Assessing the Mix and the Quality of Crude Oil and Natural Gas in the Deepwater Gulf of Mexico

Alan S. Kornacki, Shell E&P Technology Company, Houston, TX
Karen C. Nelson, Shell Deepwater Development Company, New Orleans, LA

The deepwater realm of the northern Gulf of Mexico in large part is a moderately-sour oil province where most free (non-associated) natural gas accumulations contain a significant amount of bacterial methane. The physical and chemical properties of crude oil, condensate, and natural gas strongly influence the inherent value of these oil and gas reserves, and also play a significant role in determining the costs of developing commercial deposits and successfully operating expensive production and transportation systems. Because key engineering and economic parameters of crude oil and natural gas pools vary widely across the continental slope of Louisiana and Texas, E&P staff must understand the nature and origin of these variations in order to properly assess the risks and uncertainty of conducting deepwater operations that are very sensitive to the intrinsic properties of HC fluids. Integrating standard reservoir engineering data available in PVT reports with conventional geochemical data yields useful insights into subsurface processes that subsequently can be used to reduce these risks and uncertainties.

The gravity (Fig.1) and the gas-to-oil ratio (GOR; Fig.2) of deepwater oils range widely. Other important properties of these crudes, such as their organic acid and asphaltene contents, also exhibit considerable variability. A host of geological processes – including the type of kerogen and the thermal maturity of the organic matter in deeply-buried source rocks, and the amount and kind of secondary transformation and mixing events occurring in petroleum reservoirs – control key parameters of crude oils and gases. For example, oil pools residing in cool, shallow (<9000 ft below mud line) reservoirs commonly are hybrid mixtures of residual biodegraded petroleum and a later charge of much lighter, unaltered oil or wet gas. Unfortunately, the geological complexity of vertical and lateral migration and mixing processes makes it difficult to accurately predict crucial oil or gas properties. For example, two-fold changes in GOR are

Paper presented at the AAPG Hedberg Research Conference, "Integration of Geologic Models for Understanding Risk in the Gulf of Mexico," September 20–24, 1998 (Galveston, Texas).

known to occur between some vertically-stacked lobes of oil sand within individual pay zones. Additional risks include the presence of very sour (>3 wt% sulfur) conventional oil and non-biodegraded tarry petroleum that has been encountered at a few widely-separated locations.

Distinct oil provinces are readily identified across the deepwater Gulf of Mexico. Sweet oil that contains <1 wt% sulfur is found in the gassy Viosca Knoll and East Breaks lease areas. The carbon isotopic composition of the methane dissolved in or associated with the Viosca Knoll oils demonstrates that the natural gas there largely has a thermal origin. These sweet oil pools commonly are saturated under reservoir conditions. Sour oil pools that are found in the western Mississippi Canyon, Green Canyon, and Garden Banks lease areas, in contrast, typically are significantly undersaturated under reservoir conditions (commonly by 5,000-10,000 psi). These undersaturated sour oils furthermore generally contain a significant amount of dissolved bacterial methane (typically 25-50% by volume). Thus, most sour oils in the deepwater Gulf of Mexico apparently have inherently low “thermal” gas-to-oil ratios (GORs). The GOR of many sour oil pools reflects the relative mix between highly-undersaturated crude and a distinct charge of bacterial methane. Conversely, some natural gas pools that consist largely of bacterial methane yield significant amounts of condensate that probably represents dissolved crude oil.

