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Chapter 5

Relation of Shale Porosities, Gas Generation, and Compaction to Deep Overpressures in the U.S. Gulf Coast

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Abstract

Direct measurements of porosities from Tertiary and Cretaceous shales in the Texas-Louisiana Gulf Coast show that in many areas shale porosity is either constant or increasing at the depths where high overpressures occur and where hydrocarbons are being generated. In the absence of a decrease in porosity with sediment load (depth), gas generation becomes the principal cause of overpressures and hydrocarbon expulsion.

Gulf Coast shale porosities decrease exponentially in normally compacting shales only down to porosities of about 30%, after which the decrease is linear until a constant porosity is reached. These linear trends are believed to be related to the high quartz content (74%) of the clay-size fraction (<4 microns).

The depths at which shales reach relatively constant porosity values appear to depend on the internal surface areas of the shales. Shales containing minerals with small, internal surface areas, such as fine-grained quartz and carbonates, stop compacting at porosities around 3%, whereas shales containing minerals with large surface areas, such as smectite and illite, stop compacting around 10%. This interval of no compaction usually is reached at depths around 3 to 4 kilometers (temperatures of 85° to 110°C) prior to the development of deep high overpressures and the generation of large quantities of hydrocarbons in the Gulf Coast. Model studies indicate that gas generation is the dominant process creating these deep overpressures.

The porosity-depth profiles that show a linear decrease with depth followed by a constant porosity do not conform to the hypothesized exponential profiles used in many modeling programs today. This means that more direct shale porosity measurements are needed to confirm the type of profiles that actually exist and should be used in any basin modeling program.

INTRODUCTION

Compaction is defined as the loss of porosity due to stress. Shales showing no loss in porosity through thousands of feet of burial indicate no compaction. The objectives of this paper are to show how direct porosity measurements made on both cuttings and cores from many wells in the U.S. Gulf Coast indicate the following three points:

1. Under hydrostatic conditions shale porosities below about 30% tend to decrease linearly (not exponentially) with depth to a point below which there is no further decrease.
2. The cessation of compaction does not appear to be related to overpressuring. This phenomenon occurs with normally pressured shales. The two-stage, linear compaction is thus a "normal" compaction trend.