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ADVANCED MUD LOGGING TECHNOLOGY 'FLAIR' – NEW HORIZONS IN PETROLEUM GEOCHEMISTRY

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Characterization and prediction of reservoir fluids based on mud logging information is not a novel idea or approach, and the basic interpretation approaches have been already presented 20 years ago (Haworth et al., 1985; Whittaker, 1991; Kandel et al., 2001). However, until recently, standard mud logging technologies did not offer the resolution and sensitivity necessary to approach a quantitative aspect of fluid facies description (Blanc et al., 2003). Developments by Geoservices of the Flex (constant volume and temperature) extractor and Flair detector (GC/MS) provide tools to (1) increase sensitivity to analyze C1-C7 hydrocarbon gases down to 1 ppm, and (2) allow for specificity to analyze components up to m/z 100, such as benzene, methylcyclohexane or distinguish between ethane and ethylene during drilling operations. Moreover, a very short cycle time (60 sec) allows for a full chromatographic analysis up to C7, including differentiation of several Cn isomers. Finally, a reliable and reproducible degassing efficiency can be obtained that allows for a quantitative evaluation of the actual content of light hydrocarbon components in the mud system and provides the capability for correction of the mud composition for recycled components and contaminants (details of the technology elsewhere in this volume).

Shell has been using the Flair technology worldwide since 2004 and has tested its application in various geologic settings (deepwater turbidites, carbonates, shallow deltaic systems) and drilling environments (onshore, offshore, high pressure and temperature; oil-based and water based drilling muds). While its primary application, to date, has been for exploration wells, it has been also successfully used as a logging while drilling (LWD) tool in wells drilled horizontally in different directions to appraise extent of structures/reservoirs.

The traditional wetness, balance and character ratios (Haworth et al., 1985) are successfully used, along with oil-water contact (OWC) or biodegradation ratios such as i-C_4/n-C_4 or i-C_5/n-C_5. However, new ratios such as Benzene/n-C_6, Methylcyclohexane/n-C_6 or Ethene/Ethane are being successfully utilized. In addition to the qualitative hydrocarbon facies evaluation and ratio-based interpretations, we have observed a very good correlation between C1 through C5 composition of the actual hydrocarbons sampled from a given

reservoir with the C1-C5 normalized mud gas data from the same formation (Table 1). This phenomenon has been observed on more than 10 wells from around the world and hydrocarbon types varying from dry gas to heavy oil. A number of case studies will be demonstrating the value of the technology and its impact on E&P operations. For example:

- Flair data clearly indicating tops of formations and changes in lithology/porosity.
- Flair data used in a detailed correlation/identification of subtle flow barriers and correlation to facies change.
- The correlation with IsoTubes, wireline hydrocarbon samples and well test samples.
- Determination of changes in HC composition, from gassy shows to heavy HC's, OWC, GWC and GOC.
- Fingerprinting of HC types between wells and within the same well allowing possible correlation of pay zones across a given field.
- Flair used as a LWD tool - assistance in decision-making while drilling.

Table 1. Correlation between C1-5 hydrocarbons between mud gas data from various techniques and the actual hydrocarbon fluids recovered from formations.

Region	**Africa**		**Gulf of Mexico**					**Middle East**	
Component	**HC**	**FF**	**HC**	**FF**	**Trad**	**HC**	**FF**	**HC**	**FF**
C1	73.2	72.3	81.4	80.8	94.6	78.5	76.1	90.1	88.3
C2	9.0	9.1	7.6	8.2	3.7	9	10	5.8	6.1
C3	7.9	7.9	5.6	5.7	1.3	5.5	6.6	2.1	2.3
i-C4	3.1	3.4	1	1.1	0.4	1.2	1.2	0.5	0.7
n-C4	4.1	4.4	2.5	2.3	0	2.5	2.9	0.8	1.2
i-C5	2.6	2.7	0.9	0.9	0	1.3	1.1	0.4	0.7
n-C5	0.1	0.1	1	0.9	0	1.3	1.2	0.4	0.6

NOTE: HC – C1 through C5 normalized composition of hydrocarbons recovered from reservoir; FF – C1 through C5 normalized mud gas composition from Flair; Trad – C1 through C5 normalized mud gas composition from traditional mud logging equipment.

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