OTC 20204

The Impact of Reservoir Fluid Compositional Variation and Valid Sample Acquisition on Flow Assurance Evaluation

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This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

Abstract

The evaluation of flow assurance concerns for oilfield development necessitates corresponding careful laboratory measurements. However, there are two issues of great concern, which are often underemphasized. First, reservoir fluids are spatially variable, both vertically and laterally, and thus tend to be temporally variable during production. For flow assurance evaluation, it is critical to understand any laboratory fluid evaluation within the context of the spatial distribution of complex fluids within the reservoir. For example, asphaltene plugging can be caused by depressurization, commingling, compositional gradients, separator gas injection, 'tar' mat mobilization and water injection issues. It is required to diagnose the problem prior to treating it. Second, it is of paramount importance that downhole sample acquisition be performed in a way to acquire valid and representative samples. Here, we discuss the latest understanding of the origins of reservoir fluid variations and the corresponding impact on flow assurance concerns. Downhole fluid analysis (DFA) is shown to be critically important for elucidating these reservoir fluid variations. The importance of disequilibrium of reservoir fluids is emphasized which dictates that proper analysis must be data-driven, not simply modeled. In addition, we discuss state-of-the-art methods to acquire valid samples. Again, DFA is the method of choice for achieving sampling objectives. In addition, the protocol for optimal selection of sample acquisition points is discussed.

Introduction

Hydrocarbon and even aqueous reservoir fluids can undergo a large variety of phase transitions that can be deleterious for the production of oil and gas. Figure 1 shows various solids that can form upon change of pressure, temperature or composition individually or in combination.

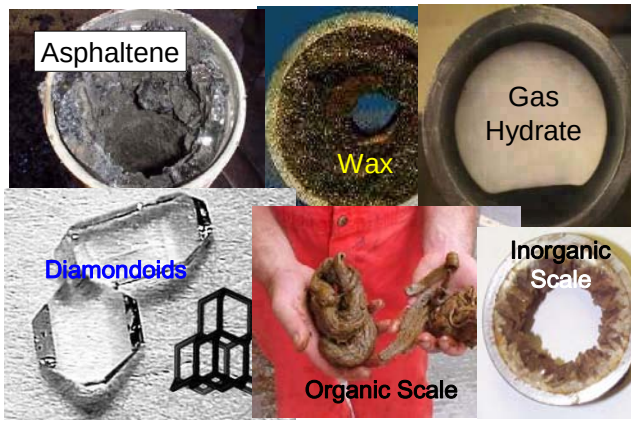

Figure 1. Pressure, temperature and compositional changes that occur during production can lead to solids blockages in pipelines that preclude flow.

Compositional changes can occur as a result of commingling of fluids from (miscible) flood, commingling of fluids from different reservoirs or even commingling of non-equilibrated fluids within a single reservoir. Some of these substances and their phase transitions are not well understood and are the subject of current research. For example, the molecular nature of asphaltenes is only now being elucidated [1] and their phase transitions are an active area of investigation.[1] For a given oilfield, it is essential to acquire representative samples of the reservoir fluids to evaluate if any flow assurance issues are of concern. Openhole wireline formation sampling tools (WFTs) are routinely used for this purpose; Figure 2 shows a schematic of a typical tool string used to acquire formation samples in openhole.[2] Also shown in Fig. 2 is a picture of the probe module which is the all important interface of the formation with the WFT tool. Within this setting, it is essential to minimize contamination of miscible mud filtrate. In particular, contamination of live crude oil samples with filtrate of oil based muds (OBM) is of prime concern. Moreover, it is imperative to avoid phase transitions during sample acquisition, otherwise the differential flow of the different phases all but guarantees invalid sample acquisition.