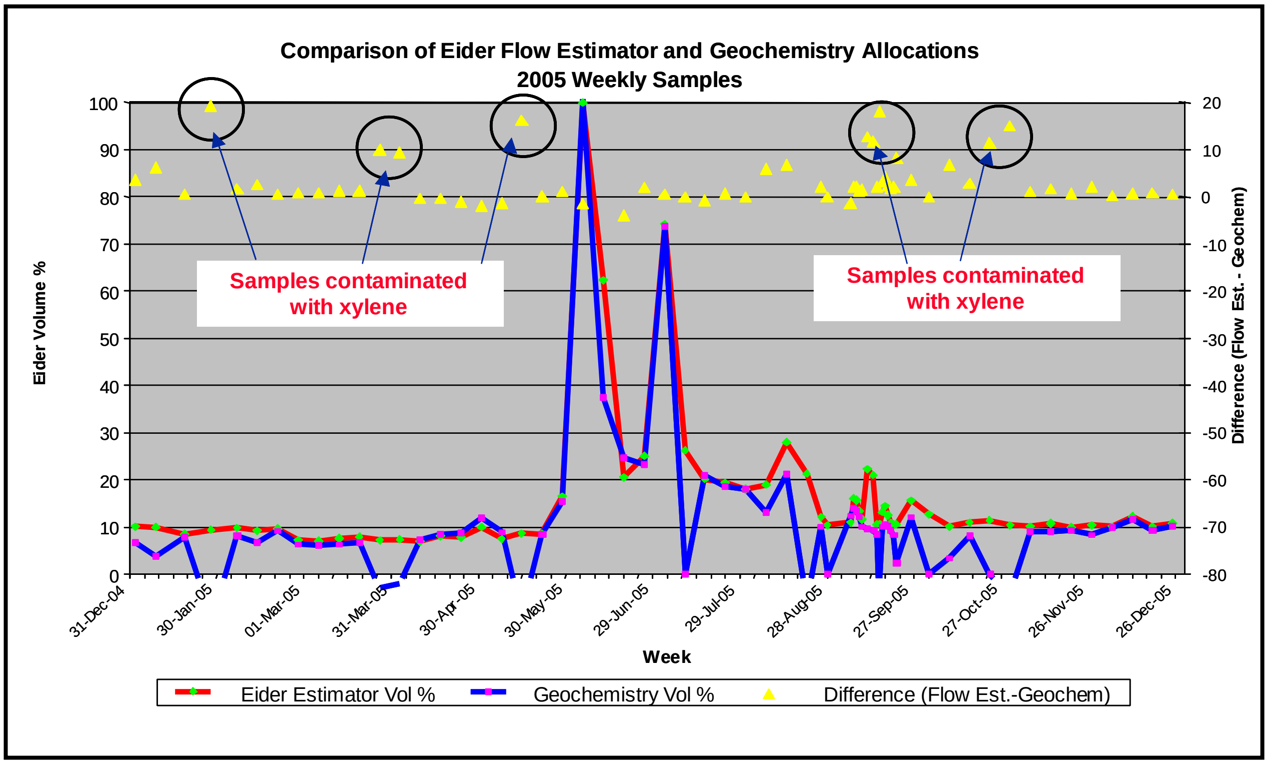

Figure 2. Geochemical allocation results are compared to the Flow Estimator for weekly-commingled samples in 2005. Except when the commingled sample was contaminated with xylene from Otter production additives, the two methods were very consistent in their results.