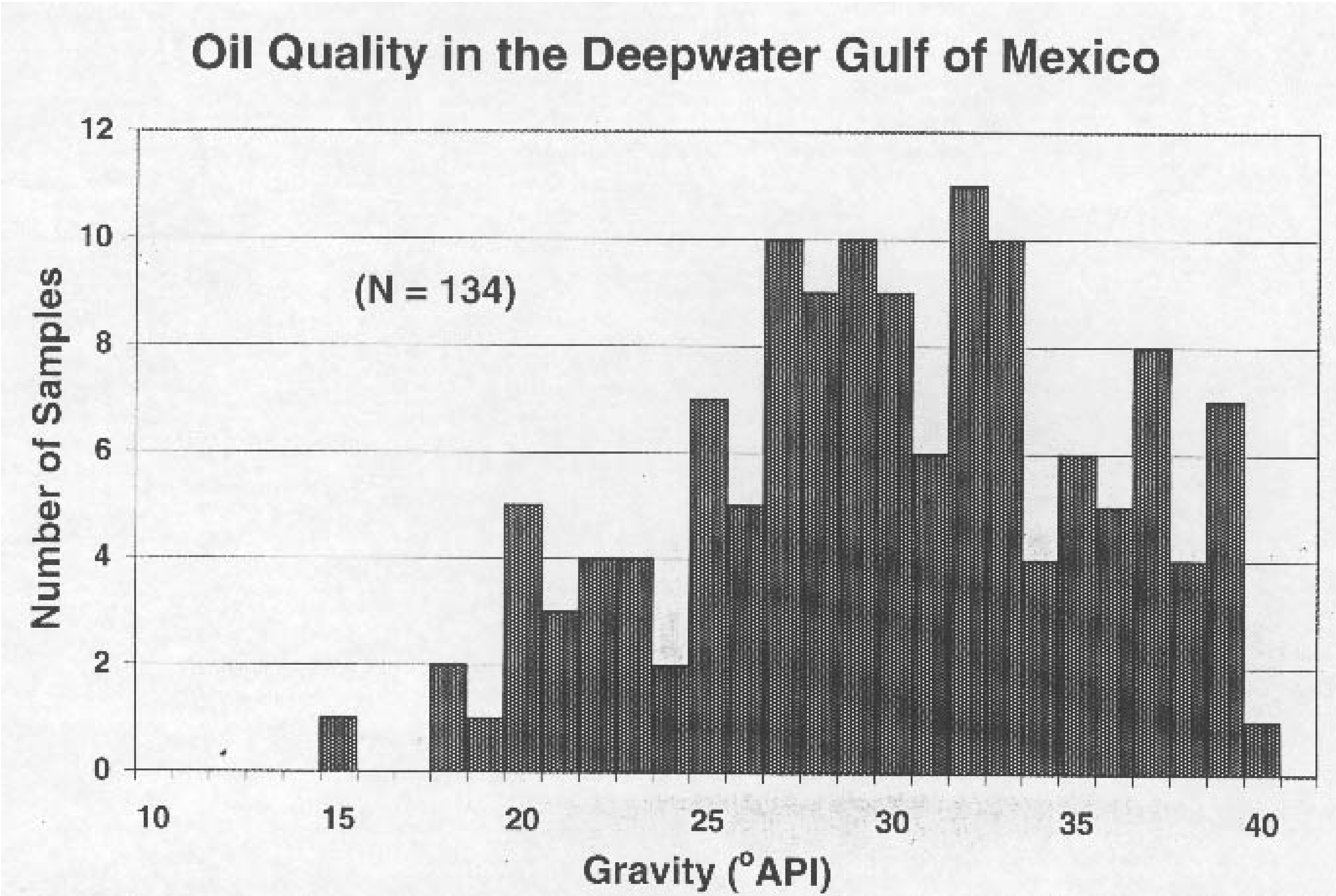
Oil Quality in the Deepwater Gulf of Mexico
(N = 134)
Number of Samples
0
2
4
6
8
10
12
10
15
20
25
30
35
40
Gravity (°API)

Figure 1

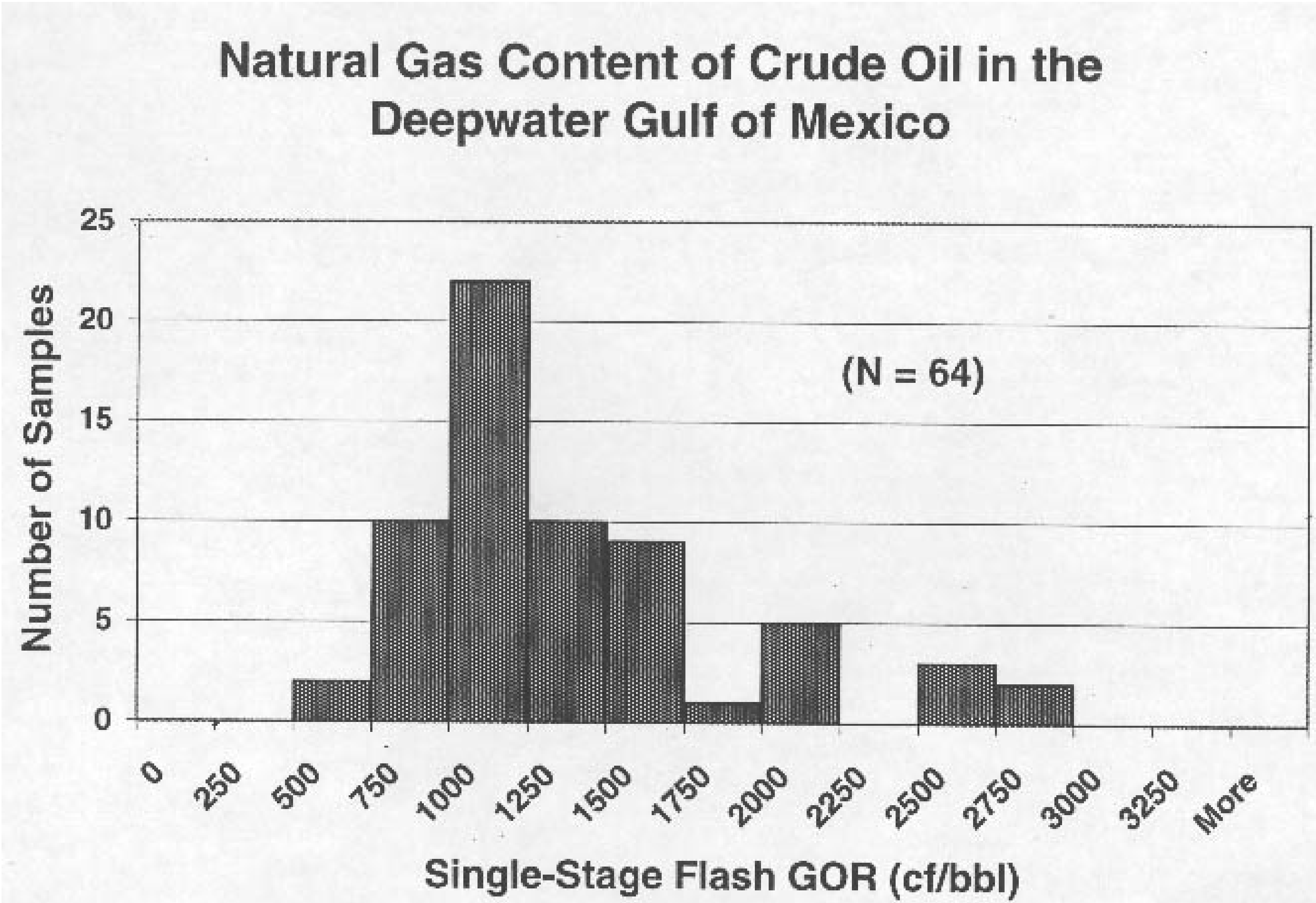
Natural Gas Content of Crude Oil in the Deepwater Gulf of Mexico
Number of Samples
25
20
15
10
5
0
(N = 64)
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
More
Single-Stage Flash GOR (cf/bbl)

Figure 2